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STRATEGIC ACTION PROGRAMME

GUIDELINES

SEWAGE TREATMENT AND DISPOSAL

IN THE MEDITERRANEAN REGION

In cooperation with

WHO

GEF

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1. INTRODUCTION

Mediterranean region generates large volumes of wastewater, with urban water use alone accounting for about 38 x10^9 m^3/year. Out of it, the northern region produces 23 x10^9 m^3/year; eastern 7.5 x10^9 m^3/year, and southern 7.5 x10^9 m^3/year. Wastewater also comes from industry, commerce and tourist resorts. The wastewater from urban areas, “urban/municipal wastewater”, means domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water. Treated wastewater, known as effluent, is normally discharged to the environment (land, inland waters, and coastal waters), requiring proper management to protect public health and the environment.

A wastewater collecting system:

- receives domestic, commercial and pre-treated industrial wastewaters;

a wastewater treatment and disposal system:

- treats the wastewater to the required level;
- discharges the resulting effluent and solids into the environment.

In providing this service, the wastewater sanitation system (the combined collection, treatment and disposal system):

- manages the liquid waste produced by a community, to protect public health and the environment;
- treats and disposes of the effluent at a location distant from population and protected areas;
- enables where appropriate large scale treatment installations with combined wastewater from many small settlements to be built and operated, resulting in considerable cost savings;
- results in few point source rather than many scattered point and diffuse source discharges, which are easier to manage, monitor and modify.

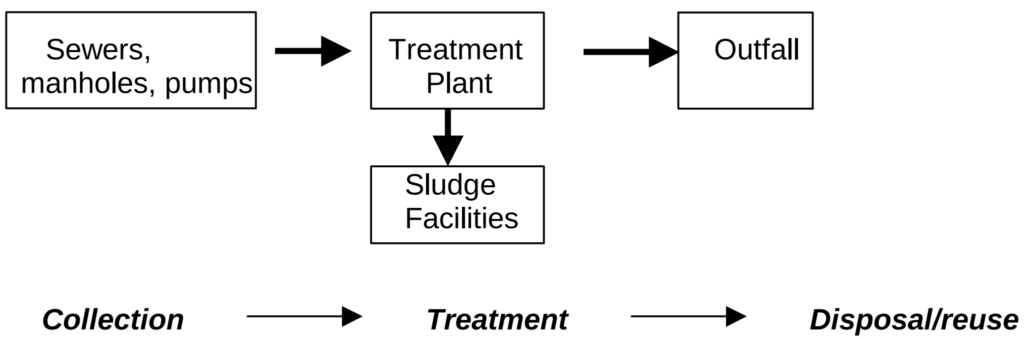

Figure 1: Wastewater sanitation system components

Purpose of Document

This document is a part of the MAP MEDPOL programme and the Mediterranean GEF Project related to Strategic Action Programme (SAP) to address pollution from land-based activities. This series of documents-guidelines covers different issues of protection of the Mediterranean Sea against land-based sources. This document deals with the overall management of the wastewater sanitation system, and particularly with the problem of wastewater treatment and disposal. It has been developed as a basis for a common Mediterranean approach throughout the Mediterranean region.

These guidelines deal with urban wastewater and effluent from urban wastewater treatment plants for domestic and pre-treated industrial wastes. They do not cover effluent discharged directly into the environment from sources such as:

- industries;
- storm water drains;
- overflows;
- septic tanks, etc.

The guidelines do not apply to cases where raw wastewater is applied to land as a part of the treatment processes.

Wastewater treatment and discharges from treatment plants of industries are not covered by these guidelines.

In these guidelines it is assumed that the industrial wastewater connected with urban wastewater collecting system was pre-treated at the industrial treatment plant in accordance with the local and national guidelines for industrial trade wastewater-effluent. The general rule is that industrial effluent, prior to being discharged into the urban wastewater collecting system, should have quality equal to or better than the typical domestic wastewater in order to be transported to and treated at the urban wastewater treatment plant. Only certain higher levels of concentration of biodegradable organic matter than domestic wastewater can be acceptable, which has to be regulated in advance.

These guidelines are intended to apply until the next revision of this document. They describe the principles and practice of managing effluent in accordance with the Mediterranean context, and help identify and select appropriate methods for the Mediterranean region. These guidelines consider and respect the generally known principles, as well as relevant EU directives, and especially the Council Directive concerning urban wastewater treatment (91/271/EEC). The effluent parameters of major concern, the minimum level of treatment, and the commonly required level of treatment are indicated for each of the discharge options. The guidelines can be applied for assessment of the existing effluent discharges, new schemes, and proposals for effluent management. The guidelines are not intended as a replacement for national or international regulations in this field, and especially not for EU countries and the relevant directives.

Target Audience

These guidelines are intended to be used in the Mediterranean region, and particularly in the non-EU countries in the region by:

- decision makers on the wastewater treatment, disposal and effluent management in the urban areas;
- planners and designer of wastewater treatment and disposal systems;
- individuals and organisations such as: government agencies, water authorities, decision makers, regulators, community and special interest groups involved in the preparation of coastal areas, river basin or catchment management plans;
- those involved with different levels of the approval processes;
- as a training material for capacity building in the field;
- all others with an interest in the management of wastewater sanitation systems.

2. ENVIRONMENTAL CONSIDERATIONS

Water is essential for life. It also plays an important part in the economy of a modern country. Ensuring that water resources are understood, respected and managed correctly is vital for any nation future. Coping with the various demands for water, and seeking to maintenance and improve the quality of water, is an important and sometimes difficult challenge.

Rivers, estuaries, coastal water and underground water are all integral parts of the natural environment. Careful planning and management is needed to protect and conserve them, and to ensure that the water they supply is suitable for a variety of uses.
Water provides important habitats for wild plants and animals. We use water for agriculture and industry, for leisure activities- and of course for drinking.

The water we use eventually returns to watercourses and sea. Provided it is not polluted with harmful, persistence substances, water can be used again and again. Evan so, we do need to ensure that we do not take too much water at any one time from a river or other sources.

Waters, with the plants and animals that live in them, can dilute, disperse and break down some materials that enter them. For a long time we have made use of this capacity, both of coastal and inland waters, to dispose of waste. That why we must seek to ensure that the water body and its living components are able to purify the water, and that the entry of pollutants does not threaten water quality.

Background water quality

The water environment is a complex system controlled by a variety of physical, chemical and biological processes. The understanding of these processes is a prerequisite of any consideration of man’s past or future impact on water. Of particular interest in this context is the description of the processes and their spatial and temporal scales, which are important in different water areas and for different pollution situations.

Identification of water sensitive areas is one of important background activities for implementation of appropriate treatment. A water body can be identified as sensitive related to their ecological characteristics (e.g. eutrophic or potentially eutrophic waters) as well as related to water uses (e.g. water intended for the abstraction of drinking water or food production).

Wastewater characteristics

Municipal wastewater consists of a mixture of domestic wastewater, effluents from commercial and industrial establishments and urban runoff. Municipal wastewater composition depends on the specific water consumption. This can vary from 50 - 300 l/capita/day and together with other than discharges from households (industry) explains the wide concentration range of main wastewater constituents.

Municipal wastewater contains over 99.1 percent water. The rest includes material such as suspended and dissolved organic and inorganic matter and microorganisms. These materials give physical, chemical, and biological quality that are characteristics of municipal wastewaters. A typical composition of municipal wastewater is given in Table 1. The values vary with the type of wastewater collecting system used and wastewater input. Concentrations are higher in separate systems than in combined systems. Wastewater quality data show seasonal, daily, and hourly variations. Concentrations are also different in wet and dry periods. For design, the actual composition of wastewater should always be measured.

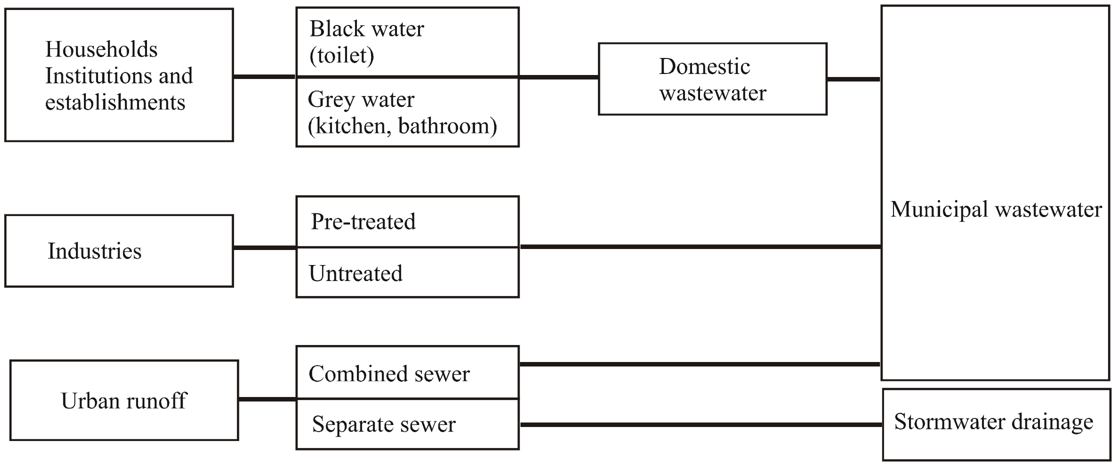

Figure 2: Municipal wastewater components

<u>Table 1</u>

Typical composition of municipal wastewater (UNEP - GPA, 2000)

Parameter	Description	Range of Concentration
Qm (l/capita/day)	Average wastewater flow per capita per day	150 - 250
TS (mg/l)	Organic and inorganic, settleable, suspended and dissolved matter.	300 - 1000
SS (mg/l)	Portion of organic and inorganic solids that are not dissolved.	150 - 350
BOD5 (mg/l)	Biochemical oxygen demand (5-d, 20 C). It represents the biodegradable portion of organic component.	100 - 400
Total N (mg/l)	Total nitrogen includes organic, ammonia, nitrite, and nitrate nitrogen.	20 - 85
Organic N (mg/l)	It is nitrogen bound in protein, amino acid, and urea.	8 - 35
N - NH3 (mg/l)	Ammonia nitrogen is produced as first stage of decomposition of organic nitrogen.	12 - 50
Total P (mg/l)	Total phosphorus exists in organic and inorganic form.	5 - 15
Organic P (mg/l)	Organic phosphorus is bound in organic matter.	1 - 5
Inorganic P (mg/l)	Inorganic form of phosphorus exists as orthophosphate and polyphosphate.	4 - 10
Total Coliforms	The group of aerobic and facultatively anaerobic Gram-negative, non-spore-forming, lactose-fermenting bacteria which typically inhabit the large intestine of man and animals.	10^6-10^9/100ml
Cl^- (mg/l)	Chloride in wastewater comes from water supply, human waste and domestic water softener.	30 - 100
Sulphates (mg/l)	Sulphates contents in wastewater.	20 - 50

Loading of suspended and dissolved solids in municipal wastewater on a per capita basis remain relatively stable, Table 2. The variation in constituent loading per capita per day may be due to industries served, usage of garbage grinders and domestic water softeners, and discharge of septage. In small treatment facilities their effects may be significant.

The population equivalent of a waste may be determined by dividing the total mass per day by the per capita mass load.

Table 2

Typical unit waste loadings

Constituent	Loading
BOD_5 (g/cap/d)	60 - 80
COD (g/cap/d)	110 - 160
Total suspended solid (TSS) (g/cap/d)	70 - 100
Total nitrogen (as N) (g/cap/d)	11 - 14
Total phosphorus (as P) (g/cap/d)	2 - 4
Total coliforms (b.c./cap/d)	10^{10} - 10^{12}

Characteristics of wastewater discharges

Effluent management requires wastewater treatment to a level, which will prevent further deterioration, secure protection and enhance the status of aquatic ecosystems, minimise risk of human disease, and protect environmental uses/values of the waters. Inappropriate treatment of wastewater can cause significant and irreparable damage to receiving waters and land environments. Major threats to the environment are contaminants such as: for inland waters primarily phosphorus and than nitrogen, for the sea waters primarily nitrogen and phosphorus, BOD/COD, suspended solids, heavy metals and toxic substances, pathogens. They can cause environmental damage and threat to human health, directly or indirectly, by food chain processes.

Aesthetics

Protection of aesthetic environmental values is necessary to avoid unacceptable visual, odour, and taste problems, as well as other visual evidence of wastewater solids being discharged: colour, floating materials, grease and oils. Generally, there should be no surface slick visible and no floatable wastewater solids, especially in the bathing areas. This can be achieved through the application of pre treatment processes, and much better, by primary treatment.

Pathogens

Faecal waste from humans and animals contains pathogen micro-organisms (viruses, bacteria, fungi, and protozoan) which are directly harmful to human health. Water-related diseases, such as gastro-intestinal diseases, remain among the main health concerns.

Raw wastewater contains many species of micro-organisms which determine the potential health risk associated with recreational uses of receiving waters or consumption of seafood. Discharged by effluent, pathogens end up in the waters. The pathogens die off slowly in rivers, lakes and sea, and taint fish and shellfish. Rate of die off is significantly higher in sea than fresh waters. The level to which pathogens have to be reduced to ensure appropriate environmental values/uses is prescribed in appropriate standards.

Faecal coliforms are the most widely used indicators for likely presence of pathogens, selected because of their ability to indicate the presence of fresh faecal material and thus the possible source of pathogens.

Nutrients

The nutrients, phosphorous and nitrogen are usually present in domestic wastewater. Increased concentration of nutrients (phosphorus and nitrogen) in receiving waters usually leads to over-fertilisation and blooms of algae or dino-flagelates (eutrophication) which alters the natural ecosystems. This can also in some cases cause development of undesirable species - cyanobacteria which produce biotoxins that cause skin rashes on bathers, and can kill animals which drink affected waters. Once these organisms die off, they start rotting and deplete oxygen, which in turn affects all higher life forms in waters.

Acceptable levels of nutrients vary widely and must be assessed on a case-by-case basis. A water body must be considered as nutrient-sensitive if:

- natural freshwater lakes, other bodies, estuaries and coastal waters are found to be eutrophic or have poor water exchange;
- surface waters intended for the abstraction of drinking water contain more than the concentration of nitrate laid down under drinking water standard.

Less sensitive areas are marine water bodies or fresh-water areas in which wastewater does not affect adversely the environment as a result of morphology, hydrology or specific hydraulic conditions which exist in that area. Generally, these areas have high rate of water exchange/circulation and are not subject of eutrophication or oxygen depletion.

Toxicants

Toxicants in effluent, such as heavy metals (mercury, cadmium, etc.), and persistent organic substances, such as PCBs, can influence health, either as acute or chronic effects. Toxicants are a chronic risk to human health when they are:

- persistent in the aquatic environment:
- bioconcentrated several thousand fold;
- exerting a toxic effect after prolonged exposure to low concentrations of the toxic constituent.

The most common toxicants are heavy metals and chlorinated organic. They are of concern in all environments. PCBs and other persistent organics can be transferred through marine food chain to end up in the fat tissues and milk of adult seals. It is necessary to set out a list of priority substances, on the basis of their toxicity, persistence and bio-accumulation, which present a significant risk to or via the aquatic environment.

The appropriate approach is to control toxicants at the source. It is necessary for all industrial wastewaters, which contain such matter. The aim is to eliminate or to reduce pollution of water by certain dangerous substances. To do so it is necessary to set emission standards for sewers and waters, establish system of prior authorisation, and implement programmes to prevent or reduce pollution. Toxicants can be partly removed from wastewater through biodegradation, or are retained in the sludge. The substances should not be allowed to contaminate wastewater sludge to such extent that the reuse of sludge can be prohibited.

The use of chlorine for disinfection is of special concern if the discharge is to water, as the concentration present can be harmful to aquatic life. Where the discharge is to waters, treatment techniques that do not add to the aquatic toxicity of the effluent are preferred. Good example is long submarine outfall, which uses sea water for disinfection. Where a chlorine is the only practical disinfection option, the need for dechlorination of the effluent should be considered where there is not sufficient dilution through dispersion to ensure that chlorine concentrations are below toxic levels.

Toxic inorganic chemicals, like metals, in higher concentrations may cause synergistic or antagonistic effects in terms of toxicity in biological wastewater treatment plants.

Dissolved solids

Dissolved solids are portions of organic and inorganic solids that are not filterable. The impact of concentration and nature of soluble salts in treated effluent on land and fresh waters has to be considered very carefully. Salt discharged with effluent may alter salinity of fresh water, which may affect ecosystems, depending on the level of stress and ecosystem characteristics. It can also affect possible uses of fresh waters.

Dissolved solids in land application must be also very carefully considered. They may create serious environmental problems, particularly in association with higher water tables. This is especially a problem in the case when effluent or water are used for irrigation. Even if the concentration of dissolved salts is low it can result in a high concentration of salt in soil and reduction in crop production.

Suspended solids

Suspended solids originate form households and industrial waste, but also from urban run-off. The suspended solids render river and lake waters turbid, which in turn affects the biological productivity in water. Much of suspended solids are organic. When it settles out in lakes, rivers and estuaries it will start rotting creating a local oxygen-poor environment with same effects as BOD. Also, disposal of wastewater in shallow and close sea may lead to this condition. At the same time, suspended solids are comparatively cheap to remove. It is the logical first step to build primary treatment to remove suspended solids, and add the next biological treatment steps later as funds become available.

Other considerations

In the review of each discharge all other parameters must be considered. Such parameters are temperature, sand, pH, oils, biochemical oxygen demands, etc. Organic matter (BOD) causes depletion of oxygen in the surface water. As a result, fish die, the water turns black and septic.

The review should assess the impact of parameters on the ecosystems and environmental values of receiving water or land.

Box 1: Constituents in wastewater and their impacts on the marine environment

Characterisation	Impact
Solids	High levels of suspended solids may cause excessive turbidity, shading of seagrasses and result in sedimentation, which is potentially damaging to benthic habitats and can cause anaerobic conditions at the sea bottom. Fine particles may be associated with toxic organics, metals and pathogens that adsorb to these solids.
Organic matter	Biological degradation of organic matter poses oxygen demand and can deplete available dissolved oxygen. The strength of wastewater is commonly expressed in the BOD parameter

	(Biochemical Oxygen Demand). High BOD levels in natural waters can therefore cause hypoxia and anoxia, especially in shallow and enclosed aquatic systems, resulting in fish death and anaerobic conditions. Anaerobic conditions subsequently result in release of bad odours (due to formation of hydrogen sulphide).
Nutrients	Nutrients increase primary production rates (production of oxygen and algal biomass); adverse levels cause nuisance algal blooms, dieback of coral and seagrasses, eutrophication that can lead to hypoxia and anoxia, suffocating living resources (fish). Massive die-off of algal matter will result in additional organic matter.
Pathogens	Pathogens can cause human illness and possible death. Exposure to human pathogens via contact with contaminated water or consumption of contaminated shellfish can result in infection and disease.
Toxic organic chemicals	Many toxic materials are suspected carcinogens and mutagens. These materials can concentrate in shellfish and fish tissue, putting humans at risk through consumption. Bio-accumulation affects fish and wildlife in higher food chain levels.
Metals	Metals in specific forms can be toxic to various marine organisms and humans; shellfish are especially vulnerable in areas with highly contaminated sediments
Fats, oil and grease	Fats, oil and grease float on the surface of sea water, interfere with natural aeration, are possibly toxic to aquatic life, destroy coastal vegetation, reduce recreational use of water and beaches and threaten water fowl.

Environmental uses and water quality

<u>Use area definition</u>

The usual generalised uses of the receiving waters have been identified, and are listed in Table 3.

<u>Table 3</u>

Water uses

Use Area
Drinking
Fisheries
Shell-fisheries
Agricultural uses
Ecosystem
Abstraction
Bathing
Water/marine recreation
Visual enjoyment
Mixing zone

The water uses are often specific to a particular area of the receiving waters. The "shell-fishery" applies to shellfish beds, "bathing" to bathing beaches, "recreation" to the area used for different water recreation activities, and so on. These areas are defined as Uses Areas.

The water use specified as "ecosystem" often applies to all areas outside the mixing zone. However, special protecting/conserving areas have to be specified.

Waters used for drinking purposes are of a strategic interest, with the highest level of protection needed in order to ensure sustainable long-term water use. Generally, discharges of effluent are not permitted in these water bodies.

The drawing up of the water use area boundaries is a multidisciplinary activity involving biologists, chemists, environmentalists, the general public, politicians and other interested parties. These areas are generally defined by development planning processes of the regions.

Definition of the water use in the area concerned is one of the first steps in the wastewater management planning after considering the environmental conditions.

The most sensitive selection of the Use Area is the "mixing zone" selection, which is practically the selection of the point of discharge of effluent. The selection of this zone requires close co-operation with the public and relevant authorities. An appropriate tool for the selection of this zone is Environmental Impact Assessment, or similar assessment methods.

Environmental Quality Objective and Environmental Quality Standards

The fundamental principle of the Mediterranean policy for the protection of the aquatic and marine environments is that the standards to which individual discharges are required to confirm should be set with reference to and objective for the quality of the water affected.

An Environmental Quality Objectives (EQO) is the requirement that a body of water should be suitable for those uses identified by the controlling authority. The uses are protected by one or more Environmental Quality Standards (EQS). An EQS is a specified concentration of substance in the water body, which must not be exceeded if a given use is to be maintained.

Inherent to this approach is the need to allow a reasonable zone in the environment for a discharge to mix with the receiving water. The "mixing zone" is the area around a discharge point wherein the EQS my be exceeded and some level of environmental damage may occur. The decision as to whether or not a "mixing zone" is reasonable in size is a matter of judgement for the controlling authority.

The most important WQO defined to protect the Uses of the aquatic environment are presented in Table 4.

Table 4

Environmental Quality Objectives

EQO No.	Environmental Quality Objective	Description
1	Drinking water	Objective is protection of consumer, by restricting levels of substances in the water depending on level of possible water treatment to achieve drinking water standard.
2	Human Food Source Protection 2a) Fisheries 2b) Shellfisheries 2c) Agricultural water use	Objective is protection of consumer, by restricting levels of substances in any food derived directly or indirectly from fresh and saline water, or by use of water for agricultural purposes.
3	Fish and Shellfish Protection	The objective is to preserve fish and shellfish, primarily for commercial exploitation, and also for angling interests, protection of an ecosystem or general environmental management. EQO2 may also apply, but only if the fish are eaten by humans. Protection must extend to the most sensitive stages of the lifecycle.
4	Aquatic Protection	The objective is protection of other aquatic life and dependent non-aquatic organisms, not of commercial interest, its food sources and/or an ecosystem. Where necessary the sensitive stages in the lifecycle are taken into account. If human consumption is involved, EQO2 above will also apply.
5	Industrial Abstraction Protection	Saline waters are usually only abstracted for cooling purposes, with a low quality requirement. Fresh water can be abstracted for different uses in industry with specific objectives and corresponding quality requirements.
6	Recreation 6a) Bathing (primary body contact) 6b) Contact Water Sports (secondary body contact) 6c) Visual use	For the protection of swimmers and those engaged in water sports and for protection of aesthetic values of the waters.
7	Public Nuisance Prevention-Aesthetic considerations	This is the minimum environmental quality necessary to protect public health and to prevent visual and smell nuisance. General amenity interests, such as protection of fish, aquatic plants, bird life and so on are covered by other objectives above.

Each use of the waters requires appropriate Environmental Quality Standards (EQS)/water quality. For the EU countries and the acceding countries appropriate EU Directives provide appropriate Standards. Non-EU countries generally have standards similar to the EU directives or standards recommended by international institutions such as the World Health Organisation, the Barcelona Convention and its Protocols, and relevant MAP Interim Environmental Quality Criteria (MAP-IEQC).

The possible Environmental Quality Standards for waters are presented in Table 5. They are given as minimum standards. Each country may apply stronger standards in accordance with the specific conditions and/or international/regional obligations.

Table 5

Environmental Quality Standards associated with Use Areas

Environmental value/use	EQO No. (Table 1.)	Aesthetic standard	Microbial standard	Physical-chemical standard
Drinking water	1	None	WHO/EU directives	EU/WHO Drinking Water Directives
Fisheries	2a, 3	None	No restrictions	Appropriate EU Directives (limit for selected substances); MAP-IEQC
Shell-fisheries	2b, 3	None	EU Directive; MAP-IEQC	Appropriate EU Directives (limit for selected substances); MAP-IEQC
Agricultural water	2c, 3	None	Appropriate EU or WHO directives; MAP-IEQC	Appropriate EU/WHO Directives (limit for selected substances); MAP-IEQC
Ecosystem	3, 4	None	No restrictions	Appropriate EU Directives (limit for selected substances); MAP-IEQC
Abstraction	5	None	No restrictions	No restrictions
Bathing	6a	Presence of recognisable solids prohibited	EU Bathing Waters Directives; MAP-IEQC	Appropriate EU Directives (limit for selected substances); MAP-IEQC
Water/marine recreation	6b	Presence of buoyant recognisable solids prohibited	No restrictions	Appropriate EU Directives (limit for selected substances); MAP-IEQC
Visual use	6c	Presence of recognisable solids prohibited	No restriction	In accordance with ecosystem characteristics and requirements
Mixing zone	7	Presence of buoyant recognisable solids prohibited	No restrictions	EU TiO_2 Directive No other restrictions

Legislation and role of authorities

Approaches

There have been basically two different approaches to tackle water pollution problem, and therefore approaches to wastewater management:

(i) The Water Quality Objective approach (WQO) defines the minimum quality requirements of water to limit the cumulative impact of emissions, from both point sources and diffuse sources. This approach, therefore, focuses on a certain quality level of water which is not harmful for the environment and human health.
(ii) The Emission Limit Value approach (ELV) focuses on the maximum allowed quantities of pollution that may be discharged from particular source into the aquatic environment. This approach, in fact, looks at the end product of a process, such as wastewater treatment, or which quantities of pollutants may go into the water.

In case of WQO approach, the level of wastewater treatment and method of disposal of effluent have been selected to achieve required water quality objectives of the receiving waters/sea body with the most appropriate method/solution (economically and technologically). It means that the level of the wastewater treatment has to be regulated on the basis of characteristics of the wastewater (source of pollution) and prescribed water quality objective of receiving water body.

In case of ELV approach level of the wastewater treatment and method of the effluent disposal are prescribed directly or indirectly (by allowed quantities of pollutants that may be discharged) by appropriate regulations in accordance with the characteristics of the particular point source of pollution.

There has been a long scientific and political debate about these approaches. As a result, recent legislation of many Mediterranean countries, as well as of the European Union, is based on a “combined approach” where WQOs and ELVs are used to mutually reinforce each other. Such approach has to be used in the Mediterranean region too. In this concept, the more rigorous approach will apply in any particular situation. This combined approach is in accordance with the precautionary principle, and the principle that environmental and health damage should, as a priority, be rectified at the source, as well as the principle that environmental conditions in particular regions shall be taken into consideration. It means that the Mediterranean regional environmental conditions, as well as the environmental conditions of various sub-regions (countries) in the Mediterranean, have to be considered.

The “combined approach” to pollution control requires:

- limiting pollution at the source by setting **emission limit values** or other emission controls; and
- establishing water **quality standards** (objectives) for water bodies receiving effluent and permissible water uses.

In each case, the more stringent approach will apply. In this case, the country have to set down both the measures to limit values to control emissions from individual point sources, and the environmental quality standards to limit the cumulative impact of such emissions as well as diffuse source of pollution.

In this approach, the level of the wastewater treatment and method of disposal of the effluent are directly or indirectly prescribed by appropriate regulations. It has to be done in accordance with the characteristics of the particular source of pollution (emission limit value), and in accordance with the prescribed water quality objective and permissible uses of the receiving water body (required environmental quality standards). The stringest limit values apply for discharges into freshwaters prescribed for drinking purposes followed by uses like swimming, recreation etc.

Successful implementation of this concept requires, among others, an appropriate control system. Achievement of such degree of control require that the competent authorities have sufficient legal power and resources to be in a position to:

- identify and monitor all types of discharges and other impacts in the catchment area;
- grant permits for the discharge of effluent and enforce compliance with permit conditions; and
- undertake pollution prevention activities such as: enforcing protection zones, or controlling activities which could have adverse impacts on the state of water and sea.

Specific environmental objectives or emission limit values have to be set for the relevant pollutants and pollution sources of priority concern substances (“priority substances”) such as: mercury, cadmium, hexachlorocyclohexane (HCH), DDT, PCP, choloform, aldrin, dieldrin, cyanides, metaloids and metals, etc.

Waters used for drinking water abstraction have to be subject to particular protection. For each significant body of water that is used for abstraction or that may be used in the future, an appropriate set of environmental quality standards has to be established.

The most important element of the sustainable wastewater management system is the balance among the three critical and interrelated aspects: (1) water quality, (2) investment, and (3) tariffs. The objective water quality standard and target levels for wastewater treatment should be defined. These quality standards should then determine the investment required for achieving water quality objectives. Finally, the investment level drives the tariffs, which aim to recover the cost. These tariffs, in turn, determine the service level which can be provided, and the associated water quality objectives. If the balance does not exist, the designed water quality objectives will hardly be achieved.

<u>Role of authorities</u>

General trend in today’s national regulation systems is to clearly identify and separate the roles of:

- water resources management;
- regulation; and
- operation.

The central government institutions have to properly distribute responsibilities among different national ministers and/or regional and local authorities, necessary for successful implementation of the strategy for sustainable water resources management. The key questions, which should be addressed, are:

- Decide on the “lead” institution for implementing the Strategy, as well as for ensuring the co-operation and decision-making process in case of other ministers being involved. In general, ministries that will be involved are: Ministry of the Environment (water quality standards, emission limit values), Ministry of Health (drinking water, use of treated wastewater), Ministry of Agriculture and Forestry (use of sludge, pollution); Ministry of Industry (emission control), and Ministry of Foreign Affairs (transboundary pollution).
- Decide on the distribution of responsibilities (legislation, implementation) among national, regional and local bodies;

- Arrange for the involvement of other public bodies and agencies (institute, environmental agency, water agency, water/environmental inspectorate, etc.)
- Decide, design and implement a national plan for water protection.

The competent national authorities are generally responsible for:

- Planning and implementation activities, including setting clear water quality goals and emission limits values which integrate environmental and economic considerations, with the full participation of stakeholders and consideration for community views;
- Regulation addressing duplications and gaps in government and sectors responsibility for water and wastewater regulation;
- Putting in place clear accountabilities and establishing management for water resources;
- Meeting the community's legitimate demands for input into decision making processes;
- Establishing an inspectorate authorised to inspect installations and monitor management practices and water quality against objectives.

The role of regional and local governments in the water sector is important because:

- In many countries they have administrative structure in which certain powers are devolved to the regions or local level of government (planning authorities, municipality);
- Modern concept of water management is based on decentralisation of catchment or river basin, and involves local people as much as possible in the planning and decision making process.
- Needs of the co-operation of regional and local authorities in developing operational objectives which are also use-related (water for bathing, water for aquaculture, water for drinking water abstraction, water for irrigation, etc.).
- The provision of water and wastewater services is the responsibility of the regional or local government.
- The responsibility for the construction of water and wastewater treatment plants, water pipelines and sewer networks.

The responsibility for ensuring that drinking water is safe and that human waste products are disposed of in a satisfactory way so as to minimise public health risk.

Monitoring

Monitoring is an essential part of the implementation of the water legislation. Systematic monitoring of surface water and ground water quality and quantity includes:

- surveillance monitoring;
- operational monitoring;
- investigative monitoring; and
- compliance checking.

Proper co-ordination of monitoring contributes to achieving the environmental objectives, but also reduces the administrative and financial burden of monitoring.

The monitoring in general has to be established for:

- discharges of wastewater, for parameters depending on the particular case;
- surface waters, for ecological, physical-chemical and morphological parameters;
- groundwater, for physical-chemical parameters;
- bathing water (fresh and marine) during the bathing season, for bacteriological and chemical parameters;
- drinking water, for bacteriological and physical-chemical parameters;

- re-used water, for bacteriological and physical-chemical parameters.

Reporting is one of the most important elements necessary for progress tracking good public relations and information. The competent authorities must have the power to collect information and their duties should include the requirement to set up a data collecting and reporting system. This can be achieved through requirements for licensed wastewater discharges to report information to the competent authority on the activities to which the license permit relates.

3. MANAGEMENT FRAMEWORK

Aims and Objectives

The objective of wastewater management is to avoid long-term deterioration of fresh and coastal sea water quality by appropriate treatment of wastewater and disposal of effluent aiming at sustainable protection and uses of fresh and sea water resources. Thus, the basic aim of wastewater management is to return treated wastewater to the environment in a way which the community accepts after considering both environmental and cost factors. The objective of wastewater management include:

- avoiding health risks;
- preventing the degradation of the aquatic environment;
- promoting sustainable water uses;
- minimising both adverse impacts to land and contamination of surface and ground waters when used in land applications;
- maintaining the agreed water quality objectives for receiving waters when discharging to surface waters and sea;
- maximising the reuse of treated wastewater considering both the value of water and the nutrients.

The water quality objectives will usually be decided after considering:

- existing ecosystems;
- existing state of waters and water quality trends;
- the environmental uses/values of the receiving water;
- uses of the receiving waters;
- environmental flows (biological minimum flow);
- other community objectives.

Quality objectives apply to bodies of water and are related to ambient conditions, and are also based on the toxicity, persistence and accumulative characteristics of substances.

Strategy and Principles

Ecologically sustainable development includes the enhancement of individual and regional well being by economic development, which balances economic, ecological and social demands, and safeguards the welfare of future generations.

This concept of ecologically sustainable development considers a more global approach to a water policy based on integrated river basin/catchment management. River basin and catchment areas, including coastal catchment areas, are the most appropriate defined geographical areas for the water resources management and coastal sea management. This enables assessment of all activities, which may affect a watercourse, the associated estuary and coastal sea, and their control by measures which may be specific to the conditions of the river basin/catchment area.

This concept of catchment management embraces:

- comprehensive approach to natural resources management within a catchment area with the water quality considered in relation to land and water uses, characteristics of aquatic and riparian ecosystems, and other natural resources;
- co-ordination of all the agencies, authorities, water users, water providers, and interest groups;
- extensive opportunity for consultation and participation.

A comprehensive strategy for achieving sustainable water quality management in the Mediterranean region has to be based on a set of principles, such as:

- High level of protection;
- Precautionary principle;
- Prevention action;
- Rectification of pollution at the source;
- Polluter pays principle;
- User pay principle ;
- Waste hierarchy approach (prevention, minimisation, treatment/disposal); and
- Integration of environmental protection into other national policies (transport, agriculture, energy, tourism, fishery, etc.)

Control Mechanisms

<u>Regulations</u>

Most important control mechanisms are regulations and economic tools. Regulation of water in the Mediterranean region varies from State to State. The regulations adopted at the regional Mediterranean level include the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention, 1975); Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona, 1995) and the related protocols. One of the most important for this subject is the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (Athens, 1980/1996).

Legally binding for the Mediterranean region are UN and other international and regional conventions, protocols, and agreements, such as: Agenda 21 (Rio, 1992), Convention on Protection and Use of Transboundary Watercourses and International Lakes (Helsinki Convention, 1992); Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991/1998); Convention on Public Participation (Aarhus, 1998), and others.

However, for the EU countries and the acceding countries there is a set of EU Directives and the appropriate EU policy on the water management and protection, which have to be applied. Water is one of the most comprehensively regulated areas of the EU environmental legislation. The new European Water Policy has been developed, as well as its operative tool, the Water Framework Directive (2000/60/EC). This Directive provides a managerial framework for the whole range of water protection policy and legislation. The most important directives for wastewater companies and thus for these guidelines is: Council Directive concerning urban wastewater treatment (91/271/EEC).

Discharges should normally comply with regulations, such as:

- Health Department regulations;
- planning regulations;
- catchment/river basin regulations;
- environmental/water authority works approval;
- environmental/water authority discharge licences;
- pollution control.

Enforcement

In order to achieve the water quality objectives the measures put in place must be properly implemented and enforced. This can be achieved by developing a suitable regulatory regime with adequate resources to implement and enforce the law. Regulation in this sector, in general, involves the following activities:

- authorisation and/or permitting;
- monitoring, inspection and enforcement;
- data collection and reporting.

The principal tasks related to authorisation and permitting is:

- issuing permits for discharges to water and sea, including quantity and quality of the discharge, setting emission limit values and ensuring compliance with the water quality objectives;
- issuing permits for the abstraction and use of water and sea, bearing in mind the principle of long-term balance between abstraction and natural recharge, environmental needs and competitive uses of water/sea body.

In setting conditions, the competent authority may have to take account of the interests of other statutory bodies and others who may be affected by the discharge or activity through consultation. The details of the permit must be available to the public in some readily accessible form.

Economic tools

The uses of economic instruments are a part of a programme of measures for sustainable water quality management. The principles of recovery of the costs of water services, including environmental and resources costs associated with damage or negative impact on the aquatic environment, have to be taken into account in accordance with polluter-pays and user-pays principle. This means that anyone whose action pollutes or adversely effects the environment should pay the cost of the remedial action. The application of economic tools cannot currently replace the regulatory approach to combat pollution. It should be seen as a part of an integrated system of incentives and regulations where price driven forces such as costs for water use promote preventive measures in households, industries and thus reduce the wastewater quantities and relevant costs for treatment and disposal. Market based instruments rely upon market factors to change the relative price of goods and services, which in turn modifies the behaviour of public and private polluters so that environmental protection or improvements can be achieved. In so doing, have regard to the social, environmental and economic effects of the recovery, as well as the geographic and climate conditions of the Mediterranean region or sub-regions affected.

The main instruments of cost recovery are:

a) *Pricing*: Wastewater tariffs or charges which cover the cost of the collection plus treatment, and this can include organisations to bring in recycling or reuse.
b) *Pollution charges:* Effluent charges based on actual quantities and/or pollution loads of effluent or on some surrogate, though they need to be set at a realistic level to encourage reduction in effluent production. The collected money can be used to fund operating cost and loan charges for capital investment. Administrative charges, which are used only to cover the cost of operating the regulatory system.
c) *Tradable permits:* The responsible authority sets a limit on the total allowed emissions of pollution, and allocates this amongst the sources of pollution by issuing permits to emit a stipulated amount over a specified period of time. After the initial distribution, permits can

be bought or sold. Trade can be external, between different organisations, or internal, between different installations within the same organisation (restricted use in accordance with specific situation).

d) *Subsides:* Subsidies include tax incentives, tax credits, grants and low-interest loans.
e) *Deposit-refund systems:* Customers pay a surcharge when buying a potentially polluting product. On returning to an approved centre for recycling or disposal their deposit is returned.
f) *Enforcement incentives:* These are penalties to induce polluters to comply with environmental standards or regulations. They include fines (for exceeding limits), performance bonds (payments to regulatory authorities before a potentially polluting activity is undertaken, which is returned when the correct regulatory levels are met), and liability assignment (where polluters are made liable for any environmental damage they cause).

Any wastewater programme needs to address financing and cost recovery for sustainable sanitation schemes and ensure equity as much as possible. Unfortunately, users are willing to pay only for what they see as a benefit or priority. Usually it is not sufficient to pay the full cost of the systems, including collecting system and treatment. Complementary financing has to be secured through a variety of taxes presented above. However, tax collection in some developing countries is not efficient, and in addition significant part of population does not pay taxes at all. It is often the reason why the wastewater management is insufficiently effective.

The concept of “full economic cost recovery” can and will provide an adequate signal only when the following are met:

- There is a clear relationship between the water use (pollution) on one hand, and the costs of providing the necessary services, and environmental cost on the other, and it is possible to put monetary value on these costs;
- The institutional framework enables governments to charge the polluter, and there is a political “willingness to charge”, which again depends strongly on the social and economic context and the public “willingness to pay”.

Effluent Quality

Two procedures have been used to identify appropriate levels of effluent quality:

1. Effluent management and environmental values/water uses;
2. Technology based guidelines.

<u>Effluent management and environmental values/water uses</u>

The underlying principle of managing effluent discharges is maintaining the environmental values and uses (Box 2.) of waters and sea, and for land application, the sustainable use of land. Environmental values or beneficial use are values or uses that promote public benefit, welfare, safety or health, and ecosystem protection, and are in need of protection from the effects of pollution, waste discharge and deposits. Environmental values or beneficial uses within a catchment and coastal sea have to be defined by balancing the social, environmental and economic benefits and costs. This is generally the responsibility of the State or regional governments, and should be defined through the development of the river basin management plans which have to be drawn up on a river basin basis, considering land-use plans and other sectoral development plans. It may be necessary to sub-divide a larger river basin into smaller units (catchment), and sometimes a particular water type may justify its own plan (e.g. coastal sea catchment area).

The adoption of environmental values/uses has to be based on balancing financial costs and environmental benefits. The balancing should consider all local and specific factors of the catchment/coastal sea area, such as urbanisation, growth and development, and waste management practice. The goal is to achieve ecologically sustainable development, which can be done only by optimising these factors in the process of development of the river basin/catchment management plans.

Application of water quality based effluent standards should take into account the relative contribution of diffuse sources and background waters/coastal sea conditions to ensure the achievement of the good state of the fresh and marine waters, and thus of the required environmental quality standards.

Box 2. Environmental values/uses

Environmental values for the aquatic systems are:

- Protection of aquatic ecosystem
    - Protection of freshwater ecosystem
    - Protection of marine ecosystem

- Protection of habitats and species directly or indirectly depending on water

- Recreational water quality and aesthetic
    - Primary body contact (swimming, surfing, etc.)
    - Secondary contact (boating, fishing, etc.)
    - Visual use

- Raw water for drinking water supply
    - Raw water subject to coarse screening only
    - Raw water subject to coarse screening and disinfection
    - Raw water subject to other treatments

- Food production in freshwater and sea
    - Production of shellfish
    - Production of fish
    - Production of other edible organisms

- Agriculture water uses
    - Irrigation
    - Stock watering
    - Farmstead use

- Industrial water quality
    - Heating and cooling
    - Hydro-electric power generation
    - Textile industry
    - Chemical and allied industries
    - Food industries
    - Beverage industries
    - Iron and steel industries
    - Tanning and leather industries
    - Pulp and paper industries
    - Petroleum industry, etc.

- Mixing zone

Technology-based guidelines

Effluent guidelines are to be based on the application of an appropriate and accepted modern technology. A large variety of conventional and non-conventional wastewater treatment technologies exists, ranging from simple screening and settling operations to sophisticated biological and chemical operations. Wastewater treatment products, besides adequate effluent, consist of the material removed as sludge and other residual matter. This removed material requires additional treatment and appropriate disposal. As a rule, the treatment costs, energy and sludge production increase with increasing pollution removal capabilities. Effluent guidelines have to consider:

- technology that has demonstrated a consistent achievement of acceptable protection of the receiving water/sea, or contaminant levels in the environment while maintaining economically viable operations (“best available techniques” and “best environmental practice”);
- sludge management requirements based on local possibilities;
- time limits for installation in both new and existing plants;
- local experience, skills and knowledge for design, construction, operation and maintenance;
- conditions that may affect sustainability of the management/operation;
- nature and volume of the wastewater concerned;
- engineering and scientific developments in wastewater treatment, and economic feasibility of such techniques;
- opportunities for waste minimisation/prevention;
- the potential of new and emerging technologies to economically achieve higher levels of performance.

These guidelines are also necessary in the case where technology-based guidelines can produce ambient water quality above the state objective in order to cope with possible future requirements (discharges).

Determination of effluent quality

Effluent quality has to be determined in accordance with the national legislation in the field. A prerequisite of sustainable wastewater management is the determination of the required effluent quality in accordance with the selected environmental values/water uses of the water/sea bodies and their sensitivity to adverse effects on the environment, such as eutrophication or increased concentration of nitrates in drinking water. When adopting action plan and measures, it is necessary to take into account the best available techniques and the best environmental practice. On the basis of the EQS it is necessary to establish and/or implement (i) emission controls based on best available techniques or (ii) the relevant emission limit values.

The technology-bases guidelines have to be applied progressively to the existing installations. New installations would generally comply at start up. The existing installations would be expected to adopt phase-down programmes to progressively bring their discharges into compliance. However, in case of non-existence of a complete collecting system of the agglomeration, treatment installations have to comply with the requirements progressively in accordance with the quantity of wastewater and/or pollution loads.

If scientifically/technologically based effluent criteria are not sufficient to meet well defined water quality criteria, then waste prevention/minimisation measures should be applied, in order to remove the “difficult” pollutants before wastewater treatment and effluent discharge into receiving water. This approach should be applied at the planning or design stage of new installation, and used as the target for any planned major augmentation of the existing discharge.

It is necessary to determine, in co-operation with local and regional authorities, the current state of the existing collecting system and wastewater treatment plants, and identify those, which need an additional sewers to collect wastewater, and the provision of a wastewater treatment plant.

In particular situations it is possible to apply “appropriate treatment” underlining that such treatment has to ensure the necessary quality of receiving water/sea - WQS.

Receiving Water Body and Aquatic Ecosystem Protection

The eco-classification is necessary for the management of waters and sea. It will provide general framework for determining aquatic ecosystem management objectives and the resulting guidelines for water quality and physical habitat.

The receiving water aquatic ecosystem has to be classified in accordance with the ecosystem characteristics. Unfortunately, there is no unique scheme for the categorisation. The aquatic ecosystem can be generally classified in two major groups:

- fresh water system, and
- marine water system.

Where appropriate, each of these is further subdivided forming four broad classes:

- freshwater (flowing)
- upland rivers and streams;
- lowland rivers.

- freshwater (standing)
- lakes and reservoirs;
- wetlands.

- estuaries
- open (drowned river valley)
- closed (barrier or island)
- deltaic.

- coastal and marine
- barrier lagoons or embayments;
- open coast.

The EU Water Framework Directive (Annex XI) divided the waters of Europe in ecoregions. The transitional and coastal waters of the Mediterranean region belong to the ecoregion-Mediterranean Sea, while the rivers and lakes belong to several ecoregions: Iberic-Macaronesian region, Pyrenees, Dinaric western Balkans, Hellenic western Balkans.

The basis for the protection of an ecosystem is the ecosystem conditions and recommended threshold levels of acceptable change for each.

Three ecosystem conditions are recognised:

1. High conservation/ecological value systems.

These are highly valued ecosystems such as in national parks or in remote and/or inaccessible locations.

2. Slightly to moderately disturbed systems.

The biological communities remain in a healthy condition and the ecosystem integrity is largely retained. These are ecosystems in which biological diversity may have been affected adversely to a small but measurable degree by human activity.

3. Highly disturbed systems.

These are measurably degraded ecosystems of lower ecological value. It means that these systems are under significant human pressure, and that for practical reasons it may not be feasible to return them into one of higher categories/conditions.

A level of protection is a level of acceptable change from a defined reference condition (defined from reference sites). However, appropriate level of protection has to be based on the community's long-term desires for the ecosystem.

Stakeholders

Different stakeholders participate in wastewater management. The most important are:

1. Governments - implementation and maintenance of compliance with policies and legislation in the field, provide environmental/wastewater agencies with authority, reporting and response to the community.
2. Environmental agencies working on behalf of the central government - provision of planning, setting standards and regulations, application of standards and regulation, monitoring and compliance assessment, and technical assessment.
3. Regional and local governments/municipalities - provide input to the system and may be affected by the decisions of agencies/government and of the wastewater authorities, construction of public owned collecting system and wastewater treatment works.
4. Wastewater company/authorities (public and/or private)- managers of wastewater sanitation systems, constructors and operators of privately owned wastewater treatment works.
5. Industrial companies - compliance with permits for effluent discharged.
6. Public - involvement in consultation processes for the planning. Reporting pollution incidents.
7. Environmental and consumer NGOs - lobbying on behalf of the public with respects to water quality objectives, setting treatment plants, pollution problems.
8. Research institutions and universities - technical research into environmental quality standards, toxicity assessment, water analysis, treatment technology development.

The Role of the Wastewater Company/Authority

The wastewater company/authority can be public and/or private. They act for the shareholders, customers and the community they serve. Their roles include:

- managing the wastewater sanitation system as efficiently as possible;
- maintaining and encouraging community participation in different issues;
- informing the community about the results and impacts of its decisions;

- participating in a comprehensive catchment/river basin management approach and planning activities;
- identifying the financial, environmental and social costs of decisions for the community;
- advising government agencies on technical issues and options available;
- maintaining close liaison with government agencies/authorities on the performance of the wastewater collecting system and treatment works;
- informing and providing returns for its shareholders.

Community Consultation

An important aspect of the wastewater management is the need to involve the public. For many years, the responsibility for environmental decisions, and thus for wastewater management, was taken by governmental an/or by wastewater authorities and other agencies and water authorities. The community now expects to be involved in the decision-making process because much of what is decided will have a direct impact on people's lives. Impacts include the quality of waters in their neighbourhood, costs of water and wastewater services. Since the emission limits influence industry and end-uses such as bathing, fishing and aquaculture farms, the public has also strong and legitimate interest in setting water quality objectives.

The policy-making process must provide the community with:

- information on the benefits, costs and environmental and public health impacts of alternative methods of effluent management;
- opportunities to participate in decision making.

Public involvement in decision-making will encourage the community to consider effluent and waste management options in a broader water resource management context. It will ensure that community consider and be more interested in options in a broad catchment context rather than on more narrow grounds, which can result in more sustainable wastewater management: higher water quality, lower investments and lower tariffs. To achieve this it is necessary to make information widely available and provide opportunities for public involvement in decision making.

Most of wastewater services in the Mediterranean countries are publicly owned monopolies. The cost of pursuing higher water quality results in intensive wastewater investments and recurrent terms and must either be passed on as higher charges or absorbed as lower returns. The cost of operation and maintenance of those wastewater sanitation systems is often higher than the annual depreciation of the investment. Only a few (developed) countries in the region manage to recover all costs directly from their customers through user charges. There is a role for the local community to have a say about balancing the costs and benefits to achieve improvements in water and sea quality, or reductions in environmental impacts of wastewater flows, at the least cost to society and a maximum value to consumer.

Costs of wastewater management programmes are very high in both capital and recurrent terms, and those programmes depend critically for their success on effective advocacy and public awareness through information, education and communication. That way the process must be open to a systematic community scrutiny to ensure benefits and justify the cost.

The ultimate decision on the discharge quality to be met lies with governments in their roles as standard setters and regulators. The aim of public involvement is to achieve waste management solutions that reflect the community preference on its use of resources.

It is very difficult to quantify all the costs and benefits of wastewater management. The comprehensive cost-benefit analysis approach has substantial merit in determining standards. However, the benefits of improved environmental amenity are very difficult to be quantified in monetary or other terms. In particular, it is very difficult to reflect the benefits of long-term environmental sustainability in traditional cost-benefit analysis.

This means that it is necessary to consider a wider range of assessment techniques, which ensure that informed decisions are made. Some of the approaches which should be used to explain and make transparent the costs and benefits of various options include:

- Establishing programme of communication with community and reporting the views expressed via community input processes;
- Identification and determination of the issues, and presenting evidence about the nature and scope of the identified problem (e.g. current situation with regard to wastewater management, current knowledge and scientific evidence, evidence of recreational and commercial use of receiving waters, evidence of existing reviving water quality, etc.);
- Providing the context within which the proposed options have been developed (e.g. description of previous attempts to solve the problem, relationships to the wastewater authority's capital investment programme, existing regulatory regime, etc.);
- Assessment of current know-how, attitude and practices, and providing information on the relevant trends and options (e.g. present knowledge in the field of the waste management, the range of available waste management options, etc.);
- Risk assessment and sensitivity analysis;
- Environmental impact assessment;
- Calculating and presenting the total capital and recurrent costs of pursuing various levels of environmental enhancements, and equating these to an annual cost or rate that the individual must meet;
- Assessing the range of possible environmental and other benefits that might flow, quantifying these where possible;
- Consulting the community on the level of enhancement it wishes to accept.

These as well as other approaches for community consultation will result in a sound understanding of community preferences. People tend to change when they understand the nature of change and view it as beneficial, and when they feel that they are part of the effort. That way they have to be informed and convinced. Unless their circumstances are taken into account and their felt needs are met no effort for change will be successful.

Failure to undertake such a process can result in:

- adoption of solution or elements of solution that the community does not support (e.g. type of the wastewater collecting system, level of treatment, location of outfall or treatment plant, etc.);
- investments and tariffs which community can not support;
- excessive and for public undesired exploitation of the environment;
- communities incurring high cost for what may be low priority environmental goals;
- non-sustainable wastewater management, etc.

4. OPTIONS FOR EFFLUENT MANAGEMENT

Options of the wastewater management have to be based on the philosophy, objectives and principles presented in the previous chapter - Management Framework. Each country in the region has some specificity related to wastewater management as a result of cultural, environmental, political, economic and other factors, and thus needs to have a specific list of sustainable options. However, general philosophy, objectives and principles have to be respected because they are part of global and regional policy of sustainable development and water resources management.

Wastewater management options should address the management of the wastewater sanitation system as a whole (users/wastewater, collecting system, treatment and disposal) and each of the aspects individually.

The general aspects are:

- waste minimisation;
- managing of collecting system;
- managing of treatment system (wastewater and sludge);
- effluent reuse;
- effluent discharge to:
    - land,
    - coastal waters,
    - inland waters.
- marine disposal system.

Choice of preferred options is made after considering:

- public health and environmental impacts;
- social needs and community expectations;
- regional and state ecologically sustainable development policy;
- associated river basin/catchment management policy and plans;
- national, international and regional obligations;
- feasibility- technical, operational, financial, social and environmental criteria, options and alternatives;
- cost of the scheme and social impact;
- available and feasible technology.

In the selection of the options it is necessary to apply a hierarchical approach for waste management by encouraging wastewater producer, services providers and authorities to choose waste management options towards the top of the hierarchy, as follows:

1. no use or production of unwanted substances;
2. waste minimisation or reduction of waste production quantities;
3. re-use and, thus decrease of the amount of waste to reach the environment;
4. recovery and convert;
5. treatment;
6. dispose and disperse.

It is important to understand that most of the water used in household/town is a transport medium for waste out of town. The one of the function of the water used in households is to remove unwanted matter from the location where the water is used: toilets, wash basins, kitchen sinks, washing machines, etc. The function is to clean the thing, the fabric, the place, etc. In doing it so the effect is that the matter that is removed is transported away with the water.

Waste Minimisation

Waste minimisation is the one of the priorities of any sustainable wastewater management strategy and should be first addressed. Waste minimisation means risk minimisation. It is the activity at the top of the "waste hierarchy" approach.

The application of good waste minimisation practices will push the volume of wastewater and quantity of potential pollutants to a minimum, and thus the risk to the human health and the environment.

The most important areas that have to be considered are:

1. Reduction of contaminants in industrial wastes discharged to the collecting system (good trade effluent characteristics);
2. Reduction of contaminants in wastewater from small industrial enterprise in towns where it is difficult to implement the trade effluent standard;
3. Minimising of wastewater flows by applying water conservation and demand management principles to industrial, commercial and domestic customers;
4. Management of domestic products that may add contaminants to the wastewater flow;
5. Management of collecting systems to exclude infiltration and stormwater;
6. Control, at the country level, of product constituents (organic matter, metals), and especially home and industrial dumping of chemical substances.

Reduction of the quantity of the pollutant being discharged to the wastewater system also has a positive impact on the entire system, such as: savings in treatment plant operation cost and resources used, reduction in sludge production and costs of sludge treatment and disposal, maintenance cost of collecting network and treatment plant, etc.

A reduction has direct impact on the capacity of the system as a whole, which can be appropriately smaller, as well as the relevant investment and operational costs. However, the most positive aspect of the reduction is minimisation of the negative impact to the environment.

A range of actions in different areas can be applied for waste minimisation, and at different management levels. Usually, actions in the areas are:

- reduction of inappropriate use of potable water as transport medium in sewer, or reduction of reliance on water as transport medium for waste: water saving rules, such as requiring the use of water saving devices (showers, toilets), and pressure reduction;
- incentives, such as quantity and quality based charges for major industrial and commercial discharges, and user-pays for domestic wastewater;
- education, such as providing information on the use of water-efficient appliances and environmental friendly products and practices;
- regulation, control or ban of use/import/production of certain type of products, devices and appliances;
- education on and promotion of on-site recycling of materials;
- on-site treatment and reuse.

The usual measure for control and reduction of industrial and commercial wastewater discharge to the communal wastewater collecting, treatment and disposal system is the application of Trade Effluent Discharge Standards. It is a very efficient measure that leads to waste minimisation activities at the source. It is well known that actions at the source are the most productive for the waste minimisation. It will result in waste prevention activities, internal recycling and reuse, and local treatment of wastewater.

The most common waste minimisation measures, which can be employed in domestic, commercial and industrial situations, are presented in Table 6.

Table 6

Waste minimisation measures in domestic, commercial and industrial situations

Type	Measures
Domestic	minimise water usage and discharge through legislation and public education, e.g. : dual flush (6/3) toilets, low flow shower heads, low water use washing machines and dishwashers, systematic repair of leak
	bans on the use of westwater systems for the disposal of drainage water
	detect and remove illegal connections, such as roof drainage
	minimise pollutant loads via public education on not using the wastewater collection system as a rubbish disposal system, limiting the amount of oil and grease going down the sink, minimising the amount of soaps and detergents used, including possible alternatives; and regulation of product constituents (for example, phosphorus in detergents).
	supporting and enforcing restrictions or bans on the use of sink garbage grinders
	minimising the amount of household chemicals in wastewater by educating the community on their proper disposal and by having proper disposal available, e.g. programmes aimed at cultural change; separate the toilet waste where appropriate to agricultural use; divert where appropriate, kitchen waste to solid waste, or to recycle.
Commercial and industrial	minimise water usage, discharges and pollutant loads through a combination of legislation, education and financial incentives (for example, a charge for service based on the strength and volume of trade waste).

Managing the Collection Systems

The wastewater sanitation system is an integral part of the urban society. The objectives of that system are to protect and to maintain the health and safety of communities, to protect the natural environment and to be sustainable. There is strong interaction between these three objectives and that way they have to be *considered integrally.*

To be sustainable, an urban drainage should:

- be efficient and cost effective;
- maintain an effective public health barrier and provide sufficient protection;
- avoid local and more distant pollution of environment (air, land, and water);
- minimise the utilisation of natural resources (water, energy, materials);
- on-going operation of the system is necessary;
- be operation in the long-term and adaptable to future requirements;
- be practicable within the social context of the community that is expected to use the technology;
- the chosen technology is in balance with the available infrastructure, institutions, human resources and economic conditions.

The system will only be truly sustainable if its financing is compatible with the long-term ability and will of the community to pay for it.

A properly managed system will:

- minimise potential for incidental spills to the environment;
- minimise potential for overflows and restrict occurrence to situation where they cause least problems;
- minimise odour and gasses emissions;
- minimise infiltration (leakage of groundwater into the pipes and channels), inflow of storm water through sewerage elements (manholes), and illegal discharges of stormwater to keep wastewater volumes to a minimum;
- deliver wastewater quicker and so as fresh as possible to the treatment plant so that it is easy to treat;
- minimise energy and other resources usage;
- avoid deposition and blockage in the sewer;
- minimise exfiltration;
- avoid any contact of humans and animals with wastewater.

Box 3: Indicators of sustainability for urban wastewater sanitation systems

Possible indicators for urban wastewater sanitation systems are:

Wastewater sanitation system	Dimension	Indicators
Wastewater	Production	Wastewater production per day
	Treatment performance	Removal of BOD_5, P, N, S.S., COD (%)
	Loadings to receiving waters	Loadings of BOD_5, P, N, S.S., COD (kg/day)
	Resource use	Chemical use per P removed and effluent disinfected (in case chlorination)
	Energy use	Energy use per BOD_5 and N removed, and effluent disinfected (in case UV)
By-products	Sludge production	Sludge production per day
	Sludge use	Amount of sludge disposed or reused (%)
	Recycling of nutrients	P and N recycling
	Quality of sludge	Cd, Cr, Cu Hg, Ni, Pb, Zn content in sludge (mg/kg dm)
	Energy use	Energy use per treated sludge
	Energy recovery	Energy recovered, heating and power (Gwh)
	Resource use	Chemical use per treated sludge
	Transportation	Transportation needed for ultimate disposal of treated sludge

Managing the Treatment Systems

The developed environmental legislation, with respect to effluent standards, requires adequate implementation activities, such as the construction of a wastewater collection and treatment plant.

The selection of a wastewater treatment technology process should consider the average performance of a technology:

- *reliability*: under variable wastewater flows (especially due to seasonal tourism) and contents, and operational problems;
- *institutional manageability*: planning, designing, construction, operation and maintenance capacities;
- *required investment costs*: generally, analyses of two major alternatives have to be considered, land-intensive treatment systems and energy-intensive treatment processes;
- *required operation and maintenance costs*;
- local availability of *skilled manpower*.

Final technology selection also requires a detailed assessment of other pollution sources, further projection of population size and waste production, community and cultural characteristics, and financial capacity of the community.

A good plant operation is most important for the achievement of desired effluent quality, and should be environmentally responsible and sustainable. In addition to presented in designing and operating the plant to meet the effluent and sludge management requirements, the following also must be considered:

- balancing energy usage and performance (use of low-intensity energy systems, energy efficient aeration systems, use of methane for heating and energy recovery at the plant, etc.);
- recycling of effluent, where appropriate, for the plant operation and maintenance and washing and watering environment;
- minimising environmental impacts: odours, noise, vibration, insect nuisance, fire hazard;
- minimising aesthetic impact (visual appearance);
- minimising hazards to the health of the staff and the neighbouring communities;
- judicious use of chemicals;
- minimising overflows and incidental spills;
- removing solids to maintain the quality of the effluent;
- developing effluent and sludge (biosolids) as resources;
- solids disposal (screenings, grease and oil, grit and sand, biosolids sludge cake);
- conformity with the existing planning decisions and development plans.

Effluent Reuse

Effluent reuse serves an important function in water resources management by providing a means to produce a quality source of water for irrigation, industrial, and urban water requirements throughout the region. With many countries facing severe water shortages, reusing water for irrigation and industrial purposes is gaining ground. It is application of effluent in a way that also provides income, reduces costs and leads to some other benefits. Directly or indirectly, it could result in economic, social and environmental benefits.

Effluent is a product of water abstracted from resources, so if the effluent is not returned to the natural inland water bodies, the flow in rivers is reduced. It has to be analysed carefully in areas lacking water.

In addition to providing a low cost water source, other benefits include increase in crop yields, decreased reliance on chemical fertilisers, and protection form the frost damage. However, presence of pollutants should be recognised. Less obvious characteristics, such as elevated levels of dissolved solids and changes in water chemistry can be significant in both industrial and agricultural systems. Out of it serious consequence relating to salinity, soils structure and soil permeability can occur.

The most important aim of water reclamation and reuse practices is to reduce the risk to an acceptable level without having to renounce the wastewater reclamation. The origin of hazards due to reuse of reclaimed wastewater is (i) biological and (ii) chemical hazard.

Chemicals can generate hazards for humans and ecosystems. They include compounds originating in urban or industrial wastewaters, added directly to wastewater for wastewater treatment, or formed during wastewater treatment. Toxic chemicals can be found in wastewater in concentrations that can lead to acute intoxication, but when these compounds are in low concentrations, they could cause problems of chronic intoxication as, for example, in the case of heavy metals or trace organics. The most important measure for the control of chemical hazard is control of industrial discharges in the urban wastewater collection system.

Where reclaimed wastewater is used for applications that have potential human exposure routes, the major acute health risks are associated with exposure to pathogens including bacterial pathogens, helminths, protozoa, and enteric viruses. From a public health and process control perspective, the most critical group of pathogenic organisms are enteric viruses, due to the possibility of infection from exposure to low doses and lack of routine, cost-effective methods for detection and quantification of viruses.

Risk acceptability depends on various factors: existing options, cost-benefit relationships and risk evaluation. Authorities have to assure minimal and acceptable risk. The health and environmental protection measures need to be tailored to suit the local balance between affordability and risk.

Costs of additional treatment, distribution and irrigation systems, and monitoring for effluent reuse can be significant. In any case, a detailed financial analysis is necessary to ensure stakeholders' awareness of implementation costs. Analysis also has to include the costs and benefits of any change in environmental values or amenity, and has to be based on sufficiently long period (life cycle period).

A good decision can be achieved only if costs and benefits of reuse are compared with the costs and benefits of using alternative water sources. Such comparison has to be based on integrated analysis of all positive and negative aspects and impacts (environmental, social and economic). It should take into account any costs needed to achieve the desired sustainable water quality in the receiving water if the effluent is not reused.

Indirect and environmental reuse options may include reuse via surface and groundwaters. The most common uses of treated wastewater are for irrigation, industrial applications, urban applications, groundwater recharge. It includes many options, such as:

- irrigation: pasture, greenhouse crops, non raw-consumed crops, industrial crops, fruit trees, raw consumed food crops, etc.;
- non-potable urban: toilet flushing, car washing, private garden irrigation, etc.;
- municipal: irrigation of parks, sport fields, street cleaning, fire-fighting, ornamental impoundments, etc.;
- agricultural: food crops and associated food production;

- aquaculture: plant or animal biomass;
- tree growing: irrigation of forest areas, landscape areas and restricted-access areas;
- recreational: impoundments of the water bodies and streams for recreational use in which public contact with water is permitted (other than bathing) or not permitted;
- environmental; watering, controlling water flow and water bodies characteristics;
- aquifer recharge: by percolation trough the soil or by direct injection;
- industrial: instead of surface water, cooling water, cleaning, fire protection, etc.;
- indirect potable.

The degree of treatment required in individual water treatment and wastewater reclamation facilities varies according to the specific reuse application and the associated water quality requirements, Table 7. The simplest treatment system consists of solid/liquid separation processes and disinfection. Usual treatment system consists of one of secondary system processes (combination of physical, chemical, and biological processes) employing multiple-barrier treatment approaches for contaminant removal as well as disinfection.

The reuse system should obtain full approval form authorities, and reclaimed wastewater must only be reused for the uses for which the permit was issued. Reuse system must be well managed in accordance with the requirements given directly or indirectly in the permits. Quality monitoring and process controls should be implemented as a usual and important part of management. When reclaimed water quality does not meet the fixed standards, reuse must cease.

Good reuse practice should also have a good response plan for all unusual events (floods, power disruption, etc.), good protection of public health and environmental quality, public awareness programme, as well as good preventive maintenance plan.

Effluent management strategies should evaluate reuse options and implement options that are safe, practical, economic and environmentally beneficial. Surplus effluent should be managed through one of the discharge options (adequate treatment, safe disposal).

More information related to this topic can be found in Regional Guidelines for Municipal Wastewater Reuse in the Mediterranean Region, UNEP/MAP, 2003.

Land Application

Land applications have been used to return the discharged water to the water cycle. It includes systems such as evaporation ponds, soakage systems and irrigation by which water returns to the water cycle by evaporation and evapotranspiration, or infiltration. In this case irrigation has a goal to maximise the discharge of water and its return to the water cycle.

This type of discharge of effluent has been traditionally used as an on-site solution for individual houses where wastewaters, after local on-site treatment, have been discharged on land by some type of drainage system. Land application for bigger systems is rare but if it is used than, in most instances, involves the irrigation of land owned by the sewerage authorities. In this case the principles of effluent reuse have to be applied.

Table 7

Recommended guidelines for water reuse in the Mediterranean Region
(UNEP/MAP Guidelines for municipal wastewater reuse in the Mediterranean Region)

Water Category	**Quality criteria**			**Wastewater treatment expected to meet the criteria**
	Microbiological		**Physical**	
	Intestinal nematode[a] **(No. eggs per liter)**	**FC or *E. coli*** [b] **(cfu/100 mL)**	**SS** [c] **(mg/L)**	
Category I				
a) Residential reuse: private garden watering, toilet flushing, vehicle washing.	≤ 0.1[h]	≤ 200 [d]	≤ 10	Secondary treatment + filtration + disinfection
b) Urban reuse: irrigation of areas with free admittance (greenbelts, parks, golf courses, sport fields), street cleaning, fire-fighting, fountains, and other recreational places.				
c) Landscape and recreational impoundments: ponds, water bodies and streams for recreational purposes, where incidental contact is allowed (except for bathing purposes).				
Category II				
a) Irrigation of vegetables (surface or sprinkler irrigated), green fodder and pasture for direct grazing, sprinkler-irrigated fruit trees	≤ 0.1[h]	≤ 1000 [d]	≤ 20 ≤ 150 [f]	Secondary treatment or equivalent [g] + filtration + disinfection or Secondary treatment or equivalent [g] + either storage or well-designed series of maturation ponds or infiltration percolation
b) Landscape impoundments: ponds, water bodies and ornamental streams, where public contact with water is not allowed.				
c) Industrial reuse (except for food industry).	-			
Category III				
Irrigation of cereals and oleaginous seeds, fiber, & seed crops, dry fodder, green fodder without direct grazing, crops for canning industry, industrial crops, fruit trees (except sprinkler-irrigated)[e], plant nurseries, ornamental nurseries, wooden areas, green areas with no access to the public.	≤ 1	None required	≤ 35 ≤ 150 [f]	Secondary treatment or equivalent [g] + a few days storage or Oxidation pond systems

Water Category	**Quality criteria**			**Wastewater treatment expected to meet the criteria**
	Microbiological		**Physical**	
	Intestinal nematode[a] (No. eggs per liter)	**FC or *E. coli* [b] (cfu/100 mL)**	**SS [c] (mg/L)**	
Category IV				
a) Irrigation of vegetables (except tuber, roots, etc.) with surface and subsurface trickle systems (except micro-sprinklers) using practices (such as plastic mulching, support, etc.) guaranteeing absence of contact between reclaimed water and edible part of vegetables.	None required	None required	Pre treatment as required by the irrigation technology, but not less than primary sedimentation	
b) Irrigation of crops in category III with trickle irrigation systems (such as drip, bubbler, micro-sprinkler and subsurface).				
c) Irrigation with surface trickle irrigation systems of greenbelts and green areas with no access to the public.				
d) Irrigation of parks, golf courses, sport fields with sub-surface irrigation systems.				
Category V				
a) Surface spreading into nonpotable aquifers	-	None required	≤ 35	Secondary treatment or equivalent [g]
b) Surface spreading into potable aquifers	-	≤ 1000[d]	≤ 20	Secondary treatment or equivalent [g] + filtration + disinfection
c)Direct injection	No detectable	No detectable	< 5	Advanced wastewater treatment processes in order to meet drinking water maximum contaminant levels

[a] *Ascaris and Trichuris* species and hookworms; the guideline limit is also intended to protect against risks from parasitic protozoa.
[b] FC or *E. coli* (cfu/100mL): faecal coliforms or *Escherichia coli* (cfu: colony forming unit/100 mL).
[c] SS: Suspended solids.
[d] Values must be conformed at the 80% of the samples per month, minimum number of samples 5.
[e] In the case of fruit trees, irrigation should stop two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.
[f] Stabilization ponds.
[g] such as advanced primary treatment (APT) (Jimenez *et al*., 1999 and 2001).
[h] As very few investigations, if any, have been carried out on how to reach < 0.1 nematode egg /L, this criterion is considered a medium term objective and is provisionally replaced by <1 nematode egg /L.

Land application aims to utilise the water and nutrient components in a suitable way with minimum impacts on:

- soil;
- surface water;
- groundwater;
- ecosystem at or near the application site; and
- human activities near to site.

Solution/schema for land application depends strongly on the local situation and characteristics. The most important factors are climate, availability of land, topography, groundwater, soil properties, and existing and planned land use.

In situations where there is no local surface water, land application is the only way of effluent discharge to the environment. Water can be returned to the water cycle only via air (evaporation and/or evapotranspiration) or via groundwater (infiltration).

Land application is one of solutions for protection of very sensitive water bodies, such as water for drinking purposes, nutrient sensitive waters, karst waters, specially protected water bodies, etc. It is also one of management options for small communities. Land application, generally, is very rarely used for large communities.

Discharge to Coastal Waters

For the coastal communities effluent is directly or indirectly discharged to the associated coastal waters. The aim is to maintain water quality that protects the water body's environmental values/water uses. However, for coastal communities the use of the marine environment for treatment of municipal wastewater is an attractive option and, historically, the Mediterranean coastal communities have made much use of the treatment and dispersing properties of the sea for this purpose.

The important part of such concept is sea outfall, which has been designed/used to ensure that the effluent is discharged in the best practicable environmental manner. The treatment must be appropriate and the outfall has to be relatively long and equipped with diffuser to achieve high levels of dilution and dispersion. Usually, a mixing zone around the discharge point/diffuser will be specified beyond which the environmental uses are maintained.

Impact of the effluent on the receiving water body depends on numerous factors, such as:

- quality and quantity of the effluent;
- quality of the receiving water body before effluent is mixed;
- depth of the sea at the point of discharge, and density profile;
- exchange rate of the receiving water body;
- hydrodynamics of the water body;
- dilution in mixing zone and secondary dispersion out of the mixing zone;
- interactions and processes between the effluent and the receiving environment/decay;
- sensitivity of the receiving environment.

Most of the Mediterranean population lives in communities located on the coast, and discharges effluent into the sea, directly or indirectly. It also includes the largest cities. The general trend in the region is concentration of population in the coastal area/belt and in the large cities on the coast, which means that this application will be more and more in use.

Wastewater has to be treated before been discharge into the sea. The level of treatment varies from minimal to secondary treatment with nutrient removal. Level of the treatment is usually analysed jointly with the outfall arrangements because they are interlinked and of equal importance for the selection of the appropriate, environmentally safe wastewater disposal scheme.

The treatment level and the location and design of the outfall depend on many factors, such as:

- the characteristics of the existing wastewater sanitation system;
- the environmental values/water uses of coastal sea, estuary or bay;
- the total effluent and load flow, and its variation in time (daily and seasonal);
- oceanographic and climate aspects;
- dilution, dispersion and oxidation and other self-purification characteristics of the receiving sea body;
- engineering constrains;
- community desires and affordability;
- regulation and standards.

There is big difference between discharge by *coastal outlet* and *marine outfall*. When discharging treated wastewater into the sea by a coastal outlet then the point of discharge is on the coast or very near to the coast, and the effluent affects directly all coastal sea uses. In this case the level of treatment should be much higher, and generally secondary level is necessary due to absence of dilution and dispersion effects which occur in case when discharge is via a long outfall. Health risk is very high due to high possibility of direct contact of humans with mixing waters, and disinfection of effluent is necessary. By using marine outfall, primary treatment can be adequate in case where receiving water conditions allow it.

It should be pointed out that operation and maintenance costs of the alternative with a marine outfall and primary treatment are lower that those of the alternative with a coastal outlet and secondary treatment.

There is a big difference between discharging the effluent into the open sea and bays or semi-enclosed sea. In the case of effluent discharge into semi-enclosed or closed ecosystems (such as lagoons), total dilution of waste takes place in a limited quantity of seawater. As a consequence of limited dilution, waste concentration in waters of semi-enclosed and enclosed systems may increase and create very negative environmental impacts (eutrophication). In such cases it is necessary to control nutrient load in the system, and in that way, tertiary treatment must be prescribed.

In such cases it is necessary to consider also alternative points of discharge outside the bay or semi-enclosed sea, which generally requires lower levels of treatment. Decision making on the selection of the method and location of wastewater discharge in areas of semi-enclosed and enclosed systems relies on environmental capacity/impact assessment studies.

Use of marine disposal of urban wastewater for many coastal communities is very attractive because it can be safe, effective, and provides considerable cost savings, both capital and operational. It may be particularly attractive for developing countries owing to the relatively low levels of treatment, maintenance and energy use compared to alternative methods. However, environmental values/water uses have to be protected by implementation of appropriate “combined approach” to water quality management and by integrated use of treatment and long submarine outfall.

In EU countries, however, this option has been almost totally abandoned, due to the existing legislation (Directive 271/91), which prescribe rather strict treatment requirements prior to any effluent discharge into receiving waters.

Discharge to Inland Waters

Inland waters mean all standing or flowing waters on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of territorial waters is measured.

Where effluent is discharged in inland waters, the aim is to maintain a water quality that protects the water body’s environmental values (aquatic ecosystems, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystem, and water uses).

Special attention has to be on groundwater. Surface water and groundwater are in principle renewable natural resources; in particular, the task of ensuring good status of groundwater requires early action and stable long-term planning of protective measures, owing to the natural lag in its formation and renewal. Such time lag for improvement should be taken into account in timetables when establishing measures for the achievement of good status of groundwater and reversing any significant and sustained upward trend in the concentration of any pollutant load.

Factors which influence the impact of effluent on a specific water body, include:

- quality and quantity of the effluent;
- quality and status of receiving water body;
- environmental and hydrological characteristics of the receiving water body;
- sensitivity of the receiving environment;
- environmental values of the receiving water;
- prescribed water uses.

There is big difference between the characteristics of north and south inland waters in the Mediterranean region. North is much richer with constant-inland waters than south. Constant surface waters in the south region are rare, and groundwater generally has a long renewal period, and so inland waters in this region are more sensitive to pollution.

General requirement for discharging effluent into inland waters is at least secondary level of treatment. For nutrient-sensitive waters, such as standing surface waters, nutrient removal is necessary. Disinfection is commonly required for surface water discharges, and in most cases for groundwaters. Especially sensitive are standing surface waters and inland waters where the effluent is a significant proportion of the total flow. That is a common case in the arid areas. Karst water resources are also very sensitive due to short retention time in underground geological formations, fast infiltration and ground water flow (low self-purification capacity).

For the purpose of environmental protection there is a need for a greater integration of both qualitative and quantitative aspects of surface waters, groundwaters and the associated coastal sea. The impact of inland water quality on the receiving coastal sea must be considered.

Discharges into inland waters, generally, do not take into account the naturally occurring dilution and self-purification processes, and only partially the mixing zone.

Treatment of wastewater

Treatment processes

Wastewater treatment involves various processes used individually or in series to obtain the required effluent quality. Standard and most important processes are:

- *preliminary or pre-treatment*: removes gross solids, coarse suspended, floating matter, grease and oils. The main aim of this process is to protect outfall and prevent visual nuisance;
- *primary treatment*: removes readily settleable solids. It means treatment of urban wastewater by a physical and/or chemical processes involving settlement of suspended solids, or other processes in which the BOD_5 of the incoming water is reduced by at least 20% before discharge, and the total suspended solids of the incoming wastewater are reduced by at least 50%. The main aim of this process is to protect outfall operation, provide minimal environmental protection around point of discharge and prevent visual and other nuisance;
- *secondary treatment*: removes most of the remaining contaminants, suspended solid, colloidal and dissolved organic matter. It means treatment of urban wastewater by processes generally involving biological treatment with a secondary settlements or other processes in which contaminants in incoming water are reduced to a minimum: BOD5 70 - 90%, chemical oxygen demand 75 %, and total suspended solids 70 - 90 % before discharge. The main aim of this process is environmental protection from oxygen depletion and prevention of visual and other nuisance;
- *nutrient removal*: further reduces the content of nitrogen and phosphorus following the secondary treatment. It means treatment of urban wastewater by processes in which contaminants in incoming water are reduced to a minimum: total phosphorus 80% and/or total nitrogen 70 - 80 % before discharging into nutrient-sensitive waters. The main aim of this process is environmental protection from eutrophication and prevention of visual and other nuisance;
- *disinfection of effluent*: reduces pathogens to levels acceptable for the reuse or discharge of treated wastewater in most cases into receiving waters. The main aim of this process is reduction of health risk;
- *advanced wastewater treatment*: further improves the quality of effluent by processes such as granular media filtration, ion exchange, micro filtration and membrane technology including membrane bioreactor. The main aim of this process is further improvements of effluent quality due to enhanced effluent quality requirements (e.g. reuse).
- *natural treatment systems*: imply processes that also take place in the nature in the “ecosystem reactor”. Physical, chemical and biological processes are applied, as well as natural environment. This makes them different from mechanical processes where processes take place in constructed reactors and with introduced energy. The most frequent processes are: land-treatment systems, slow rate, rapid infiltration and overland flow; constructed wetlands and aquatic plant treatment systems, and aquaculture

The most common level of treatment is secondary treatment, which usually includes the first three levels (preliminary, primary and secondary treatment), in series or combined in varying configurations. Secondary treatment is normally a prerequisite of advanced treatment and disinfection. Nutrient removal, as well as advanced wastewater treatment, is generally associated with protection of nutrient-sensitive areas, or specific uses of water bodies such as drinking purposes. Advanced treatment and disinfection are also associated with effluent reuse.

Advance cleaning of wastewater that goes beyond the secondary or biological stage is also named as *tertiary treatment*. It removes nutrients such as phosphorus and nitrogen and most BOD and suspended solids.

Examples of treatment processes:

Treatment level:	Examples of treatment process:
A) Pre treatment	Screening, grit removal, grease and oils removal
B) Primary treatment	Primary sedimentation, Imhoff tank, flotation, micro screening
C) Secondary treatment	Biological treatment (conventional activated sludge, trickling filter), physical-chemical treatment, lagoons/ponds
D) Nutrient removal	Biological treatment, chemical precipitation
E) Disinfection	Lagooning, ultraviolet radiation, chlorination
F) Advanced treatment	Granular-media filtration, microfiltration, membrane technology including membrane bioreactor
G) Natural treatment	Constructed wetlands, slow-rate systems, overland-flows, floating aquatic plant, aquaculture

Degrees of treatment achieved by various processes used are presented in Table 8.

<u>Sludge processing and disposal/reuse</u>

Safe handling and disposal of various residual produced in different treatment units is of equal importance. By-products of wastewater treatment are solids: screenings, grease and oils, and biosolids or sludge cake. Screenings, grit and send are disposed on landfill or reused, while grease and oils have to be destroyed, for example, by incinerator.

The sludge (including scum), which may contain solids in concentrations of 0.5 - 5 %, offers complex processing and disposal problems. It is odours and contains large volume of water. Because the treatment and disposal of sludge is expensive, sludge-handling costs are often the overriding consideration in the design of wastewater treatment plants.

In general the sludge-processing and disposal methods include thickening, stabilisation, conditioning, dewatering, and disposal, Figure 3. Many units operations and processes are utilised at various stages of sludge processing and disposal. To develop a cost-effective system of sludge treatment, the best combination of treatment processes must be chosen. Main factor, which strongly influences characteristics of sludge treatment, is way of disposal or reuse. Most of the sludge-processing facilities produce two streams: (1) processed solids and (2) liquids. The liquid streams must be treated again, and these liquids from various sludge-processing units are returned to the head of the plan.

Sludge arising from wastewater treatment has to be re-used whenever appropriate. Disposal routes shall minimise the adverse effects on the environment.

Competent authorities have to ensure that disposal of sludge from urban wastewater treatment plants is subject to general rules or registration or authorisation.

Table 8

Degree of treatment achieved by various processes used

Treatment processes	**Removal efficiency, percent**					
	BOD-5	**COD**	**Total Suspended Solids**	**Total Nitrogen**	**Total Phosphorus**	**Total Coliforms**
A. Pre treatment	0 - 5	0 - 5	0 – 10	nil	nil	0 - 10
B. Primary treatment	30 - 40	30 - 40	50 – 65	10 - 20	10 - 20	25 - 75
C. Secondary treatment						
- activated sludge (conventional)	80 - 95	80 - 85	80 - 90	10 - 30	10 - 25	80 - 90
- lagooning	90 - 95	85 - 95	60 - 80	20 - 90	10 - 35	90 - 98
- physical-chemical	50 - 70	50 - 70	80 – 90	20 - 30	70 - 90	40 - 80
D. Nutrient removal						
- biological nitrogen and phosphorus removal	95 - 97	85 - 90	90 – 95	70 - 95	70 - 90	80 - 90
E. Disinfection						
- cholirination of treated wastewater	-	-	-	-	-	98 - 99
F. Advanced treatment						
- membrane bioreactor	>99	>90	>99	>96	>98	6 log
G. Natural treatment						
- constructed wetlands	95 - 98	85 - 90	90 – 95	85 - 90	85 - 90	90 - 98

ABBREVIATION **BOD** = Biochemical Oxygen Demand
COD = Chemical Oxyben Demand

The treated sludge is used in agriculture, as an urban soil improver for horticultural purposes, is composted or is used as landfilling or disposed on landfill. The sludge contains most of the phosphorus and part of nitrogen from the influent wastewater, but also a proportion of heavy metals, depending on wastewater quality. If a sludge treatment is supplemented with anaerobic digestion processes than biogas can be produced to be used for energy production (heating, electricity).

Sludge from treatment processes	
ς	
THICKENING	1. Gravity 2. Flotation 3. Centrifugation
ς	
STABILISATION	1. Chlorine oxidation 2. Lime stabilisation 3. Heat treatment 4. Aerobic digestion 5. Anaerobic digestion
ς	
CONDITIONING	1. Chemical 2. Elutriation 3. Heat treatment
ς	
DEWATERING	1. Vacuum filtration 2. Filter press 3. Horizontal belt filter 4. Centrifugation 5. Drying beds
ς	
DISPOSAL AND REUSE	1. Land application - to croplands (reuse) - to marginal land for land reclamation - to forest land - to dedicated sites 2. Composting 3. Land filling 4. Incineration 5. Recalcination 6. Lagoons

Figure 3: Alternative unit operations and processes for sludge processing and disposal

Selection of flow scheme

Many unit operations and processes can be combined to develop a flow scheme to achieve a desired level of treatment. The level of treatment may range from removal BOD-5 and TSS, nitrogen and phosphorous, to complete demineralisation. To develop the best possible flow scheme a designer must evaluate many factors that are related to operation and maintenance, process efficiency under variable flow conditions, and environmental constraints. Factors that are considered important in selection of flow scheme are:

- land requirements;
- adverse climatic conditions;
- ability to handle flow variations;
- ability to handle influent quality variation;
- industrial pollutants affecting processes;
- reliability of the processes;
- ease of operation and maintenance;
- occupational hazards;
- air pollution;
- waste product.

A targeted waste management strategy must set priorities and goes well beyond a selection of conventional technologies. Many developing countries simply adopt the effluent standards or regulatory water quality objectives from developed countries. These prove too ambitious, which does not allow for gradual implementation of a realistic mitigation programme. The priority wastewater constituents must be identified and cost-effective mitigation approach selected. Generally, removing the first 50% of the pollutant load is moderately expensive, but removing the next 40% is more expensive, and removal of the last 10% is often prohibitively expensive.

Box 4: Basic design consideration for wastewater treatment facilities

Basic designing factors are:
1. Initial and design years
2. Service area
3. Site selection
4. Design population
5. Regulatory control and effluent limitations
6. Characteristics of wastewater
7. Degree of treatment
8. Selection of treatment processes
9. Equipment selection
10. Plant layout and hydraulic profile
11. Energy and resource requirements
12. Plant economics
13. Environmental impact assessment

Submarine Outfall

The aim of sea outfall management is to ensure that the wastewater is discharged in the best practicable environmental manner. Wastewater treatment plant and submarine outfall must be considered as an integral part of the wastewater system, both in engineering and an environmental sense.

Coastal waters, naturally, have low biological oxygen demand (BOD) and are saturated, or supersaturated, with dissolved oxygen (DO). Significant increase in BOD and decrease in DO rarely occur, except in case of significant effluent discharges into estuaries and enclosed bays. The concentration of other variables depends on local influences such as climate, geology and hydrological characteristics/fresh water influence.

The sea characteristics have a strong impact on bacteria life cycle resulting in their quick and high reduction in the sea due to mortality and dilution. Many mechanisms contribute to the mortality of enteric micro-organisms in the sea, but two are the most important starvation and radiation.

Generally, nutrient level in the sea is too low to support the growth of enteric bacteria. Exceptions are confined waters and the vicinity of an outfall where nutrient concentration can be high. During daylight, lethal solar radiation greatly accelerates the bacterial die-off. The ultraviolet light is the most lethal.

The rate of bacterial mortality is expressed in terms of the time taken for 90% of the bacteria to die-of, the T_{90} value. The value of T_{90} = 2,5 hours for faecal coliforms, 3,5 hours for faecal streptoccocci and 3,0 hours for total coliforms are the most common applied in estimating bacterial decay in seawater.

These characteristics of seawater provide the basis for the use of the marine environment for additional treatment of urban wastewater in which submarine outfall arrangements have a very important role.

Submarine outfall equipped with diffuser provides quick and high dilution of effluent in marine environment reducing concentration of all wastewater substances to the level, which does not negatively influence the marine environment outside the mixing zone. The negative impact on the sea environment is smaller if dilution is higher and if point of discharge is more distant from the coast and protected areas.

However, environmental conditions of the receiving sea, especially sensitivity to eutrophication, as well as environmental values/water uses have a strong influence on the level of the treatment of urban wastewater prior to discharging by submarine outfall. Nutrient-sensitive areas, as well as use of the sea body for aquaculture and recreation purposes will require a high level of treatment.

The use of a long submarine outfall with lower level of wastewater treatment is acceptable in cases of smaller communities, less than 10.000 e.p., and as a first phase of wastewater sanitation system development (in case when wastewater collecting network is incomplete) insuring appropriate protection of environmental values.

The minimum acceptable level of treatment in many cases is primary treatment providing that effluent is discharged into marine environment via a long submarine outfall.

The length of the outfall from coastline should be at least 1000 m, and depth of water at the point of discharge 20 m if it is to be considering a long submarine outfall. Both criteria have to be respected. In case of small communities (smaller than or equal to 2000 p.e.) the outfall can be shorter but not less than 500 m. In all cases, length of the outfall at the point of discharge has to be determined by considering the prevailing water conditions (oceanographic studies).

In any case, effluent should not have negative impacts on environmental values of the receiving water body, which has to be confirmed with appropriate prediction model and environmental impact assessment study.

The long submarine outfall is the most practical method for the discharge of effluent into the sea because it highly reduces the risk to the environmental values of the receiving water in case of inappropriate functioning of the treatment plant and incidental situations (malfunctioning). Thus, the long submarine outfall is a very practical solution for the areas (wastewater sanitation systems) lacking skilled manpower for the running of the treatment plant.

Box 5: Main elements and steps of submarine planning and design

Main elements and steps of submarine planning and design are:
- Assessment of sewerage catchment and wastewater flow (estimation of pollution load and flow);
- Site survey information (assessment of mixing characteristics of sea and sea bed conditions);
- Use Area definition including mixing zone characteristics;
- Environmental standards determination associated with Use Area;
- Marine treatment schemes analysis and selection (wastewater collection network, pump stations, outfalls);
- Definition of land- based treatment schemes (determination of treatment plant characteristics);
- Selection of headworks and outfall site (selection of the optimal locations in accordance with local conditions/requirements and wastewater collection system characteristics);
- Headworks and storm overflow arrangements (integral analysis and selection of the optimal solution);
- Environmental design (degree of treatment, the storm overflow settings, the discharge rate, the discharge location, the degree of initial dilution);
- Outfall and diffusers arrangements (minimisation of cost of providing environmental protection);
- Hydraulic design (selection of size of outfall, velocity of flow and velocity of discharge at diffuser orifice) ;
- Environmental impact prediction (considering the most critical situation related to environmental values/water uses);
- Elimination of environmentally unacceptable schemes;
- Civil engineering design (marine structural design);
- Selection of economic options (construction, operation and maintenance costs, and comparison with other disposal alternatives).

Mixing zone

One of the important elements of submarine outfall utilisation is the definition of the “mixing zone” and relevant environmental standards. Mixing zones are adjacent to point sources of effluent. The “mixing zone” covers the initial dilution zone and the zone of rapid secondary dilution following the discharge. In mixing zone the Environmental Quality Standard values for other Uses may be exceeded except for the aesthetic standard. In a management context, mixing zones are often defined as exclusion zones.

The boundary of mixing zone is usually defined in terms of the concentrations of indicator species in the effluent. Its extent and nature depend on hydrological/oceanographic conditions at the outfall site, discharge volume, currents, depth, tides, wave actions, dilution, way of discharge, etc. In case of high and quick dilution, the zone can be small, while in case of low-energy systems, such as closed sea areas and bays with small discharge, mixing may be slower and the mixing zone will be larger.

The management objective in the allocation and monitoring of mixing zones should be to minimise the potential for ecological detriment, especially permanent degradation. A mixing zone can not be allocated in the areas where strict environmental values/water uses apply including human consumption, and areas of extremely high environmental significance.

Depending on the local conditions, the following restrictions may be applied to achieve best practice in mixing zone management:

- Adequate treatment prior to effluent discharge - minimum aesthetic standards;
- Discharge under specific hydrological conditions (tide water);
- The area extent of the mixing zone should be restricted;
- A requirement may be made for the effluent release to be pulsed (periodical discharge);
- Minimal initial dilution rate can be required to satisfy standards for some indicator species;
- Type of diffuser can be prescribed;
- Minimal depth of the sea and minimal distance from the coast for the point of discharge can be prescribed;
- Extreme conditions for selection of solution may be required and prescribed;
- Specific monitoring programme.

Generally, the acceptable distance of the boundary of a mixing zone from the discharge point is at least 300 m. Mixing zone can never be extended to the coastline.

The following has to be stressed: (i) the benthic environment/organisms in the mixing zone are under stronger stress and can be completely destroyed near the discharge point; (ii) the extent of the mixing zone can be unpredictable where oceanographic/hydrological conditions are variable; (iii) subtle ecological detriment may be caused at sites remote from the mixing zone.

Treatment and disposal design philosophy

One of the challenges of sustainable development is to find ways of enhancing our total wealth while using common natural resources prudently. Renewable resources, such as water, should be used in a ways that do not endanger the resources or cause serious damages or pollution.

Reversing or rectifying damage to the environment can be difficult and costly. For this reason pollution should be prevented from taking place, rather than cleared up after it has happened. And, wherever possible, the need to respect the environment should be reflected in other policies.

Different environmental conditions that exist in different places need to be taken into account in reaching decisions on water treatment and disposal. Decision on treatment and disposal has to be based on objectives set by the authorities for the quality of the stretch of water to which he discharge is made as well as any relevant standards from national or international Directives.

The aim of wastewater treatment and outfall/disposal design is to ensure that the wastewater is discharged in the best practicable environmental manner. The environmental safeguards have considerable effects on the capital and operating costs of the outfall and treatment plant. The costs are also strongly influenced by the interaction between the outfall/disposal system, treatment plant and wastewater collecting system.

Environmental quality objectives

An Environmental Quality Objective EQO is the requirement that a body of water should be suitable for those uses identified by controlling authorities. The uses are protected by one or more Environmental Quality Standards EQSs. An EQS is a specified concentration of a substance, which must not be exceeded if a given use is to be maintained. The idea of controlling the quantity of a substance discharged to a body of water, so that its concentration does not exceed the value above which undesirable effects are expected, goes back many years.

The concept may be applied by defining the areas for which particular Use area desired. Applying the appropriate standard protects each Use. Where more than one EQS relates the most stringer will apply. The EQSs for each Use Area comprise those directly required to achieve the Objectives and those, which are required to protect the Use.

Use Areas

The drawing up of the Use Area boundary is a multidisciplinary activity involving development and land use planners, biologist, chemists, environmentalists, the general public, politicians and other interest parties, as well as engineers designers of treatment plant and outfalls. Definition of the Use Areas provides the engineer with a set of standards to which he can design.

Consultation with the appropriate authorities should be commenced at the inception stage, to ensure that the eventual design will satisfy the consent criteria. Public consultation is generally a necessary step in the construction of a treatment plant and outfall.

Consideration should be given to seasonal variations in the Use Areas due to changing bathing habitats, the passage of migration fish and other seasonal changes. These variations in Use may be taken into account in design.

Design of wastewater sanitation schemes/sewerage schemes

On a wastewater scheme the engineer's role is generally to provide the engineering design and costs for the assessment and selection of the appropriate environmentally safe wastewater disposal scheme. The engineer is constrained to work very closely with environmental scientists during all stage of the design to ensure that the designs will be environmentally sound.

The engineering design provides the basis for the comparison and selection of the preferred scheme each stage of the design process. Good engineering design is required ensure that the financial cost of meeting the Environmental Quality Standards requirements, and hence protecting the environment, is kept to a minimum. There are a number of factors within the control of designer, which should be considered in developing a design:

- Characteristics of wastewater collection system (catchment area and wastewater flow);
- Use Areas characteristics and environmental requirements/constrains (Environmental quality standards);
- Site survey data of recipient and possible treatment plant and outfall/effluent discharge locations;
- Selection of treatment plant and outfall/effluent discharge site;
- Selection of sludge disposal site or reuse alternatives;
- Treatment plant design;
- Outfall and diffuser design;
- Hydraulic design;
- Marine and structural design;
- Environmental impact assessment;
- Risk assessment;
- Cost assessment.

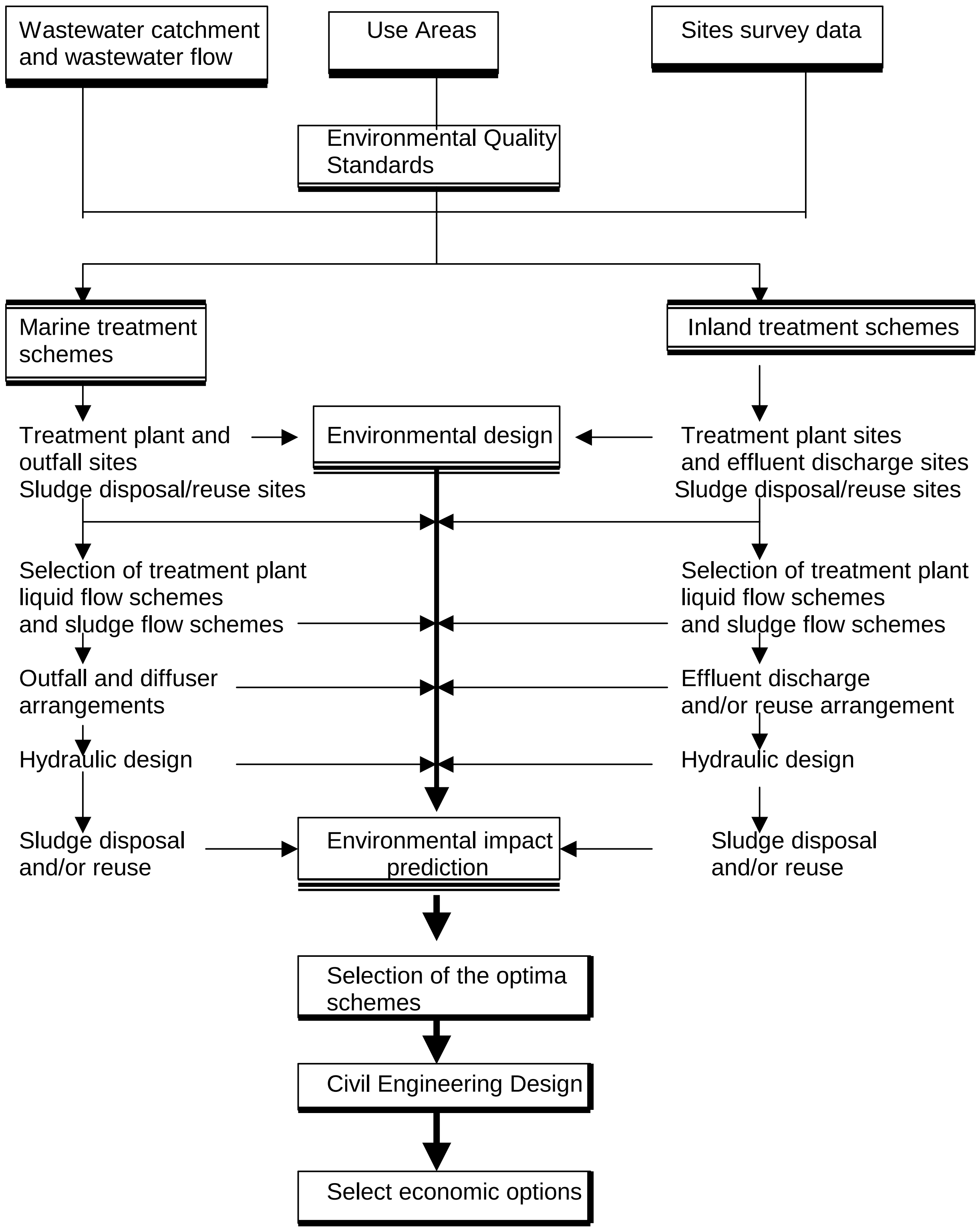

Figure 4: Wastewater sanitation schemes - design flowchart

Possible approach to engineering design is illustrated in Figure 4. The central role of the environmental activities in the design processes shows the importance of close co-operation between the engineer and scientist. It is especially important related to elements of the design process: environmental design and environmental impact assessment.

During the feasibility, outline and detailed design stages the engineering design is considered in progressively increasing detail. At the feasibility stage all the options are considered, usually as desk studies, on the basis of he existing information. A limited preliminary field investigation may well assist in the early elimination of unsuitable shemes.

The unsatisfactory schemes are eliminated and the feasible schemes costed and the likely environmental impact assessed to provide the executive decision makers with adequate facts to decide which designs should be considered at the outline design.

The outline design stage will vary from optimisation of one preferred scheme to the comparative assessment of several possible schemes. Some fieldwork is essential at this stage particularly to evaluate the mixing characteristics of receiving waters as well as environmental impacts. The aim of outline design is to present the executive decision-makers with the cost and financial basis for the selection of the final scheme.

The detailed design stage commences once the preferred outline design has been selected. Accurate field data is required for detailed design. The designer must be prepared to revise and update the preferred scheme in the light of the new data collected for detailed design.

At the end monitoring system have to be designed and set of appropriate indicators have to be proposed for verifying the degree of accomplishment of the expected results, as well as efficiency and effectiveness of the system. Monitoring system has to be harmonised with requirements set by appropriate authorities as well as characteristics of the wastewater sanitation system. Monitoring is associated to a continuous improvement process, which has to be kept continued through evaluating the results and, updating the treatment processes according to the scientific progress and changes in the socio-economic framework.

5. GUIDELINES FOR DISPOSAL

Guidelines for Land Application

Land application is the discharge of the effluent on an area of land with the primary aim of returning the water to the water cycle by evaporation, evapotranspiration and/or infiltration. This is one of measures that are part of sustainable water resources management or water conservation. These guidelines describe the levels of treatment required for effluent prior to land application, Table 9.

The land application does not include raw water discharge because it is not part of effluent management.

Water quality limits are set to minimise potential health risk and negative effects on the receiving environment. The prescribed limits should be monitored to determine compliance.

The basic principles for land application are:

- secure long-term sustainable land use avoiding build up of any substances in the soil;
- the effluent is not detrimental to the vegetation cover;
- avoid any change of the soil structure;
- any runoff to surface waters and/or percolation to groundwater should not compromise the selected environmental values of the receiving waters;
- no gaseous emissions to cause nuisance odour;
- no aerosol formation to cause health and other problems in neighbouring areas;
- implement insect control measures to reduce mosquitoes nuisance;

Land application is a feasible alternative for inland communities, especially smaller communities in arid and semiarid areas for total effluent disposal or surplus effluent disposal after application of reuse.

This method is also feasible in areas where direct discharge to the surface and ground water is not permitted, such as water for drinking purposes or very sensitive waters. Application and loading rate have to be carefully planned, managed and monitored so that any discharge in groundwater and surface waters will comply with the required quality of receiving waters and environmental values/water uses. Infiltration from land application results in aquifer recharge. In any case, it is more suitable if effluent reaches water resources by infiltration than runoff, providing that infiltration will result in additional treatment of effluent. Land application can be used as a method for artificial recharge of aquifer using appropriate levels of treatment.

In any case, it is recommended that this method use a storage capacity before land application. The storage can be used for storage of effluent for the period when rate of discharge by land application is reduced due to climate or any other reasons (maintenance, system backup, and reliability). In addition, storage provides additional treatment of effluent especially related to bacteriological quality of effluent. Longer detention period produces better quality of effluent. But, longer detention period requires bigger storage and so produces higher costs. The cost of providing the storage can be significant, and depends on local condition.

This method of effluent management varies and strongly depends on the local conditions. The biggest concerns are toxicants and the possibility of build up of their concentrations in the soil and vegetation. Anther concern is the impact on waters and aquatic environment. That way planning of this application requires close co-operation of different experts and authorities. With appropriate management of treatment processes and hydraulic system good and safe application can be achieved.

Table 9 lists discharge options, guideline treatment levels, the limiting factors for each land application option, and associated parameters likely to be of concern.

The most important element is minimal level of treatment. The level must be practical and safe for the particular discharge option. In setting the level of treatment, the local community has to be consulted. The type of land application, local conditions and public interest will determine the level of treatment required.

The limiting factors should be considered adequately and analysed in detail before adopting a particular option. Appropriate assessment of the local social, economic and environmental conditions is prerequisite of a good setting of solution. Analysis of alternative options has to be based, among others, on appropriate environmental impact assessment study.

Guidelines for Coastal Waters

Coastal marine waters serve a wide variety of exceptionally important human uses. Many of these uses produce high local benefits, such as yield of fish, shellfish and recreational activities/tourism. Others involve regional benefits or global unity of the marine system, since local events influence, and are influenced by, water quality at distant point. Many of human uses of marine waters are directly dependent upon the nature and quality of the biological, chemical, and physical systems present. That way the maintenance of acceptable water quality is a priority.

The effluent is discharged into different coastal waters: open coastal waters, estuaries and bays.

The effluent can be discharged directly into the sea by long/extended submarine outfalls far from shore, or nearshore/coastal discharge sites or coastal outlets. The effluent can also be discharged into sea indirectly, via discharges into rivers, estuaries and groundwater.

Wastewaters are collected and transferred to a treatment plant and, following an appropriate level of treatment, discharged into the sea through an outfall. The outfall consists of a pipeline, whose purpose is to convey the effluent, some distance offshore, terminating in a diffuser. Clearly, the ultimate impact of the discharge depends on the level of the treatment and the outfall design; the whole disposal process should be thought of as a system comprising the marine outfall and treatment plant.

For a long time marine waters have been used for discharge of effluent because dilution was a practical solution for the pollution. Dilution, dispersion and self-purification of sea water are valuable processes for reduction of non-toxic and non-accumulative pollutants providing that recipient is large enough to accommodate waste without unacceptable effects. General rule is higher rate of dilution less, negative impact on environment, considering that there are no cumulative build-ups of negative processes.

<u>Table 9</u>

Land discharge options and treatment levels

LAND APPLICATION OPTIONS	**LIMITING FACTORS FOR DIFFERENT SEGMENTS OF THE ENVIRONMENT**	**EFFLUENT PARAMETERS OF MAJOR CONCERN**	**MINIMUM LEVEL OF TREATMENT**	**COMMONLY REQUIRED LEVEL OF TREATMENT**
Evaporation ponds	Air - aesthetic enjoyment (odours), mosquitoes and other insects. Water - seepage, run-off.	Odour emission, aerosols, toxicants, organics (BOD-5), pathogens.	**Nil**	**C**
Evapotranspiration (irrigation) (i) agricultural (ii) landscape	Air - odours. Land - potential for long-term soil contamination and adverse impacts on vegetation and soil structure.	Odours, dissolved solids, aerosols, toxicants, pH, pathogens, nutrients.	**B (only if special safe technique of irrigation is applied)** **C**	**C and E** **C and E**
Infiltration - natural - ground artificially conditioned - aquifer recharge	Groundwater - existing and potential environmental values. Aquifer clogging. Land - potential for long-term degradation of land and/or crops and vegetation.	Solids, BOD-5, nutrients, pathogens, toxicants, dissolved solids, pH.	**C**	**C and D**

NOTES: PLANT TYPE - TYPICAL TREATMENT PROCESSES

Treatment Process Category	**Parameters to be removed**	**Examples of Treatment Processes**
A Pre Treatment	Gross solids , grease and oil	Screening, grit and grease chamber
B Primary Treatment	Gross solids plus readily settleable solids	Primary sedimentation, flotation
C Secondary Treatment	Most solids and BOD	Biological treatment, physical-chemical treat., Lagoons
D Nutrient removal	Nutrients	Biological treatment, chemical precipitation.
E Disinfection	Bacteria and viruses	Lagooning, ultraviolet radiation, chlorination.

Long outfall/extended outfall characteristics depend predominantly on buoyancy generated turbulence to achieve initial dilution. It is the rising phase as the buoyant wastewater travels from its discharge point near the seabed towards the surface. During this short period (several minutes) concentration of effluent and contaminants may be rapidly reduced. The initial dilution is usually achieved by means of a diffuser, which is a manifold system that releases the flow through a series of adequately spaced small ports.

After initial dilution, the subsequent secondary dilution or dispersion occurs. This process contributes further to the distribution of wastewater in the marine environment and occurs due to advection, turbulent dispersion, wind induced drift and water exchange in the vertical direction. Advection determines the movements of the wastewater field. Turbulent dispersion spreads the wastewater field due to shears induced by current velocity differences and large scale turbulent addies in the receiving medium. Wind-induced drift of the surface water results from the occurrence of sea breeze. Thus the bacteria and viruses may be transported towards the coastline or other protected areas in the surface layer of water, due to direct wind shear and mass transfer due to wave crest breaking. Especially landward-directed wind may be of particular importance for the bathing water quality at the beaches. The secondary dilution is usually achieved by appropriate length of outfall from the coast (distance form protected areas). In the case of persistent pollutant total dilution is the results of initial and secondary dilution exclusively.

Predators and the antagonistic effects of oxygen, salt water and ultraviolet radiation in marine environment contribute to reduction and ultimate destruction of bacteria and pathogens. For them and other non-persistent pollutants the low of decay as a function of time forms the basis for the calculation of an ambient factor equivalent to dilution named “tertiary dilution”. Longer contact time period (it generally means outfall) of non-persistent pollutant with sea, results in a higher rate of decay.

Total dilution is the product of three partial dilutions. The contribution of each phase to overall dilution is highly dependent on the local conditions. A long/extended outfall will normally have an initial dilution of 100:1 or better in near field. This is the equivalent, in terms, of contaminant concentrations, of 99 % removal in the treatment plant. This is much more than conventional treatment plant process can attain.

In case that effluent is discharged near coast or by coastal outlet, the level of dilution is very small or insignificant, and in such cases the principle of self-purification of waste in the sea can not be considered. In such cases, the mixing zone is very restricted or absent. Accordingly, in this situation the level of the treatment is higher, and the minimum required level is secondary.

Use of sea for additional treatment of effluent discharged via long submarine outfall and diffuser system is still today an attractive and realistic option for some countries in the region. Such alternative can be used if environmental capacity is sufficient to accommodate the remaining waste after a partial treatment, and if it is the initial step in the development of higher level of treatment/protection of sea. The important element of such approach is monitoring, which has to provide sufficient information on the impact on water quality, sediment and biological community. Monitoring has to be in place before discharge starts so that baseline information can be collected.

Treatment plant and submarine outfall have to be considered integrally, as a unique treatment scheme. Long/extended submarine outfall has to be used in all cases when disinfection is not used in treatment scheme. Disinfection can not be used if effluent has not been treated with at least secondary level of treatment. So, long/extended submarine outfall has to be used in all cases when secondary level of treatment is not applied.

It is recommended that long/extended submarine outfall is also used in cases when secondary or higher levels of treatment have been applied, in order to increase reliability of wastewater treatment system and protection of environment, and as back-up system for incidental or malfunctioning situations.

Table 10 lists the various categories of discharge to coastal waters, and indicates the related environmental values, issues and guideline treatment levels that apply. These categories are dependent upon the mixing processes that dominate the discharge.

By using a long submarine outfall, the level of treatment, in principle, can be lowered. For communities whose treatment schemes include long submarine outfall, the following applies:

- less than 10,000 population equivalent, minimum level of treatment is pre treatment;
- less than 10,000 population equivalent discharging water into nutrient-sensitive areas, minimum level of treatment is primary treatment
- between 10,000 and 150,000 population equivalent, minimum level of treatment is primary treatment, providing that effluent is not discharged into nutrient-sensitive waters;
- with population equivalent bigger than 150,000, minimum level of treatment is secondary, providing that effluent is not discharged into nutrient-sensitive waters;

Estuaries, bays and semi-enclosed coastal sea can be considered as sensitive areas because of small rate of water exchange in these areas, and because they are generally shallow and there is little buoyancy mixing. In addition, because of the proximity of the shoreline, there is little opportunity for subsequent dispersion/secondary dilution. In such cases, a satisfactory discharge is dependent upon the velocity of the discharge, tidal mixing and higher levels of treatment. Nitrate is usually the limiting nutrient for coastal waters, and in such cases appropriate reduction of nitrate may be required.

When considering the problem of discharge of effluent into marine environment it is necessary to adequately consider the specific characteristics of the wastewater flow and load in tourist municipalities where high seasonal fluctuation exists due to high population/tourist fluctuation. This fluctuation can be very significant, at a rate of 1:10 and more, and can limit the application of certain treatment techniques sensitive to fluctuation of flow and loads. Simpler and more robust treatment solutions with a long submarine outfall were found to be suitable and reliable discharge scheme. In such cases, discharge systems work with full capacity 3 to 6 months, and the rest of the year with significantly smaller loads. Accordingly, in such situations, less restrictive standards may be applied considering that total yearly load will not endanger the environment. Long submarine outfall is prerequisite in such situations in order to provide necessary health and safety levels to tourist and marine water users.

The most important element is minimal level of treatment. The level must be practical and safe for the particular discharge options. In setting the level of treatment the local community has to be consulted. The type of marine application, local conditions and public interest will determine the level of treatment required.

The limiting factors should be considered adequately, and analysed in detail before adopting a particular option. Appropriate assessment of local social, economic and environmental conditions is prerequisite of good setting of solution. Analysis of alternative options has to be based, among others, on appropriate environmental impact assessment study. The common required level of treatment is the level most likely to be used and approved.

It is always useful to analyse more alternative solutions for effluent discharge into the sea considering different levels of treatment and associated length of outfall taking into account the existing and long-term needs. In selection of the optimum alternative, based on prepared criteria, multicriterial analysis is usually applied. Selection criteria are generally based on:

- ecological parameters (impact on the ecosystem);
- economic effects (direct and indirect costs);
- administrative aspects (standards, influence on the existing waste management and control organisations);
- political aspects (interrelations on local and national levels);
- time aspects (time of completion and recurring impact on environment).

Time aspect is very important in the development of a sustainable solution. The solution has to be sustainable under today's conditions and under expected future condition. Marine outfall and gradual development of treatment plant with successive increase of treatment level is generally very suitable wastewater management alternative for a developing society.

Guidelines for Inland Waters

In many areas of the Mediterranean region, wastewater infrastructure does not meet the demands created by an increasing population and development, especially in coastal areas. Many Mediterranean countries, especially in the southern and eastern parts, are undergoing rapid and/or economic growth and urbanisation resulting in improper wastewater management. They experience increasing levels of water pollution with accumulative impacts on human health. Shortcomings in sanitation and wastewater management will remain the principle factor of resource degradation through water quality degradation.

These issues highlight the need for wastewater sanitation systems to manage the impact of urbanisation on land waters and the need for increasingly more stringent controls of effluent. The goal is to manage wastewater sanitation systems in such a way as to meet present and future needs by developing lower-cost but adequate services that can be implemented and sustained at the community level. It can be realised by identification and implementation of strategies and actions that will reverse current trends of resource degradation and depletion.

Waste management principles are crucial in managing effluent discharge to inland waters.

Issues to be considered in discharging effluent to inland waters include:

- avoiding or reducing the amount of contaminants in the effluent through appropriate trade waste controls and customer education;
- reusing or recycling treated effluent where practical;
- returning effluent to a stream to provide environmental flows only where effluent quality is at least commensurate with ambient water quality objectives;
- adopting accepted modern treatment technology with the aim of improvement over time;
- adapting, where necessary, appropriate treatment technologies to the local working skill/experience with the aim of gradual and sustained improvement in time;
- adapting, where necessary, appropriate treatment technologies and levels of treatment to the local population's financial capacities with the aim of gradual and sustained improvement in time;
- applying environmental quality guidelines for effluent where the discharge is a major determinant of the receiving stream quality;
- avoiding discharges entering potable water supply off-takes and stretches of streams having environmental value by optimal location of the discharge pipes.

Table 10

Coastal waters discharge options and treatment levels

DISCHARGE OPTIONS	LIMITING ENVIRONMENTAL VALUES/SEA USES APPLYING TO EACH DISCHARGE OPTION	EFFLUENT PARAMETERS OF MAJOR CONCERN	MINIMUM LEVEL OF TREATMENT	COMMONLY REQUIRED LEVEL OF TREATMENT
coastal waters via long/extended outfall * tourist community with high seasonal wastewater flow fluctuation (minimum ratio: winter/summer = 1/ 5)	Maintenance of aquatic ecosystems.	Toxicants, pathogens, floatables, oil and grease, suspended solids.	**A** **A**	**A < 10.000 p.e.** **10.000 < B < 150.000** **C > 150.000 p.e.** *** peak load in season:** **A < 50.000 p.e.** **50.000 < B < 150.000** **C > 150.000 p.e.**
coastal waters nearshore or coastal outlets (other than bays and estuaries)	Maintenance of aquatic ecosystems, recreation - primary contact, aesthetic enjoyment.	Pathogens, toxicants, floatables, oil and grease, colour, suspended solids, nutrient impact, surfactants.	**B < 10.000 p.e.** **C for others**	**C**
bays, estuaries, semi-enclosed sea or enclosed sea	Maintenance of aquatic ecosystems, recreation - primary & secondary contact, aesthetic enjoyment.	Oil and grease, nutrients, pathogens, toxicants, floatables, colour, suspended solids, BOD-5, surfactants.	**C < 10.000 p.e.**	**C and D**

NOTES: PLANT TYPE - TYPICAL TREATMENT PROCESSES

Treatment Process Category	**Parameters to be removed**	**Examples of Treatment Processes**
A Pre Treatment	Gross solids, grit, grease and oils	Screening, grit and grease chamber
B Primary Treatment	Gross solids plus readily settleable solid	Primary sedimentation, flotation
C Secondary Treatment	Most solids and BOD	Biological treatment, physical -chemical treatment, lagoons
D Nutrient removal	Nutrients	Biological treatment, chemical precipitation.
E Disinfection	Bacteria and viruses	Lagooning, ulltraviolet radiation, chlorination.

If necessary, due to financial, social and other constrains that effluent causes water quality objectives to be exceeded, the mixing zone associated with the discharge should be defined and designated in a waste discharge licence. The aim must be to progressively reduce the declared mixing zone size until the discharge no longer impairs water quality objectives. The impact of effluent on waters, including the mixing zones, should be monitored. Appropriate control measures of use and access to mixing zone have to be implemented in order to reduce health hazards.

When considering appropriate measures it is necessary to understand that the restoration of a system to its former state is usually far more costly than prevention.

The most important element is minimal level of treatment. The level must be practical and safe for the particular discharge options and environmental values. In setting the level of treatment the local community has to be consulted. The type of application will depend on the local conditions, public interest, and affordability.

The limiting factors should be considered adequately and analysed in detail before adopting a particular option. Appropriate assessment of the local social, economic and environmental conditions is prerequisite of good setting of solution. Analysis of alternative options has to be based, among others, on appropriate environmental impact assessment study. The common required level of treatment is the level most likely to be used and approved. Generally, for inland waters, the secondary level of treatment is necessary in order to protect human health and the environment. It is especially necessary for the countries lacking the water for irrigation because there is high possibility that effluent will be reused ,controlled or uncontrolled.

Table 11 sets out the effluent parameters of concern and the guideline treatment levels for discharge to inland waters.

Table 11

Inland waters discharge options & treatment levels (Inland waters related with Mediterranean basin)

INLAND WATER OPTIONS	LIMITING ENVIRONMENTAL VALUES/WATER USES APPLYING TO RECEIVING WATERS	EFFLUENT PARAMETERS OF MAJOR CONCERN	MINIMUM LEVEL OF TREATMENT	COMMONLY REQUIRED LEVEL OF TREATMENT
rivers, streams and lakes	ecosystem protection	dissolved solids, toxicants, floatables, colour, turbidity, TSS, nutrients, BOD-5, COD pH.	C	C and D
	recreation and aesthetics	toxicants, floatables, colour, turbidity, TSS, nutrients, BOD-5, COD, pathogens, odour, oil and grease.	C	C and D (E for primary contact)
	raw water for drinking water supply	dissolved solids, toxicants, floatables, colour, turbidity, TSS including algae, nutrients, BOD-5, COD, pH, pathogens, taste & odour producing compounds.	C C and D*	C, D and E
	agricultural water	dissolved solids, toxicants, floatables, TSS, BOD-5, COD, Total N, pH, pathogens.	C	C C and E*
	industrial water	dissolved solids, toxicants, floatables, colour, turbidity, TSS, nutrients, BOD-5, COD, pH.	C	C C and E*

NOTES: **PLANT TYPE - TYPICAL TREATMENT PROCESSES** *** in sensitive areas as dry rivers; other constrains also have to be considered (flow, distance from point of discharge, etc.)**

Treatment Process Category	**Parameters to be removed**	**Examples of Treatment Processes**
A Pre Treatment	Gross solids, grit, grease and oils	Screening, grit and grease chamber
B Primary Treatment	Gross solids plus readily settleable solid	Primary sedimentation, flotation
C Secondary Treatment	Most solids and BOD	Biological treatment, physical-chemical treatment, lagoons
D Nutrient removal	Nutrients	Biological treatment, chemical precipitation
E Disinfection	Bacteria and viruses	Lagooning, ultraviolet radiation, chlorination

6. SAMPLING AND MONITORING

Monitoring is an essential part of the implementation of the whole range of water legislation. EU countries have to ensure establishment for monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin. In 1975, Mediterranean countries established the monitoring programme “MED POL” in accordance with the requirements of the Barcelona Convention (Article 1), and they Article 3 of the Land-based Source Protocol (LBS). The programme includes monitoring of coastal waters and sources of pollution.

Sampling and monitoring of the environmental and effluent are needed to determine whether:

- the predicted effluent quality is achieved;
- the level of impact or change caused by the management system is as predicted;
- the agreed environmental values are met:

The Environment

A sampling programme for the environment is usually based on the output from a detailed site study and consideration of the discharge’s nature and volume. However, relevant regulations require a certain sampling programme to be implemented and information to be delivered. The EU Water Framework Directive describes in great detail a monitoring programme that has to be implemented, including:

1. Surveillance monitoring for:
    - supplementing and validation of the impact assessment procedure;
    - an efficient and effective design of the future monitoring programme;
    - the assessment of long-term changes in natural conditions;
    - the assessment of long-term changes due to widespread anthropogenic activity.
2. Operational monitoring undertaken in order to:
    - establish the status of those water bodies identified as being at risk of failing to meet their environmental objectives, and
    - assess any changes in the status of such bodies resulting from the programmes of measures.
3. Investigative monitoring carried out:
    - where the reasons for any exceedances are known;
    - where surveillance monitoring indicates that the objectives set for a body of water are not likely to be achieved;
    - to ascertain the magnitude and impact of accidental pollution.

Each country has its own monitoring programme in accordance with the national regulations and international obligations. A broad range of aspects needs to be considered when assessing the impact on the environment, such as:

A) For water:
- the current background quality of the water body;
- status of ecosystems, both pre and post discharge;
- modelling of effects on the receiving environment, including the effects from all other discharges to the water;
- sampling the water in and beyond the mixing zone, and sampling of sediments and fauna;
- establishing control sites beyond the influence of the discharge to identify changes unrelated to it;
- biological monitoring e.g. macro invertebrates;

- evaluating the biological impact of the discharge.

B) For land:
- soil type;
- vegetation cover;
- potential for runoff;
- proximity to streams and lakes;
- evaluating the impact of the discharge;
- sampling of groundwater, nearby surface waters, soil and crops.

C) For products based on wastewater and sludge reuse:
- reused effluent/sludge application;
- vegetation production and use;
- mobility of pollutants from land sources;
- prioritise sources and causes;
- possible impacts on environment and consumers of food produced by reuse;
- amount of toxic, persistent or bio-accumulable materials in effluent, sludge and products;
- health effects and risks.

Monitoring of environmental changes related to effluent discharges is complex and expensive. The frequency and scope of monitoring need to be considered on a case-by-case basis, and have to be implemented in accordance with relevant national and international standards (ISO, EN, etc.), and requirements. This problem is well documented and regulated by EU directives and norms.

The Effluent

Competent authorities or appropriate bodies shall monitor:
- discharges from urban wastewater treatment plants to verify compliance with the requirements;
- amounts and composition of sludge disposed in the surface waters.

Monitoring of effluent quality may be also undertaken to:
- assess treatment performance;
- assess self-monitoring and reporting programme;
- meet regulatory/permit requirements;
- detect changes in effluent quality that could have an impact on the environment;
- provide data for long-term planning, and confirm the design criteria;
- meet research needs.

The nature and frequency of sampling required depend of on a large number of factors, such as:

- sensitivity of the environment;
- regulatory requirements;
- nature of the treatment process;
- risk to the environment;
- quality of the environment;
- variability of the flow, daily and seasonal ;
- composition and variability of the inflow's industrial waste component;
- reliability of the treatment process;
- competence of the operating staff;
- effectiveness of the plan's maintenance and supervision;
- remoteness of the plant.

Because monitoring is a very expensive task it is necessary for it to be optimised. It is recommended that sampling be made at two levels:

- a small number of critical parameters related to the treatment process and impact on the environment;
- a broad suite of parameters covering all those with identified potential for impact on environment.

Sampling should be more frequent in case of a larger treatment plant, in case where there may be a significant impact on the environment, or in case of a sensitive environment. Potential variability of the quality of effluent may influence sampling frequency. It depends on the type of treatment processes. Processes with longer detention time, such are lagoons, are far less likely to have sudden changes in effluent quality than the plants with short detention time.

Table 12 gives the recommended sampling frequency for different plants, which have to be harmonised with relevant national regulations. Two sampling frequencies are nominated for each plant size. In small, remote communities, as well as in regions lacking adequate staff and equipment, sampling may be both logistically difficult and prohibitively expensive. In these cases, processes used should be selected to be robust and reliable. Then, sampling frequencies may be lower than indicated.

Composite sampling is more suitable for large plants and in cases when it is necessary to estimate the total load and peak pollution load to the environment. Generally, grab samples are more common. Sampling should occur within two hours of normal time of the maximal daily flow for short detention time systems.

Other details related to monitoring could be found in relevant literature, as well as standards and protocols.

Monitoring programme has to be properly designed in order to be efficient and rational. Monitoring cycle (Box 6.) is a guiding principle: the process of monitoring and assessment should be seen as a sequence of related activities that begin with the definition of information needs and ends with the use of information product. Successive activities in this chain should be specified and designed (optimised) on the basis of the required information product as well as on the preceding part of the chain. A chain is only as strong as its weakest link. Monitoring without the specification of information needs prior to the actual network design will be a waste of money.

Box 6: Monitoring cycle
Elements of the monitoring cycle are:
1. Water management goals and needs
2. Information needs for the management
3. Monitoring strategy to gather information
4. Network design and optimisation
5. Sample collection
6. Laboratory analysis
7. Data handling
8. Data analysis, validation and approval
9. Reporting
10. Information utilisation by management

Table 12

Recommended sampling frequencies for effluents

Plant Type (See notes below)	Principal Process Parameters	Plant Detention Times	Plant Size Very Small < 0.5 MLD	Small 0.5 - 3 MLD	Medium 3-20 MLD	Large >20 MLD
A, B	TSS, BOD-5	all	Q	Q	W	2 x W
C	TSS BOD-5, COD, N	long detention short detention	Q M	Q W	M 2 x W	W 2 x W
D	TSS, N, P BOD-5, COD	long detention short detention	Q M	Q W	M 2 x W	W 2 x W
E	E. coli	long detention short detention	Q M	Q M	M 2 x W	W 2 x W
F	any site specific needs	all	W	W	2 x W	2 x W
Comprehensive suite of parameters		all	T	T	Q	Q

NOTES: PLANT TYPE - TYPICAL TREATMENT PROCESSES

Treatment Process Category	**Parameters to be removed**	**Examples of Treatment Processes**
A Pre Treatment	Gross solids, grit, grease and oil	Screening
B Primary Treatment	Gross solids plus readily settleable solid	Primary sedimentation
C Secondary Treatment	Most solids and BOD	Biological treatment, physical-chemical treat., lagoons, natural treat.
D Nutrient removal	Nutrients	Biological treatment, chemical precipitation, natural treatment
E Disinfection	Bacteria and viruses	Lagooning, UV radiation, chlorination, natural treatment
F Advanced wastewater treatment	Treatment to further reduce selected parameters	Granual-medium filration,microfiltration, membrane technology, membrane bioreactor

ABBREVIATIONS **BOD** = Biochemical Oxygen Demand, **COD** = Chemical Oxyen Demand, **P** = Phosphorus, **MLD** = Megalitres per day, **2xW** = Twice weekly, **M** = Monthly, **T** = Twice yearly, **Q** = quarterly, **N** = Nitrogen, **TSS** = Total Suspended Solids, **W** = Weekly

Sampling frequency in very small remote communities may be lower than that indicated above.

APPENDICES

Appendix 1: Glossary

Advanced wastewater treatment: the application of multiple unit processes beyond the secondary treatment.

Beneficial uses: uses or value of the environment that promotes public benefit, welfare, safety, health, and aesthetic enjoyment.

Catchment area: the area of land from which all surface runoff flows through a sequence of streams, rivers and possibly, lakes to a particular point in a water course (normally a lake or a river confluence).

Chlorination: the application of chlorine to water, wastewater, or industrial waste, generally for disinfection.

Coastal waters: the waters outside the low water line or outer limit of an estuary;

Criterion: qualitative or quantitative value or concentration of a constituent, based on scientific data, from which a decision or judgement may be made about suitability of water for a designed use.

Diffuse source discharges: a source of pollution that has no single place of origin (for example, run-off of rainwater containing sediment, fertilisers and pesticides from land used for agriculture).

Disinfection: a process that destroys, inactivates or removes pathogenic micro-organisms.

Domestic wastewater:wastewater from residential settlements and services, which originates predominantly from the human metabolism and from household activities.

Effluent: the water discharged following a wastewater treatment process, e.g. secondary treatment.

Environmental flow: the flow in an inland stream needed to sustain the ecological values of aquatic ecosystems at a low level of risk.

Environmental value: See beneficial uses, above.

Estuary: the transitional area at the mouth of a river between fresh-water and coastal waters;

Eutrophication: the process of an aquatic body becoming enriched with nutrients that stimulate aquatic plant growth, such as algae, resulting in depletion of dissolved oxygen.

Floatables: Gross solids, plastic, foam or excessive oil and grease present on the surface of the effluent.

Guideline treatment level: a likely level of treatment for the particular set of discharge conditions. Actual treatment requirements should be determined in accordance with environmental value requirements and ongoing monitoring.

Groundwater: Subsurface water in a saturation zone or aquifer that can be extracted through a well.

Hazardous substances: substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern.

Lagoon: a shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater.

Industrial wastewater: any waste water which is discharged from premises used for carrying on any trade or industry, other than domestic waste water and run-off rain water;

Inland waters: all standing or flowing water on the surface of the land, and all groundwater on the landward side of the baseline from which the breadth of territorial waters is measured.

Marine waters: oceans and bays together with water in estuaries. These waters have dissolved inorganic ions greater than 30,000 mg/L.

Mixing zone: an area contiguous with an effluent discharge point and specified in the licence or permit, in which the water quality objectives applying to the water body are not required to be met.

Municipal wastewater: see urban wastewater.

Municipal treatment plant: a plant treating wastewater of essentially domestic origins in which any industrial wastes are compatible with domestic wastewater.

Natural treatment system: apply processes that take place in the natural physical, chemical and biological processes. Most frequent applied: land-treatment systems - slow rate, rapid infiltration and overland flow; constructed wetlands - free water surface, subsurface flow systems; floating aquatic plants; aquaculture.

Nutrients: substances necessary for the growth and reproduction of organisms.

Nutrient removal: an additional wastewater treatment process to reduce the amount of nitrogen or phosphorus in the effluent below the levels achieved by secondary treatment.

Objectives: the desirable, short and/or long term goals of the water quality management program. Such objectives are often derived after consideration of water quality criteria in the light of economic, environmental, social or political factors.

Organic material: in wastewater treatment, material that can be biologically consumed in the secondary treatment process. A food source for various microorganisms.

Outfall: pie or conduit used to convey treated effluent to the point of discharge terminating in a diffuser.

Point source discharges: a source of pollution from an identifiable place of origin (for example, an effluent discharge from a wastewater treatment plant or an effluent discharge from a rural industry).

Ponds: treatment lagoons for purification of raw wastewater and for the additional treatment of primary or secondary treated effluent.

Pollutant: any substances liable to cause pollution.

Pollution: the direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems, which result in damaged material property, or which impair or interfere with amenities and other legitimate uses of the environment.

Priority substances: established priority hazardous substances.

Pre treatment/preliminary treatment: wastewater treatment, which involves the removal of gross solids and some of the readily settleable solids, as well as removal of floating material, grease and oils.

Primary treatment: wastewater treatment, which removes readily settleable solids. It means treatment of urban wastewater by physical and/or chemical processes involving settlements of suspended solids or other processes followed by sludge digestion or other means of sludge disposal. The BOD5 of the incoming water is reduced by at least 20% before discharge, and the total suspended solids of the incoming wastewater are reduced by at least 50%.

Reuse: means the application of appropriate treated wastewater to some beneficial purposes.

River basin: the area of land from which all surface runoff flows through a sequence of streams, rivers and possibly lakes into the sea through a single river mouth, estuary or delta.

Sanitation: control of physical factors in the human environment that could harm development, health, or survival;

Secondary treatment: treatment of urban wastewater by processes generally involving biological treatment with secondary settlement or other processes followed by sludge digestion or other means of sludge disposal. The contaminants in incoming water are reduced to a minimum: BOD5 70 - 90%, chemical oxygen demand 75 %, and total suspended solids 70 - 90 % before discharge.

Sewage: see wastewater.

Sewer: a channel or conduit that carries wastewater and storm-water runoff from the source to a treatment plant or receiving stream. “Sanitary” sewers carry household, industrial and commercial waste. Storm sewers carry runoff from rain. Combined sewers handle both.

Sludge: the residual solids, whether treated or untreated, which are removed from wastewater treatment plants.

Sludge treatment: processes in which the volume of water is reduced and sludge quality is controlled in order to prevent detrimental environmental impacts.

Standards: currently legally enforceable levels established by an authority.

Tertiary treatment: processes, which further improve the secondary effluent quality prior to discharge or reuse. Processes such as sand filtration, ion exchange, micro filtration, membrane technology and the use of wetland filters are generally used.

Toxicant: a substance, which above a certain concentrations is poisonous to living things.

Trade effluent discharge standards: currently legally enforceable levels established by an authority for the industrial wastewater prior discharge into urban wastewater system.

Urban wastewater: domestic wastewater or a mixture of domestic wastewater with industrial wastewater and/or run-off rain water;

Wastewater: water which has been used, at least once, and has thereby been rendered unsuitable for reuse for that purpose without treatment and which is collected and transported through sewers. Wastewater normally includes water from both domestic and industrial sources.

Wastewater collection system: a system of conduits, which collects and conducts urban/municipal wastewater.

Wastewater discharge: the flow of treated effluent from any wastewater treatment process.

Wastewater disposal: collection and removal of wastewater deriving from industrial and urban settlements by means of a system of pipes and treatment plants.

Wastewater management: all of the institutional, financial, technical, legislative, participatory, and managerial aspects related to the problem of wastewater.

Wastewater pollution: the impairment of the quality of some medium due to the introduction of spent or used water from a community or industry.

Wastewater quality: the state or condition of spent or used water that contains dissolved or suspended matter from a home, community farm or industry.

Wastewater reclamation: treatment and management of municipal, industrial, or agricultural wastewater to produce water of suitable quality for additional beneficial uses.

Wastewater sanitation system: the combined collection, treatment and disposal system of municipal wastewater.

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