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## **Problems and needs of sustainable water management in the Mediterranean area**

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### **CONTENT**

1. GENERAL INTRODUCTION. PROBLEMS and FACTS
2. The Union for the Mediterranean (UfM) and Sustainable Water Management
3. Identification of tentative priority areas (projects)

*Drinking water treatment*

*Wastewater treatment*

*Reuse of wastewater*

*Treated wastewater reuse for agricultural and landscape irrigation*

*Treated wastewater reuse for groundwater recharge*

*Treated wastewater for direct and indirect potable reuse*

*Reuse of sewage sludge*

*Sewage sludge reuse for agriculture*

*Irrigation*

4. FINAL CONCLUSIONS AND RECOMMENDATIONS

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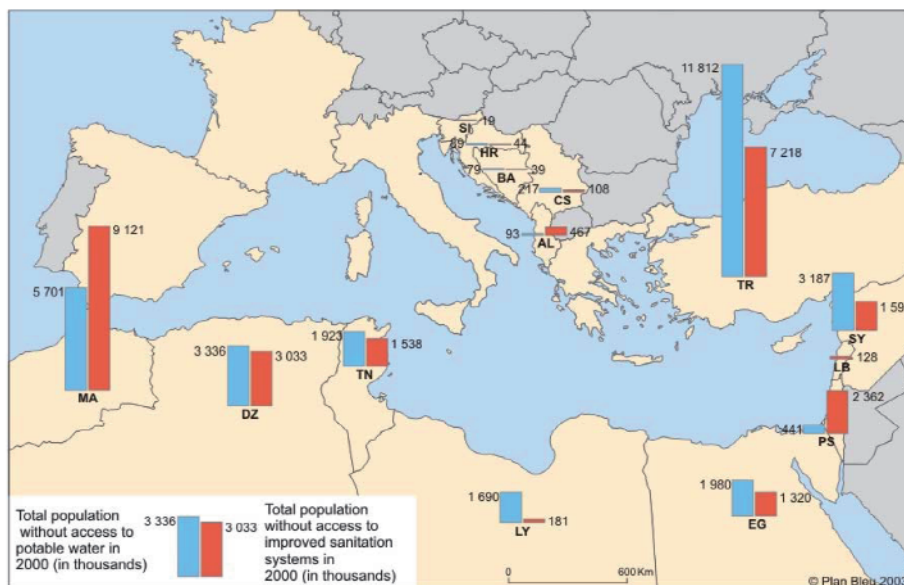
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### 1. GENERAL INTRODUCTION. PROBLEMS and FACTS

The Mediterranean Sea is the largest semi-enclosed European sea, characterized by a narrow shelf, a narrow littoral zone and a small drainage basin especially in the northern part. Today, 82 million people live in coastal cities in 21 countries on the Mediterranean rim and by 2025 there will be an estimated 150-170 million. Today the southern Mediterranean countries account for 32 per cent of the region's population; by 2025 that is expected to have reached 60 per cent. Even though the population growth is slowing down in the area, this will still mean an increase in environmental pressure in the immediate future, especially because the rise in population will be mainly concentrated in the countries located in the southern and eastern Mediterranean. The important level of human activity in coastal areas is also leading to serious pollution problems, caused by the large quantities of industrial and urban waste that are produced and discharged in the sea with a low capacity for self-decontamination and a slow water renewal cycle. Seasonal population pressures are also very high. Over 100 million tourists visit Mediterranean beaches and cities every year and this number is expected to double by 2025. In order to cater for this booming business, natural habitats have been replaced by modern resorts and the extra pollution generated is often dumped untreated into the sea, threatening the equilibrium of entire ecosystem of the region.

The regions included in the Mediterranean basin are amongst the world areas most suffering of water scarcity in addition to the pollution of freshwater resources. It is estimated that 30 million Mediterranean people live without access to clean drinking water due to lack of general investment and/or lack of resources (see Figure 1).

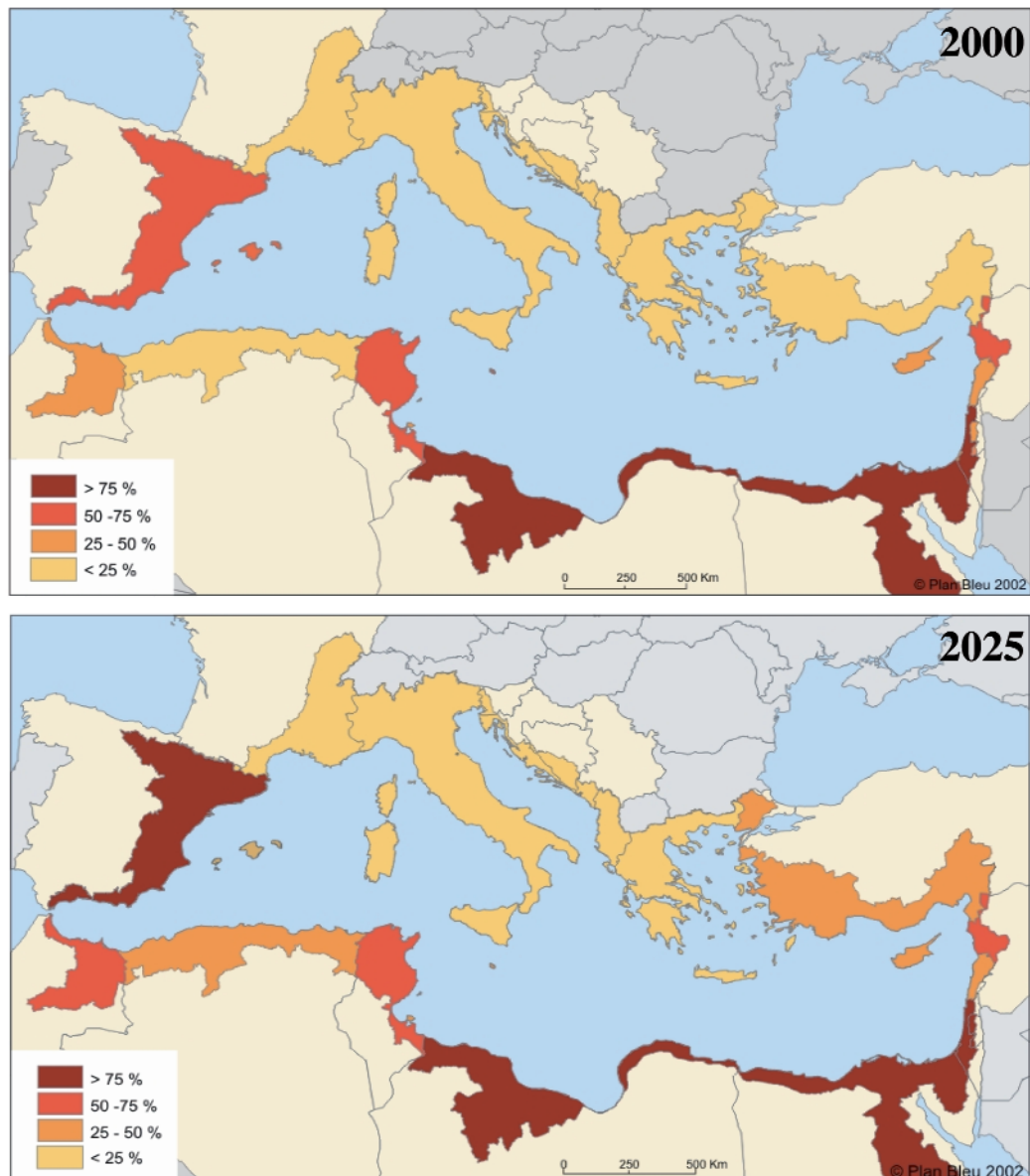


**Figure 1. Access to safe drinking water and sanitation**  
(source: UN-SDMI, OMS-Unicef, 2003)

The degree of pressure on water resources, expressed through the *exploitation index of renewable natural resources* (volume of annual abstraction on renewable natural water resources / annual



average volume of available renewable natural water resources, expressed as a percentage), and its projection to 2025 is shown in Fig. 2. Tensions on the resources are expected to be particularly high in Egypt, Israel, Libya, Palestinian Territories and in the Spanish Mediterranean catchment areas (index at 75% or higher), as well as in Malta, Syria, Tunisia and in some catchments of Morocco (index between 50 and 75%).

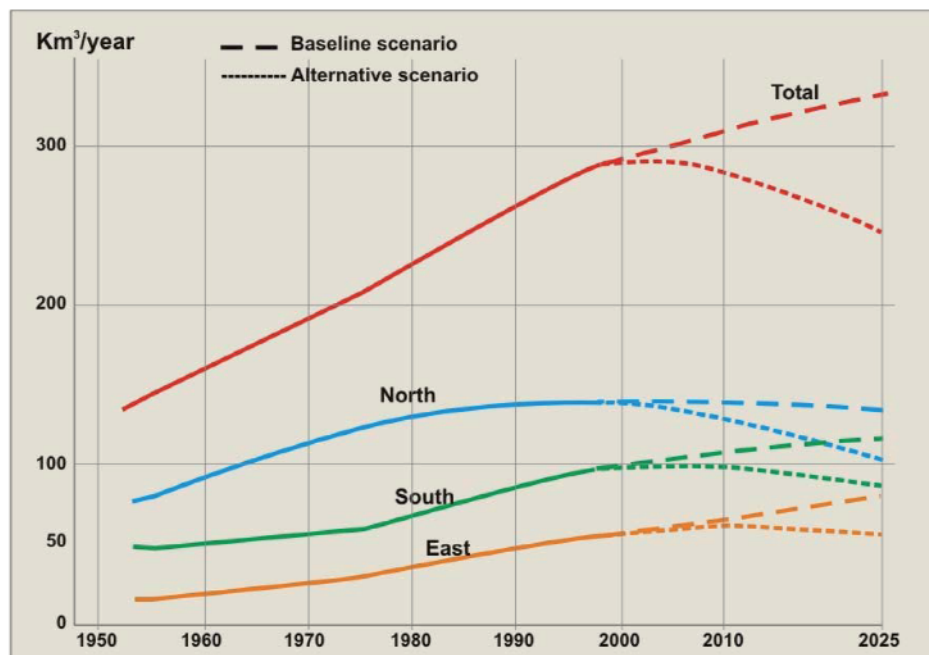


**Figure 2. Exploitation indices of renewable natural water resources** (source: Plan Bleu, UNEP – Regional activity center. Environment and development in the Mediterranean.)



Understanding water scarcity and the way to cope with scarcity is not just a matter for water managers or scientists. Water scarcity has a direct impact on citizens and economic sectors that use and depend on water, such as agriculture, tourism, industry, energy and transport. Water scarcity and droughts also have broader impacts on natural resources at large, through negative side-effects on biodiversity, water quality, increased risks of forest fires and soil impoverishment. Ultimately, the shortage of available water may not only have effects on water quality, but also on the ecosystems' integrity, and may result in economic and social disarrangements.

The increased pressure on water resources will cause additional effects on aquatic ecosystems, with some direct and indirect effects. This is particularly relevant since freshwater ecosystems deliver relevant services to human societies. The effects on watersheds are commonly focused upon streams and rivers. Hence there will be effects on morphology (incision, channel simplification), chemistry (higher nutrient and pollutant concentrations) and biological communities (lower diversity, arrival of invasive species, lower efficiency of biological processes). Regional climate models provide a series of consistent high resolution scenarios for several climate variables across Europe. Analyses in Mediterranean watersheds consistently suggest that the climate will be significantly hotter and drier, especially in summer. It is foreseen that this will influence both the fate and behavior of pollutants.



**Figure 3. Total water demand of Mediterranean sub-regions (evolution 1950-2000) & baseline and alternative projections 2000-2025)** (source Source : Plan Blue)

Since, it is evident that the physical, socio-economic and environmental limits of supply-based policies have been reached future scenarios includes implementation of a number of policies



based on improved water demand management and policies aimed to increase exploitable potential through improved water and soil conservation, and increased recourse to the artificial replenishment of water tables in arid areas. Alternative scenario (see Figure 3.) accounts for potential savings in agriculture (including wastewater reclamation and reutilization, reduction of transport losses and increase in efficiency in irrigation), industry (increase in recycling rate) and domestic water (reduction of transport losses and leaks).

Analyzing potential alternatives and needs indicates that there is not a single and simple solution for water scarcity because multiple causes (or stressors) require multiple solutions. Several options need to be applied when considering the existing resources. In particular, for the scenario of climate change, increased demand and decreasing resources must be considered. These options need to consider the delicate coupling between social and natural systems, where each has their share. Both improved technologies and upgraded water management practices are necessary in all sectors where water is used (e.g. agriculture, manufacturing or tourism). In agreement with the European Water Framework Directive (article 9), it is essential that the full economic and environmental costs are considered in evaluating the alternatives, where conservation of resources and their quality *at the source* could also be included. The use of decision support systems may be helpful in integrating the multiple actors, as well as in optimizing drought management and mitigation measures.

More relevant options to deal with water scarcity in the Mediterranean area are:

- Working for a culture of water-saving and efficiency is essential. That requires an active public awareness from citizens and economic sectors. Potential savings can be stabilized into the future and these savings extended to domestic and agricultural needs. Developing water savings in irrigation, within general planning for the economical needs of the whole territory, is essential.
- Valuing ecosystem services can provide a framework for understanding that social needs and natural capital are not separated. Public education is critical to achieve the goal of compatible use of water resources and the conservation of our natural heritage.
- Improvement of wastewater treatment (WWT) quantitatively and qualitatively. Any choice of treatment technology performed should rely on those Best Available Technologies not Entailing Excessive Costs (BATNECC) and providing the best environmental practice and option. Furthermore, new and innovative control strategies could be adopted in order to improve the biological process performance and reach a proper water quality and energy consumption. Adoption of new technologies for wastewater treatment will help to face up these goals. An interesting strategy to improve water treatment along with maintaining power consumption under control is to combine different technologies (biological and physico-chemical) in a single wastewater treatment plant (WWTP) according to the different characteristics of the wastewater and the receiving media (combined approach).
- Pilot plant tests and benchmarking of existing works will provide a useful knowledge to help in the choice of the proper wastewater treatment plant (WWTP) technology and its layout. These activities will improve the long term performance of the new WWT infrastructures.



- Sewage waters reclamation may be considered as an adequate water source for urban, tourism and agricultural uses. With proper treatment, sewage water can even be used for drinking water under certain circumstances. There exist several techniques adequate for the improvement of chemical and microbiological quality that could help to provide these uses. (in Catalonia, up to 101 Mm<sup>3</sup> will be available in 2027). The solutions are linked, however, to available energy; this sometimes becomes the critical limitation. Public perception and cultural issues also need to be evaluated and improved when this source of water is considered. Thus public consultation would help to early detect future misunderstandings.
- Desalination is one of the current options to obtain water resources that could provide a source of water independent of the potential changes in climate. (in Catalonia, up to 190 Mm<sup>3</sup> will be available by 2027). However, energy needs and costs are high, although recently researches are being developed using solar energy in desalination. (average energy costs can be estimated around 3.40 kWh/m<sup>3</sup>.) Nevertheless, desalination should not be considered the unique option.
- Use of ground waters requires adequate protection of aquifers. Overexploited aquifers affect the water available for surface aquatic ecosystems, and may create problems of subsidence and salt water intrusion. Recharging aquifers requires good chemical and microbiological quality of the waters. Some techniques to improve the water quality of underground waters exist, even at the large scale. Recovered ground water wells can provide additional resources (up to 43 Mm<sup>3</sup> in Catalonia which could be raised to 90 Mm<sup>3</sup> during extreme droughts).
- There are a lot of universities and research centers with international prestige what can provide knowledge and experience in order to evaluate or assess (during the planning of the actions) the foreseeable effects of the new water projects identified within the UfM to the global change. Furthermore, short and medium term monitoring with adequate indicators, has to be considered in order to check the evolution of water bodies and to acquire "in situ" experience for future projects and to assess the impact of the planned "actions".



## 2. THE UNION FOR THE MEDITERRANEAN (UfM) AND Sustainable Water Management

**Environment - De-pollution of the Mediterranean** is identified as one of the six priority areas (programmes) of the Union for the Mediterranean and listed in the Annex of the Paris Declaration. The Programme '*Sustainable Water Management and De-pollution of the Mediterranean*' aims to promote sustainable water management policies in the context of the current increasing of water scarcity. In total €22 million is allocated for 2009-2010. Part of the funds will be dedicated to support the Mediterranean Water Strategy and the implementation of the 'Horizon 2020' Programme. This initiative is built around 4 elements:

- Projects to reduce the most significant pollution sources focusing on industrial emissions, municipal waste and urban waste water, responsible for up to 80% of pollution in the Mediterranean Sea (Reduction).
- Capacity-building measures to help neighboring countries create national environmental administrations that are able to develop and police environmental laws (Capacitation).
- Using the Commission's Research budget to develop and share knowledge of environmental issues relevant to the Mediterranean (Knowledge).
- Developing indicators to monitor the success of Horizon 2020 (Monitoring).

The preparation of the long term Strategy for Water in the Mediterranean (SWM) was the key decision of the Euro-Mediterranean Ministerial Conference on Water (22 December 2008, Jordan). Recently, the Water Expert Group of the Union for the Mediterranean, held in, Athens, Greece, 7-8 September 2009, prepared the Terms of Reference for the elaboration of the SWM. Among the content of this document it was pointed out that SWM should be oriented to specific and measurable objectives and commitments like water saving potential, de-pollution targets, etc. Among the different issues to be tackled by SWM reference should be made to water allocation, water scarcity, efficiency, extreme phenomena like floods and droughts, trans-boundary water resources, sanitation, groundwater and health among other issues.

The Water Expert Group of the Union for the Mediterranean was also informed on key strategies, processes and initiatives in water that already exist in the Mediterranean. One of these key strategies is the implementation of the Water Framework Directive (WFD) within which the river basin management plans should be adopted by 2009, after public consultation. In this scenario, it is necessary to remind that the Water Framework Directive 2000/60/EC (WFD) and the Council Directive 91/271/EEC concerning urban wastewater treatment has proved to be useful in order to improve the water quality in continental (and indirectly in marine) waters. This European experience is valuable and should be an starting point in the framework of the UfM projects in the sense of the following items: adopting the river basin as planning unit; the public participation; the cost-benefit analysis of actions, considering the receiving media quality above discharge emission limits,... This expertise could be useful to deal with the big job of implementing the large number of different projects to "de-pollute" the Mediterranean.

Under the France-Egyptian presidency, on the Ministerial meeting on sustainable development projects (Paris, June 2009), a list of 113 projects was proposed in the domain of Horizon 2020 ini-



tiative and proposed by UfM members following priority concerns of (i) de-pollution of the Mediterranean; (ii) technologies and efficient use of water; (iii) balance between supply and demand; (iv) conservation and rehabilitation of natural environments and (v) adaptation to climate change.

To satisfy the growing demand, the proposed projects are in the line with national policies that are largely dominated by efforts to increase water supply and multiply the number of large water infrastructures.

The re-activation of UfM in June 2009 gives also the opportunity to re-activate, under the Spanish presidency, the Programme of Sustainable Water Management and De-pollution of the Mediterranean, refining the existing projects and considering new ones aligned with the priority concerns. A special stress should be made in the area of management of urban water cycle (including production of drinking water, water supply, sanitation, treatment of wastewater and re-utilization of wastewater and sludge) aspects which are crucial to reach the goals of this program. The involvement of companies should be focused towards **long-term projects**, such as those dealing with management issues, strengthening technology research, technology transfer and capacity building, as well as monitoring water quality, that also imply the need to interact permanently with local administration and local companies, and therefore straitens the links with those companies and increase in general commercial presence of European companies in the Mediterranean market. In addition, Spanish companies have interest in participation in **short-term activities**, such as construction of infrastructure (building of new treatment plants, sanitation and sewerage infrastructure and expansion of existing facilities), where they can participate as constructors, as well as experts in planning and operation.



### 3. IDENTIFICATION OF TENTATIVE PRIORITY AREAS (PROJECTS)

- Drinking water treatment and distribution
- Wastewater treatment
- Reuse of wastewater
- Reuse of sludge

#### 3.1 Drinking water treatment and distribution

As the world increasingly comes to the realization that a combination of population increases, development demands and climate change means that freshwater will be in chronically short supply in rich and poor areas of the world alike, there is increasing interest in desalination as a technique for tapping into the vast and infinitely tempting water supplies of the sea. Until recently, widespread desalination for the purpose of general water supply for land-based communities has been limited by its great expense and it is notable that the area where desalination made by far the greatest contribution to urban water supplies were in the oil-rich and water poor States around the Persian Gulf. Improvements in the technology of desalination, coupled with the rising cost and increasing unreliability of traditional water supplies, are bringing desalinated water into more focus as a general water supply option with major plants in operation, in planning or under consideration in Europe, North Africa, North America, Australia, China and India among others.

However, seawater desalination is also raising significantly the overall energy intensity, potential climate impact and the price of water. Despite improved technology and reduced costs, desalinated water remains highly expensive and sensitive in particular due to the increases of energy costs. Our knowledge of impacts is largely based on limited research from relatively small plants operating in relative isolation from each other. The future being indicated by public water authorities and the desalination industry is of ever larger plants that will frequently be clustered together in the relatively sensitive coastal environments that most attract extensive settlement.

Besides the issues on desalination plants, there is a need of implementing new infrastructures or rehabilitate or upgrade the existing ones as to the Water Treatment Plants (WTP), wells and pipes. To increase the efficiency of all these infrastructures, they must be properly planned, designed, built and operated. As settled before, there is a high level of expertise in Mediterranean countries about all these items.

#### Short-term projects

- Planning, design, construction & Operation of desalination plants
- Planning, design, construction & operation of WTPs
- Planning, design, construction & Operation of urban water supply systems
- Planning, design, construction & Operation of well systems
- Capacity building (practical issues, operational parameters, control, improving of analytical capabilities)

#### Long term projects

- Study of long-term environmental impact of desalination
- Innovative technologies for treatment of concentrates; technology research and technology transfer



### 3.2 Wastewater treatment

Sewage generation from coastal cities is one of the major pollution problems on the Mediterranean coast. The problem is exacerbated due to the rapid growth of many coastal cities and towns, especially on the southern Mediterranean coast. The sewage collection system is often only connected to parts of the urban population, which leads to direct discharge of untreated wastewater into the sea through other outfalls.

Existing wastewater systems are generally capital-intensive and require expensive, specialized operators. Therefore, before selecting and researching in a wastewater treatment technology, an analysis of cost effectiveness needs to be made and compared with all conceivable alternatives. The selection of suitable technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the users, and affordable to those who have to pay for them. Simple solutions easily replicated, that allow further upgrading with subsequent development and that can be operated and maintained by the local community are often considered the most appropriate and cost effective. The choice of a technology will depend to the type of wastewater. In the developing countries usually characterized by high population density and notable shortfall in available water resources, the proper wastewater technology to be adopted under the prevailing local conditions is one of the critical issues which should be well defined.

For the local application of treatment techniques, studies must be undertaken including a detailed risk assessments evaluating microbiological, chemical and biological factors, to identify necessary technologies, uses and control tools. For regional utilities, this minimum treatment level is expanded to include tertiary treatment. For that, rules and regulations need to be established or adjusted to the new requirements of WHO (2006). Farmers should be involved in the project as they might get benefit from wastewater or sludge reuse as appropriate treated wastewater is a valuable resource that must be utilized and agriculture is given priority for reuse.

The lack of personnel with the appropriate technical and managerial skills for the use of advanced technological tools and implementation of modern management strategies are among the major constraints for achieving the goals of improved and attain more efficient wastewater management practices. Moreover, there is a general necessity to transform the concepts of water efficiency improvement and water saving in industrial applications into implementation policies, programs and actions on the ground in the countries which are particularly affected by water shortage problems as the arid and semi-arid areas from the South Mediterranean and Middle East Regions.

Technologies available are many and well known, but it has been widely demonstrated that certain industrial wastewaters require the application of innovative treatment technologies. Moreover, any choice performed should rely on those not entailing excessive costs (BATNECC) and providing the best environmental practice and option.



#### **Short-term projects**

- Planning, design, construction and operation of WWTPs, sea outfalls and sewer networks
- Rehabilitation and upgrading of existing WWTP, sea outfalls & sewer networks
- Capacity building (practical issues, operational parameters, control, improving of analytical capabilities)
- Building capacities for the use of appropriate technical and managerial skills in water efficiency and water saving.
- Legislation for wastewater treatment, using the combined approach to improve water quality

#### **Long term projects**

- Projects on integrated management of wastewaters
- Monitoring of water quality and environmental risk assessment
- Development of innovative technologies for wastewater treatment; technology research and technology transfer

### **3.3 Reuse of wastewater**

The scarcity of water and the need for protecting the environment and natural resources are the main factors leading countries in the Mediterranean region to introduce the reuse of treated wastewater as additional water resource in their national plans of water resource management. The key types of constraints to such practices are:

- *Financial constraints* (related e.g. to high costs of treatment systems and sewerage networks, high operational costs especially for electricity, low prices of freshwater compared to reclaimed wastewater, low user willingness to pay for reclaimed wastewater).
- *Health impacts and environmental safety* especially linked to soil structure deterioration, increased salinity and excess of nitrogen.
- *Standards and regulations*, which are in some cases too strict to be achievable and enforceable and, in other cases, not adequate to deal with certain existing reuse practices.
- *Monitoring and evaluation* in both treatment and reuse systems, often related to lack of qualified personnel, lack of monitoring equipment or high cost required for monitoring processes.
- *Technical constraints*, including, for instance, insufficient infrastructure for collecting and treating wastewater, inappropriate set up of existing infrastructure (not designed for reuse purposes), improper functioning of existing infrastructure, insufficient skilled and qualified personnel.
- *Institutional set-up* (especially poor coordination at relevant intra- and inter-sector levels) and lack of appropriate personnel capacity
- Lack of *political commitment* and of *national policies/strategies* to support treatment and reuse of wastewater.



- *Public acceptance and awareness*, related to low involvement and limited awareness of both farmers and consumers of crops grown with reclaimed wastewater (and/or sludge).

Main area of application of re-use practices are:

- Agriculture and landscape irrigation
- Groundwater recharge
- Direct or indirect potable use

#### *Treated wastewater reuse for agricultural and landscape irrigation*

Because of the nature of sewage, fears have expressed about the possible hazards associated with effluent reuse. In assessing these hazards various pathways for the dissemination of undesirable pollutants have been examined. Two aspects of wastewater reuse in agriculture have become subjects of paramount importance: the possible risks to health and the potential environmental damages. Health considerations are centred around the pathogenic organisms that are, or could be, present in the effluent and the build-up of toxic materials within the soil, and subsequently within plant and animal tissues which might eventually reach the human food chain. The leaching of materials such as nitrates and toxic soluble chemicals into the groundwater is also a matter for concern. Environmental risks involve the effects of the use wastewater containing dissolved substances which have deleterious effects on the growth and development of plants.

The reuse of treated wastewater for agriculture irrigation has some advantages as well as some disadvantages.

Advantages include:

- Source of additional irrigation water.
- Savings of high quality water for other beneficial uses.
- Low-cost source of water supply.
- Economical way of wastewater disposal, pollution prevention and sanitary problems.
- Reliable, constant water source.
- Effective use of plant nutrients contained in the wastewater, such as nitrogen and phosphorus.
- Provides additional treatment of the wastewater before being recharged to groundwater.

Disadvantages include:

- Wastewater not properly treated can create potential public health problems.
- Potential chemical contamination of the groundwater.
- Some of the soluble constituents in the wastewater could be present at concentrations toxic to flora.
- The treated wastewater could contain suspended solids at levels that may plug nozzles in the irrigation distribution system as well as clog the capillary pores in the soil.
- The treated wastewater supply is continuous throughout the year while the demand for irrigation water is seasonal.
- Major investment in land and equipment.
- Final key question: who will pay the bill?



*Treated wastewater reuse for groundwater recharge*

- The purposes of groundwater recharge using treated wastewater can be:
- To establish saltwater intrusion barriers in coastal aquifers.
- To provide further treatment for future reuse.
- To augment potable or non potable aquifers.
- To provide storage of treated water, or to control or prevent ground subsidence.

Also, groundwater recharge will help to provide a loss of identity between treated water and ground water. This loss of identity has a positive psychological impact where reuse is contemplated and is an important factor in making treated water acceptable for a wide variety of uses, including potable water supply augmentation.

*Treated wastewater for direct and indirect potable reuse*

Direct reuse of wastewater for potable purposes is clearly limited, indirect reuse for potable purposes takes place constantly and on a worldwide basis. Nevertheless, it will be necessary to develop educational campaign about the use of reuse water for drinking. Indirect potable reuse is more acceptable to the public than direct potable reuse as the water loses its identity as it moves through a river, lake, or aquifer. Indirect reuse, by virtue of the residence time in the water course, reservoir, or aquifer, often provides additional treatment and offers an opportunity for monitoring the quality and taking appropriate measures before the water is ready for distribution. In some instances, however, water quality may actually be degraded as it passes through the environment.

**Short-term projects**

- Planning, design, building and operation of infrastructure for collecting and treating wastewater for re-use purposes
- Institutional set-up (improving personnel capacity)

**Long term projects**

- Planning and development of regional irrigation systems using reclaimed water
- Creation of expertise networks
- Monitoring and evaluation of reuse systems and environmental risk assessment of different re-use options
- Increase of public acceptance and awareness

**3.4 Reuse of sewage sludge**

*Sewage sludge reuse for agriculture*

Most wastewater treatment processes produce a sludge which has to be disposed of. The reuse of sludge on agriculture has beneficial plant nutrients. Sewage sludge also contains pathogenic bacteria, viruses and protozoa along with other parasitic helminthes which can give rise to potential hazards to the health of humans, animals and plants. Thus, sewage sludge will contain, in addition to organic waste material, traces of many pollutants used in our modern society. Some of these substances can be phyto-



toxic and some toxic to humans and/or animals so it is necessary to control the concentrations in the soil of potentially toxic elements and their rate of application to the soil. Apart from those components of concern, sewage sludge also contains useful concentrations of nitrogen, phosphorus and organic matter which makes sewage sludge a valuable resource for agricultural purposes. The availability of the phosphorus content in the year of application is about 50% and is independent of any prior sludge treatment. Nitrogen availability is more dependent on sludge treatment, untreated liquid sludge and dewatered treated sludge releasing nitrogen slowly with the benefits to crops being realized over a relatively long period. Liquid anaerobically-digested sludge has high ammonia-nitrogen content which is readily available to plants and can be of particular benefit to grassland. The organic matter in sludge can improve the water retaining capacity and structure of some soils, especially when applied in the form of dewatered sludge cake.

Other options for sludge re-use include:

- Sewage sludge reuse for biogas production
- Sewage sludge reuse for co-incineration and co-firing
- Biosolids production
- Sewage sludge composting

#### **Short-term projects**

- Planning, design, building and operation of facilities for recycling and treatment of sludge
- Capacity building and legislation

#### **Long term projects**

- Monitoring of sludge quality and environmental risk assessment
- Development of innovative technologies for sludge treatment; technology research and technology transfer

### **3.5 Irrigation**

At world level, agriculture accounts for 70% of the use of water. Usually, water is used in irrigation with very low efficiency. Increasing this efficiency would then free a large amount of water for other uses. On the other hand, present and future needs for feeding a growing population will increase the need for irrigation. Therefore, there is need for improving the existing irrigation systems and plan and design the new ones from the point of view of the efficiency. Doing so a better use of the water in irrigation will be achieved, and there will be a larger amount of water available for urban and other uses.

The water scarcity episodes in the northern Mediterranean countries along with the wide experience of eastern Mediterranean countries have led to a high development of knowledge and expertise about high efficient use of water. It would be possible to combine this knowledge and to apply it to the ongoing and future irrigation projects in other countries in the Mediterranean Region.

#### **Short-term projects**

- Planning, design, building and operation of efficient irrigation systems
- Modernization of existing irrigation systems (conversion from low efficient gravity systems into high efficient pressurized systems)
- Capacity building



#### 4. FINAL CONCLUSIONS AND RECOMMENDATIONS

This document should be an additional step towards the long term Strategy for Water in the Mediterranean (SWM). In this respect, water saving, water scarcity, sanitation and water demand and efficiency of non-conventional water resources are key issues of the SWM regarding climate change.

Scarcity of water resources and needs for protecting the environment and the natural resources are the main factors leading the Mediterranean Countries (MC) to introduce treated wastewater as additional water resources in the national plan of water resource management. Analyzing potential alternatives and needs indicates that there is not a single and easy solution for water scarcity because multiple causes (or stressors) require multiple solutions. Several options need to be applied when considering the existing resources. In particular, for the scenario of climate change, increasing water demand and decreasing resources must be considered. It is necessary to integrate water quality in wastewater reuse and to implement a strategy and policy to promote reuse. The selection of the treatment system must be based on the type of the possible reuse. Cost-benefit analysis should include socio-economic and environmental aspects. Finally, there is also an important need of emphasis on community and end users information, and education programs with pilot areas for any wastewater reuse program to make clear both the advantages and disadvantages.

From this it can be concluded that wastewater systems are generally capital-intensive and require expensive and specialized operators. This aspect gain special importance when new techniques would be applied, for example membrane bioreactors, tertiary chemical oxidation treatments, or ultrafiltration and nanofiltration systems for obtaining high quality reusable water. Therefore, before selecting and researching in a wastewater treatment technology, an analysis of cost effectiveness needs to be made and compared with all conceivable alternatives, taking into account that the use of solar energy in these countries will significantly reduce the operational costs in MC due to their suitability of climate and weather conditions. The selection of technologies should be not only environmentally sustainable, but mainly appropriate to the local conditions, acceptable to the users, and affordable for those who will pay the bill. Capacity building and the monitoring of new infrastructures performance are also issues of concern.

Apart from this considerations, some issues remained insufficiently addressed, which give more work for the future, among them we can find water and energy issues: the interactions between water and energy are numerous and are becoming more and more important within the present energy context. It is important that we develop a better understanding of these interactions in order to improve the sustainability of the global water management.

Key issues to be considered are listed below:

- Working for a culture of water-saving and efficiency is essential. This requires an active public awareness from citizens and economic sectors. Potential savings can be stabilized into the future and these savings extended to domestic and agricultural needs. Developing water savings in irrigation, within general planning for the economical needs of the whole territory, is essential. This policy not just contributes to reduce water stress, but due to the water-energy-climate change nexus it will save energy and reduce the greenhouse gas emissions as well.



- Developing sustainable and resilient economic and legal frameworks is of utmost importance to ensure long-term solutions to the water and sanitation issues. This will open the possibility of developing public-private partnerships and improve the general efficiency of the services associated to the water cycle.
- Strategic asset management of water supply and wastewater infrastructures is of paramount importance in order to achieve a sustainable economic water policy. As a matter of fact, the length of the water distribution pipes that supply water to the 82 million of people living in the Mediterranean coastal cities should be on the order of magnitude 300.000 km with a nominal value 60.000 millions of Euros. And this figure does not include sewer systems and water and wastewater treatment plants. Because all this infrastructure has its own technical life, it is even more important identify and concentrate investment on critical assets than to built news infrastructures.
- Institutional building. While it is out of question that water must be managed in an integrated way, with passing time water competences and responsibilities are becoming atomized and spread between too many water bodies. This is a major problem because decisions are not taken usually in a coordinate way. To model human behavior is by far much more difficult than to model any other complex physical system. Because of that this issue is not easy to handle and politicians tend to skip it. But this is the only key that can open the door to the governance ant then to sustainable water policy.
- Desalination is a current option to obtain water resources that could provide a source of water that could be considered as independent of potential changes in climate. However, energy needs and costs are high, although researchers are developing solar energy desalination plants. Consequently, desalination should not be considered the only option. Spanish companies are already leading the construction of new desalination plants in the Mediterranean countries. In any case, a rational cost – benefit analysis of the different possible solutions will help in the decision making process.
- Reuse of treated sewage waters can be considered as an adequate water source for urban, tourism and agricultural uses. Once the appropriate tertiary treatments for these uses are proved and accepted by the users a further step should be made in the sense that, with a proper treatment, sewage water can even be used, mixed with river or ground water in some cases, for drinking water. There exist several techniques adequate for the improvement of chemical and microbiological quality that could help to provide these uses. In addition, the increasing use of wastewater for irrigation will certainly help to decrease the degree of groundwater exploitation thus avoiding seawater intrusion in the coastal areas. However all the solutions are linked to available energy, this sometimes becomes the critical limitation. Public perception also needs to be improved when this source of water is considered. Several water companies have a wide experience on building up and managing wastewater treatment plants (WWTP) due to the experience acquired during the implementation of the directive 91/271/CE and WFD. It should not be so difficult for Spain to achieve a leadership in this area in a similar way as it occurs in the Mediterranean desalination projects. Other aspects where Spanish water companies will be competitive in the Europe are drinking water supply (due to the implementation of 98/83/EC Drinking water directive) and the management of water infrastructures in general, including water for agriculture.



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Projects for the Future**