Jornades Tècniques: La integració de l'aigua regenerada en la gestió dels recursos
Jornadas Técnicas: La integración del agua regenerada en la gestión de los recursos
Technical Workshop: The integration of reclaimed water in water resource management
Lloret de Mar, Costa Brava, Girona, Octubre 2005

WATER REUSE IN THE NORTHERN MEDITERRANEAN

Marcelo Juanicó[1], Miquel Salgot[2]

[1] Juanicó - Environmental Consultants Ltd.
Israel
E-mail: juanico@juanico.co.il

[2] Institut de l'Aigua de la Universitat de Barcelona
Unitat d'Edafologia, Facultat de Farmàcia
Joan XXIII s/n
08028 Barcelona
E-mail: salgot@ub.edu

INTRODUCTION

Northern Mediterranean countries fulfil all the conditions to perform massive water reuse:

- Water scarcity
- Increasing water demand
- Seasonal water demand
- Large quantities of sewage treated to relatively high standards
- A policy for protection of the environment requiring decreasing discharge of effluents to rivers and sea
- The technological, institutional and financial resources to develop massive water reuse under controlled conditions.

Thus, the potential for reuse of treated wastewater in the region is huge. Most countries are in different stages of developing official policies on the issue, some of them with specific plans for the next decade. Spain and Italy are expected to have the most conspicuous developments at short-term. The adoption of long-waited regulations for reuse in the urban sector will boost urban reuse; thus, agriculture is not expected to be the sole consumer of treated effluents in the future. In-factory water recycling will probably continue to increase in the industrial sector. Groundwater recharge could also become important, especially against seawater intrusion.

Climate

Temperate-rainy winters and hot-dry summers characterize the Northern Mediterranean basin; agriculture, parks, gardens and artificial landscapes require summer irrigation. Precipitations are above 800-1000 mm/y in the Northern areas of European countries while dropping to below 300-500 in the Southern areas of Portugal, Spain, Italy, Greece and Israel. Besides, precipitations have a high annual variation with frequent droughts in the driest areas.

Water resources

Water scarcity is a constraint shared by most countries in the region. Some countries have water resources below the chronic water scarcity level estimated at 1500 m^3/inhabitant.year. Other (e.g. Greece, Turkey, France, Italy and Portugal) have enough water resources at a national level, but long distances and/or topography create serious regional or local problems of water scarcity. Finally, some countries (e.g. Cyprus) seem to have enough water only on theoretical terms while actual exploitation capacity is much lower. Water availability is also threatened by the influx of about 150 million tourists to the Mediterranean coast each summer. The situation will worsen even more in the future due to population growth, further tourism development and increasing living standards. Spain, Malta, Cyprus and Israel have lately lunched massive seawater desalination programs and other countries will probably implement similar plans.

One approach to evaluate water scarcity is the WSI – Water Stress Index: the ratio between the annual water withdrawals and the available renewable water resources. It is supposed that when WSI exceeds 20% water management starts to become stressed: complicated and expensive. According to Fig. 1, half of the Northern Mediterranean countries are suffering water stress at national level (and most of them have specific areas with high WSI).

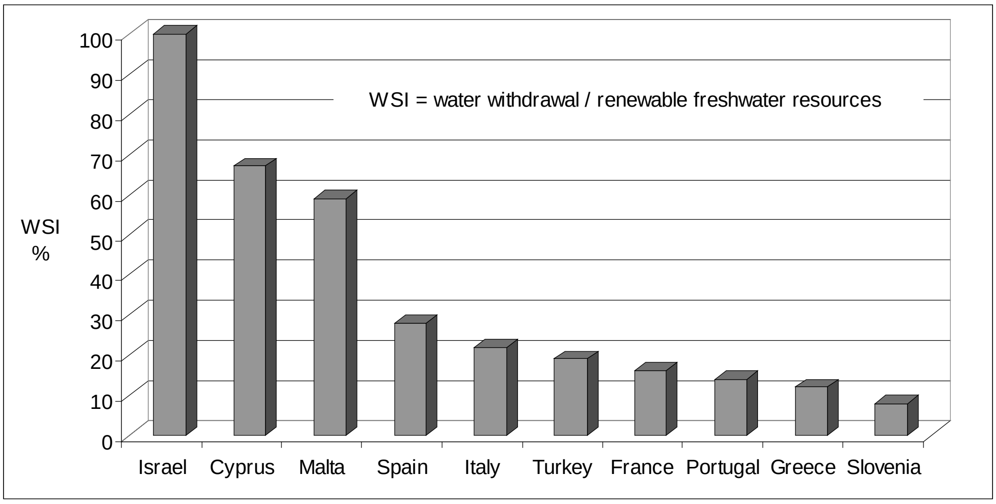

Figure 1. Water stress index at national level in Northern Mediterranean countries (differences within a country may lead to local problems of water stress). A WSI above 20 % points out the need for comprehensive water management efforts. Source: Modified from AQUAREC (2005) plus updates and additions.

Another approach to evaluate water scarcity is to divide renewable water resources by the population. It is supposed that a value of 1500 m^3/inh.year indicates a level of chronic water scarcity. Table 1 indicates that, according to this ratio, at least three countries (Cyprus, Israel and Malta) suffer from chronic water scarcity. Again, the calculations at the national level hide water scarcity problems at specific locations within the countries.

Regulations

Cyprus, Israel and Italy have regulations following the "California school", while Andalusia, Catalonia and Balearic Islands have regulations following the "WHO school". Albania, ex-Yugoslavia countries, Greece, Malta, Portugal, Spain and Turkey have not regulations yet. In Cyprus, Portugal and Spain, regulations are being developed or reviewed. New guidelines for the whole Mediterranean basin have been recently drafted with the aim to overcome the discrepancies between regulations in the region; the draft is presently being discussed. So far, there are no supra-national guidelines on water reuse in Europe.

Table 1. Water resources and reuse in Northern Mediterranean countries.

			Freshwater availability				Wastewater reuse	
			2003		2025 (1994 UN Forecasting)			
Country	Area[a] km^2	Renewable freshwater resources[b] MCM/year	Population, thousands	Availability m^3/inh.year (sorting column)	Population, thousands	Availability m^3/inh.year	2002 ± 3 MCM/year	Amounts planned to reach during next decade MCM/year
Malta	320	30	400	75	420	70	4	9
Israel	20,300	2,000	6,100	330	7,800	260	280	380
Cyprus	9,250	(300?) 900	772	(390?) 1,170	930	(320?) 890	25	30
Italy	300,000	85,000	57,000	1,500	52,000	1,600	45	250
Level of chronic scarcity				1,500				
Spain	500,000	111,000	40,220	2,760	37,570	3,500	(?) 300	1,200
Turkey	771,000	203,000 110,000 feasible	68,110	2,980 1,740 feasible	90,900	1,910	50	no data found
France	544,000	150,000	44,800	3,300	45,000	3,300	negligible	no plans set
Albania	27,400	21,000	3,580	5,870	4,670	3,990	6-7	no plans set
Greece	131,000	69,000	10,670	6,470	9,970	6,970	> 10	> 15
Portugal	92,000	66,000	10,100	6,530	9,680	7,220	not clear	> 20
ExYugosl.[c]	255,000	265,000	22,470	11,800	24,600	10,840	negligible	no plans set
Total	**2,320,400**	**884,000**	**199,950**		**222,390**		**> 700**	**~ 2,000**

(a) Land area: does not include territorial sea waters
(b) MCM: million cubic meters. It does not include seawater desalination or water imports
(c) No specific data available yet on the new countries formed from Ex – Yugoslavia

WASTEWATER REUSE PRACTICE

Today

In most Northern Mediterranean countries, 70 - 80% of water demand goes to agricultural and landscape irrigation. Thus, wastewater agricultural irrigation became a common practice even without appropriate treatment. With the exception of Albania and Ex-Yugoslavia countries, wastewater is reused at different extents all over the region. However, only Cyprus and Israel have developed an official policy defining treated wastewater as an integral part of their water resources. Much effort has been made in reporting large projects above 5 MCM/year, but there exist thousands of unreported small projects below 0.1 MCM/y (many of them artisanal) generating an important social, economical and environmental and health impact. Urban and golf courses irrigation is also an increasing practice. Industrial in-factory water recycle is growing due to increasing costs for supplied water and wastewater treatment; some industrial parks have reduced their water consumption to a half during the last decade.

Future perspectives

The potential for reuse of treated wastewater in the region is huge. Most countries are in different stages of developing official policies on the issue, some of them with specific plans for the next decade. Spain and Italy are expected to have the most conspicuous developments at short-term. The adoption of long-waited regulations for urban reuse will boost the reuse of treated wastewater in this sector; thus, agriculture is not expected to be the almost sole consumer of treated effluents in the future.

However, wastewater reuse implementation is facing obstacles and delays mainly due to lack of clear policies defining treated wastewater as part of the water resources of the countries, legal and institutional frameworks for the implementation of reuse projects, proper training to farmers and information to public, and multi-national standards. A problem observed in some countries (e.g., France, Italy and Spain) is that while water scarcity and potential for water reuse are much more conspicuous in the Southern areas of the countries (e.g., Provence, Sicilia, Andalusia) the water reuse policy and regulations are developed, approved and controlled by a central administration located far away (Paris, Rome, Madrid) and generally disconnected from the scenarios where the policy and regulations will apply.

Water stress in the Northern Mediterranean imposes a whole family of innovations in the water sector. Water reuse is only one of the elements of this family:

- Maximum exploitation of conventional water resources
- Strict water saving policy and practice
- In-factory water recycling
- Exploitation of non-conventional water resources: e.g., brackish and fossil waters
- Full integration of treated effluents to the water resources
- Desalination of sea and brackish water
- Allocation of water resources for the recovery and preservation of natural aquatic habitats: rivers, lakes, wetlands, etc.

The lack of coordination between the different agencies that traditionally regulate the water sector is a common problem, both vertically (different stages of the water cycle) and horizontally (health, agriculture, industry, municipalities, environment, etc.). It seems that the old structure of the water sector is not made to match the challenges of the sophisticated management required by the above quoted family of innovations.

COUNTRY INFORMATION

Italy

Water reuse in Italy has been recently reviewed by Barbagallo et al. (in press). The herein presented summary is based on that work by the Italian colleagues.

Water resources

Although water resources are large in theory, the usable amount of water is estimated to be limited to 85,000 MCM/y while existing infrastructure allows the use of only 55,000 MCM/y (Barbagallo et al., op. cit.). This figure locates Italy as a whole in the limit of chronic water scarcity: 1500 m^3/inh.year. Precipitations are evenly distributed in space and according to population (Table 2) but Southern Italy and main Islands suffer much serious water scarcity due to their warmer and drier climate, unevenly distribution of the precipitations during the year (short rainy winters) and frequent droughts.

Table 2. Distribution of area, population, precipitations and water resources in Italy (data from Barbagallo *et al.*, *op. cit.*)

Region	Area	Population	Precipitations	Usable water resources
North	40 %	45 %	40 %	53 %
Central	24 %	22 %	24 %	40 %
South	19 %	22 %	24 %	
Main Islands	17 %	11 %	12 %	7 %

Table 3. Quality requirements for wastewater irrigation in Italy, approved in 2003.

Parameter	Standard	Parameter	Standard
pH	6.0 ÷ 9.5	Vanadium [mg V/l]	0.1
SAR	10.0	Zinc [mg Zn/l]	0.5
Coarse solids	absent	Cyanides [mg CN/l]	0.05
TSS [mg/l]	10.0	Sulphides [mg H_2S/l]	0.5
BOD_5 [mg/l]	20.0	Sulphites [mg SO_3/l]	0.5
COD [mg/l]	100.0	Sulphates [mg SO_4/l]	500
Phosphorus [mg P/l] (total)	2.0	Chlorine residual [mg/l]	0.2
Total Nitrogen [mg N/l]	15.0	Chlorides [mg Cl/l]	250
Ammonia [mg NH_4/l]	2.0	Fluorides [mg F/l]	1.5
EC_W [µS/cm]	3,000	Oils & fats [mg/l]	10.0
Aluminium [mg Al/l]	1.0	Mineral oils [mg/l]	0.05
Arsenic [mg As/l]	0.02	Phenols [mg/l] (total)	0,1
Barium [mg Ba/l]	10.0	Pentachlorophenol [mg/l]	0.003
Boron [mg B/l]	1.0	Aldehydes [mg/l] (total)	0.5
Cadmium [mg Cd/l]	0.005	Tetra/tricloro-ethylene [mg/l]	0.01
Cobalt [mg Co/l]	0.05	Chlorinated solvents [mg/l]	0.04
Chromium [mg Cr/l] (total)	0.1	TTHM [mg/l]	0.03
Chrom. hexavalent [mg Cr/l)	0.005	Aromatic solvents [mg/l]	0.001
Iron [mg Fe/l]	2.0	Benzene [mg/l]	0.01
Manganese [mg Mn/l]	0.2	Benzo(a)pyrene [mg/l]	0.00001
Mercury [mg Hg/l]	0.001	Org. N solvents [mg/l]	0.01
Nickel [mg Ni/l]	0.2	Surfactants [mg/l] (total)	0.5
Lead [mg Pb/l]	0.1	Chlorinated biocides [mg/l]	0.0001
Copper [mg Cu/l]	1.0	Phosphorated pesticides [mg/l]	0.00001^
Selenium [mg Se/l]	0.01	Other pesticides [mg/l] (total)	0.05
Tin [mg Sn/l]	3.0	*E. coli* [UFC /100/ ml] (80% of samples)	10
		Constructed wetlands	*50*
		Stabilisation ponds	*100*
Thallium [mg Tl/l]	0.001	*Salmonellae* [UFC /100 ml]	absent

Management of water resources

Water resources are public property and regulated by the state that owns most water distribution systems. Water for agricultural irrigation is usually not metered and farmers pay water according to the irrigated surface (e.g. 100 €/ha.year in Consorzio Villoresi – Northern Italy). It is planned that treated effluents for irrigation will be metered and paid by m^3. The water sector was fragmented into thousands of different poorly coordinated agencies causing inadequacy, inefficiency and high costs. The "Galli" law of 1994 "erased" the municipal limits and unified the fragmented water sector into Optimum Territorial Areas, but this reform is still being implemented.

Table 4. Main reuse projects in Italy (data from Barbagallo *et al.* ,*op. cit.*) .

Place	Project
Valle d'Aosta	In construction. Landscape irrigation and fire protection. 150,000 hab. equivalent
Alto Adige	Planned. 2,500 hab. equivalent
Friuli-Venezia	In construction. Industrial reuse.
Lombardia	In construction. Industrial reuse.
Veneto	Planned. Industrial reuse: 50,000 m^3/d Irrigation: 6000 m^3/d
Basso Rubicone Emilia-Romagna	Running. Orchads irrigation (400 ha)
Toscana, Prato	Running. Industrial reuse. 15,000 m^3/d
Toscana, Piombino	Running. Industrial reuse. 10,000 m^3/d
Toscana, Pistoia	Pilot. Irrigation.
Campania, Sarno	Planned. Irrigation.
Puglia	Starting by 2004-2005 ?. Irrigation. 250,000 m^3/d
Sicilia, Grammichele	Running. Citrus irrigation. 1,550 m^3/d.
Sicilia, San Michele	Running. Olive trees irrigation. 1000 m^3/d
Sicilia, Palermo and Gela	In construction. Irrigation. 30,000 m^3/d
Sicilia, Catania	Feasibility. Irrigation. 110,000 m^3/d
Sardegna, Is Arenas	Running. Irrigation. 95,000 m^3/d
Sardegna, Villasimius	In construction. Irrigation. 3000 m^3/d

Sewage treatment

Most existing sewage treatment plants are based on activated sludge, but some new ones are based on submerged aerobic filters. About 10-15% of the existing plants perform "tertiary" treatment: i.e., nutrient removal, according to EU urban wastewater Directive. About 80% of the treatment plants discharge to rivers and 3-4% to sea and lakes. The remaining wastewater is discharged to undefined places (that may include reuse).

Regulations

A new set of standards for water reuse in irrigation was promulgated in June 12th, 2003 (Ministry Decree, D.M. n. 185/03) (Table 3). Barbagallo et al. (op. cit.) criticize the standard noting that it addresses 54 parameters, 11 of them with the same values required by the drinking water standard, 20 of them not addressed by the drinking water standard, "and some other parameters (for instance biocides and pesticides) are difficult to be explained in an agricultural environment".

Table 5. Representative reuse projects for irrigation in southern Italy (1998 survey, data taken from Barbagallo *et al.*, *op. cit.*). C: citrus trees; Ch: cherry trees; Fr: fruit orchards; F: fodder; G: greenhouses; O: olive trees; P: pasture; V: vineyards; Vg: vegetables.

Region	Site	Wastewater [MCM / y]	Irrigable area (Ha)	Main crops	Construction cost (10^3 €)
SICILIA	Caltagirone	2.5	500	C	1,945
	Catania	47.9	9,600	C	3,113
	Enna	1.5	290	O V	0,840
	Mineo	0.5	100	C O	1,421
	S.M. di Ganzaria	0.3	150	O	930
	Vittoria	6.1	1,500	C G	5,188
SARDEGNA	Dorgali	0.57	162	V O	1,348
	Rio Posada	0.66	270	F V	4,791
	Sassari	29.1	7,000	Various	16,006
	Tortoli	9.5	2,000	Various	2,971
PUGLIA	Conversano	2	477	O Fr	13,489
	Lecce	11.1	2,450	W P	20,753
	Martina Franca	5.8	2,086	O Ch F V Vg	10,579
	Putignano	3.9	1,000	O Ch F	8,892
	Tricase	2.2	300	Fr P	4,929

France

Water resources

Waste resources are estimated as 3,300 m^3/capita.yr (World Resources 2000-2001) well above the stress level. Nevertheless, during the last ten years there has been a 20 % increase in water demand (mainly for agriculture and resort areas) coupled with a series of drought years. In more than one-third of the country, water tables are falling as the autumn and winter rains are no longer making up for the amounts drawn off in spring and summer, situation that forced authorities to impose restrictions to water use (Angelakis et al., 2000; US-EPA, 2004).

Sewage treatment

France treats about 4000 MCM of sewage per year. There are more than 10 MBR projects where industrial wastewater is treated for reuse (Angelakis et al., 2005). Disinfection is accomplished either by chlorine or UV, with a current trend towards UV. Several research projects and demonstration studies are underway addressing treatment technologies, water quality, and integrated water management. These studies include research on pharmaceuticals and personal care products in reclaimed water used for potable purposes, cost-effective technologies for agricultural reuse, MBR treatment, sustainable water management, and desalination of groundwater (Crook et al., 2005).

Regulations

The country's regulatory framework (Circular n° 51 of July 22, 1991, of the Ministry of Health) is based on the WHO guidelines (1989), but it is more stringent having additional requirements concerning irrigation management, timing, distance and other measures for preventing health risks related to human exposure and negative environmental impacts. For example, in the case of spray irrigation, a 100 m distance must be respected beyond the reach of the spraying system for residences, sport and leisure areas and motorway toll gates. In addition, to the above microbiological standards the document requires: (a) guarantees that the aquifer will not be contaminated; (b) knowledge of the treated wastewater effluent quality and fertilising capacity; (c) trained operation and control personnel (Lazarova et al., 2000, US-EPA, 2004).

A government decree of 1994 provides the basis for water reuse rules in France. First, it clearly states that treated effluents can be used for agricultural purposes only if this is conducted without any risk for the environment or the public. Second, wastewater treatment requirements, irrigation modalities, and monitoring programs must be defined according to recommendations from the Conseil Supérieur d' Hygiene Publique de France(CSHPF), and the Interministerial Water Mission through ordinance of the Ministry of Health, the Ministry of Environment, and the Ministry of Agriculture. Third, the approval of a wastewater reuse project still depends on the approval of the local representative of the Ministry of Health (Lazarova et al., 2000).

These rules and regulations should allow wastewater reuse projects to become part of France water resource management policy. Yet, local French sanitary authorities impose very strict controls on wastewater reuse projects. The water quality required for these projects is often more stringent than the required by the regulations approved by the CSHPF, and even more stringent than California Title 22 in the case of some urban applications (grey water recycling, for example). In addition, the heavy administrative procedures required for the approval of any water reuse project has slowed down the emergence of water reuse in France (Lazarova et al., 2000).

New water reuse guidelines are under preparation. They may introduce some new parameters for unrestricted irrigation (i.e., *Salmonella*, *Taenia* eggs and viruses).

Reuse practice

France has irrigated crops with wastewater for more than a century, in particular around Paris. Until 1940, it was the only method of treating and disposing wastewater of the Greater Paris conurbation. This practice is still going on in the Achères region, where some of the wastewater is used after screening and settling, but is likely to be discontinued soon.

Interest in water reuse rose again in the early 1990s for several reasons:

- The development of intensive irrigated farming (such as maize), in particular South-western France and the Paris region
- The fall of water tables after several recent severe droughts which have paradoxically affected the regions traditionally considered to be the wettest (Western and North-western France)
- Pollution control in recreational and shellfish farming areas along the Atlantic coast
- Industrial in-factory reuse by MBR technology allow for less water consumption and effluent discharge (more than 10 projects in France)

Potable unplanned indirect reuse is common in France, where surface water diluted with wastewater is used for potable supply. An example is Aubergenville, in the Paris region, where the Seine River, which is 25 percent wastewater effluent, is treated and used to recharge the drinking water aquifer.

Presently, there are at least 30 water reuse projects in France, half of which use reclaimed water for agricultural irrigation covering more than 3000 ha; the other 15 projects use reclaimed water for golf courses and urban area irrigation (Angelakis et al., 2003, 2005, US-EPA, 2004).

The Clermont-Ferrand recycling scheme implemented in 1999, where 10,000 m^3/d of effluents treated by activated sludge followed by maturation ponds, are used for irrigation of over 700 ha of maize, is today considered to be one of the largest projects in Europe.

One of the first examples in France of integrated water management with water reuse is on Noirmoutier Island. The lack of water resources, the 10-fold increase in tourist population during the summer and the intensive agricultural activities required water reuse. Wastewater treatment on the island is achieved through two treatment plants with a total capacity of 6,100 m3/d. The plants have activated sludge systems followed by maturation ponds for storage and disinfection. Thirty percent of the treated wastewater (0.33 MCM/yr) is used for the irrigation of 500 ha of vegetable crops. There are plans to reuse 100 percent of the wastewater flow in the near future (US-EPA, 2004).

Spain

Spain can be divided into humid and arid areas. The humid Atlantic basins do not have water scarcity problems, while the Mediterranean basins, mainly arid or semiarid, are suffering structural or occasional water scarcity. The main archipelagos (Balearic and Canary islands) also suffer from water scarcity.

In the Mediterranean basins, periodic droughts or excess demand are unbalancing the water distribution among agriculture, industry, ecology, recreational activities and urban needs. Because the development of the country has been linked in an important extent to tourism activities, including different aspects as mass and golf tourism, water demands increased accordingly. Peak demands for agriculture, tourism and leisure coincide with the dry season, the summertime, when a strong pressure is exerted on existing resources. The problem has been managed until now by overexploiting groundwater resources or fully diverting surface waters. Several water transport infrastructures have been created, increasing water holding capacity through dams or reallocating resources diverting rivers into neighbouring basins.

Nevertheless, such solutions reached a limit during the nineties, because of the lack of resources to be diverted, increasing demands (resident population increase, tourism, agriculture, and industry), heavy droughts and bad distribution systems. Several islands needed to develop new resources desalting sea and brackish water using RO or EDR. Numerous attempts of developing a National Hydrologic Plan did not succeed and at present, some solutions based on river flows diversion, which include national rivers and the extension of the Rhône river water carrier from Montpellier (France) to Barcelona, have been discarded while an increase of seawater desalination, reclaimed water reuse and other minor issues are under consideration and planning.

Planned wastewater recycling and reuse is now being publicized as being part of the possible solutions, although the translation into the common practice is still not applied. Unplanned reuse used to be a classical solution for arid and semi-arid areas all around the Spanish Mediterranean coastline. There are several causes for this illegal practice. Perhaps, one of the most important is the lack of reuse regulation at state level. In Spain, the Government issued fourteen years ago one Law and one Decree where wastewater reuse was indicated as a possibility and a minimal statement appeared, indicating the need for an administrative concession and a compulsory report of the Health Authorities. An indication was made that further legal developments would be needed.

Raw sewage has been used for agricultural irrigation, but the efforts to develop wastewater treatment according to EU rules are reducing the amount of available raw sewage and increasing the amount of treated wastewater to be disposed off. Many rivers in the Mediterranean coastline have no running water during the summer due to the lack of rain during these months, except treated or untreated wastewater. If wastewater is reclaimed and reused, some of the rivers will become dry. This circumstance is leading the “Ecologist” (Greens) movements to ask for wastewater not being diverted. This will lead to problems when trying to reuse wastewater in the inner parts of the country. Conversely, the major opinion is that wastewater reuse all along the coastlines is a good solution and needs to be promoted (Salgot, 2002).

Spain is presently reusing about 300 million m^3/y of wastewater. The main approved uses are agriculture and golf courses irrigation, and secondarily groundwater recharge and industrial reuse. There is also a strong pressure for discharging treated wastewater into rivers, but after advanced treatment in order to improve running water quality. Recycling systems are today relying on tertiary classical technologies (coagulation-filtration plus disinfection) and extensive natural technologies (wetlands, lagooning and infiltration-percolation). Mostly used disinfection technologies are UV and chlorination. The areas where recycling and reuse are most operative at present are Balearic Islands (golf courses, urban parks and groundwater recharge), Canary Islands (golf courses and agriculture) and the entire Mediterranean coastline (agriculture, golf courses and leisure activities other than golf) and Vitoria in the Basque country where municipal wastewater is reclaimed and reused for agricultural purposes.

The water suppliers become increasingly concerned with the business opportunity that the reclamation and reuse of wastewater is opening. Several companies and administrations support research and development (R&D) activities in collaboration with the Universities, and a number of experimental recycling facilities are already operative. AEAS (the Spanish chapter of EUREAU, the association of water and wastewater treatment companies) is also supporting innovation on theoretical and control tools to improve reclaimed water quality. University research groups on wastewater reuse are spread all around the Mediterranean basin and are mainly working on wastewater tertiary treatments (advanced treatments in Catalonia, natural treatments in Andalusia, Catalonia, Murcia, and Valencia) and rules and regulations in Catalonia and Andalusia.

There is a bright future for wastewater reuse in Spain, but at present it is compromised owing to the fact that while new projects are proposed, a lot of difficulties arise due to the lack of a more complete legal definition. In Spain there is a strong tendency to decentralize the Administration and give more power to the “Autonomous Governments” (Regional Governments). The decisions and permissions for wastewater reuse are given now in a case per case basis, depending on the Regional Administrations.

Since it is difficult to get such approvals without having definite legal health regulations, several Regional Health Authorities have decided to develop their own guidelines for wastewater reuse for irrigation. By 2005, three guidelines (Balearic Islands, Catalonia, and Andalusia) are operative. Draft guidelines for the Spanish national regulation were proposed in 1996, taking an approach more similar to the California standards than to the WHO guidelines. However, this draft was never approved and the present trend is not to adapt the Californian criteria (Salgot, 2002). So far, a new "White Book" on water was prepared and published in 1998, incorporating wastewater reuse into the recognized available water resources. On that basis, a group of experts jointed by the Ministry of Environment elaborated a proposal of minimal criteria (physical-chemical and microbiological) for wastewater reuse, criteria that follow the WHO guidelines (Angelakis et al., 2001). It was submitted to the Government for approval. By 2005 this minimal criteria have not been approved yet and a revision was undertaken to adapt the draft to new findings in wastewater reclamation and reuse. The main present idea is to define 5 water qualities for different uses.

Israel

Israel is one of the countries with most intensive water reuse (Juanicó, *in press*)

Israel has performed massive reuse of effluents for agricultural irrigation since the early seventies and is presently reusing almost 75% of all the sewage produced in the country. It is using all of its conventional water resources and water shortage is a chronic problem. Sewage is defined by law as an integral part of the water resources of the country.

The numerous reuse projects in the country are not similar, with differences in size, technology, irrigated crops, etc. This diversity is positive.

Part of the success of the wastewater reuse practice in Israel is due to the capacity of the well organized and informed farmers to adapt quickly to the switch from water to wastewater.

Early regulations adopted an approach of “different qualities for different crops” with single poor level of environmental protection. Recently approved (2005) new regulations switch to a single high standard for “unrestricted irrigation” and address sustainable environmental protection.

Salination is one of the sustainability related problems of long-term massive water reuse. The country has implemented several measures to reduce the concentration of salts and Boron in municipal sewage.

Cyprus

Cyprus has developed an official policy defining treated wastewater as an integral part of their water resources.

Water resources

The average annual precipitation, including snowfall, amounts to approximately 500 mm, but during the past thirty years (1973-2003) this amount was reduced to 480 mm (Cyprus Water Development Program, 2005).

Precipitation increases from the south-western windward slopes to the top of the central massif, from less than 450 mm to nearly 1100 mm. On the leeward slopes precipitations decrease to 300 - 350 mm. The potential annual water resources have been estimated in 900 MCM, of which 600 MCM are surface water and 300 MCM are groundwater. However, the water amounts that are presently available are less than 300 MCM per year (MEDAWARE, 2004; Cyprus Water Development Program, 2005).

Cyprus has no rivers with perennial flow while rainfall is highly variable and droughts occur frequently. Since groundwater is reliable, clean and most importantly cheap, water resources development in Cyprus initially focused on groundwater, and until 1970 groundwater was the main source of water for both drinking and irrigation purposes. As a result almost all aquifers were seriously depleted because of overpumping and seawater intrusion was observed in most of the coastal aquifers. At the same time large quantities of surface water were lost to the sea.

Table 6. Annual Demand by Sector for the Year 2000**.**

Demand Sector	MCM	Percentage, %
Agriculture	182,4	69
Domestic	67,5	25
Industry	3,5	1
Environment	12,5	5
TOTAL	265,9	100

Source: MEDAWARE (2004)

In order to face the situation, desalination units have been constructed since 1997 aiming at rendering the water supply of the major residential and tourist centres independent of rainfall. Desalination units at present contribute up to 33.5 MCM per year. Water restrictions finished by 2001 (MEDAWARE, 2004; Cyprus Water Development Program, 2005).

Reuse of treated sewage effluent amounts for only about 3 MCM, from which 2 MCM for agriculture and the rest for landscape irrigation (MEDAWARE, 2004)

Management of water resources

All water resources including wastewater belong to the state, but the laws give the right to private individuals to construct wells for ground water abstraction after getting a permit from the District Officer. The Laws also give the right to individuals to form Irrigation Divisions or Associations to construct irrigation works, and to villages and towns to form their own Commissions for constructing their own waterworks for domestic supply, and their own sewage and drainage Boards for the collection, treatment and disposal of sewage effluents. Presently, about 60 % of the annual amount of water for irrigation purposes is provided from Government Irrigation Schemes and the sources of irrigation water are surface water, groundwater and reclaimed water. The water demand in the non-Government schemes is satisfied mainly by groundwater.

The Laws, except in the cases of Irrigation Divisions, Association, Commission and Sewage Boards, do not mention the administrative authority which keeps the water resources inventory, or evaluates, or allocates and controls the use of water. This seems to be a basic setback of the water legislation (MEDAWARE, 2004).

There are three main institutions involved in the production, treatment and reuse of wastewater. The Water Development Department, which is responsible for the implementation of water policy, is responsible of tertiary treatment as well as allocation and distribution to the farm level. The Department of Agriculture is responsible for the training of farmers in all matters related to agricultural production with the use of treated wastewater. It has also the mandate of monitoring the code of practice at farm level. The sewerage boards have the responsibility of operation and maintenance of the main sewer systems (pipes, pumping stations and treatment plants) (Bazza, 2003).

Sewage treatment

The number of Sewage Treatment Plants currently (STPs) in operation is around 30 with a total capacity of about 20 MCM/year (Table 6). These STPs cover the four major greater urban areas and some large tourist centers (Lefkosia, Lemesos, Larnaka, Pafos and Agia Napa – Paralimni) and part of the rural areas. Centralized sewage networks now serve 12% of the rural population. There is also a large number of small STPs in the hotels. In addition there exists a programme for building such units in 28 large rural centers (having a population of more than 2000) and in sensitive mountain villages by the year 2012. This is in accord with the instructions/principles of the Urban Wastewater Directive 91/271/EEC of the European Union (EU). It is worth noting that all plants have provisions for tertiary treatment (MEDAWARE, 2004).

Regulations

Cyprus regulations regarding wastewater quality for irrigation follow the California school although with some small differences. De facto, most sewage treatment plants are using intensive processes with tertiary treatment.

Table 7. Sewage Effluent Treatment Plants

Name	WW Produced m^3/year	Treatment	Use
Lefkosia Sewage Board	3,650,000	Secondary	Diverted to Pedieos River
Anthoupolis-Lefcosia	127,750 (max 2.56 million)	Secondary	Stored in open Reserv. for evaporation
Larnaca Sewage Board	912500	Tertiary	Landscape Irrigation
Agia Napa – Paralimini	2,500,000	Tertiary	Landscape-Forest
Lemesos Sewage Board	3,000,000	Tertiary	Agriculture-Landscape of Hotels
Pafos Sewage Board	4,895,000	Tertiary	Agriculture
Bathia Gonia	803,000	Tertiary	Agriculture
Dhali-Nisou	182,500	Tertiary	Agriculture
Platres	73,000	Tertiary	Not operating-Agriculture
Carlsberg	146,000	Tertiary	Agriculture
Lefkosia New Hospital	182,500	Tertiary	Not operating-Landscape
Lemesos Hospital	47,450	Tertiary	Landscape
Alassa (new site village)	18,250	Tertiary	Agriculture
Palechori	73,000	Tertiary	Diverted to the River
Apostolos Loucas	25,550	Secondary	Used by The Agr. Res. Instit.
Kofinou	65,700	Secondary	Agriculture
Zenon-Kamares II	109,500	Secondary	Landscape irrigation
Agglisides	365,000	Secondary	Agriculture
Kornos	25,550	Tertiary	Landscape Irrigation
Stavrovouni	25,550	Tertiary	Landscape Irrigation
Agios Ioannis	17,900	Tertiary	Landscape Irrigation
Malounda	7,300	Tertiary	Landscape Irrigation
Klirou	26,300	Tertiary	Landscape Irrigation
Kyperounda	109,500	Tertiary	Agriculture
Troodos	8,800	?	Landscape
TOTAL Maximum	**19,829,850**		

Source: MEDAWARE (2004)

Reuse practice

Recycled domestic water is presently used for the watering of football fields, parks, hotel gardens, landscape, road islands and forestation (1,5 MCM/yr) and for agricultural irrigation, mainly permanent crops (Citrus Olives Vines) and fodder (3,5 MCM/yr). It is estimated that by the year 2012 an amount of approx. 30 MCM of treated sewage effluent will be available for agriculture and landscape irrigation. MEDAWARE (2004)

Cyprus is facing two major obstacles in its continued development: 1) a growing scarcity of water resources in the semi-arid regions of the country and, 2) degradation of water at its beaches. The government has recognized that a water reuse program would address both problems. In addition, it is expected that reclaimed water will provide a reliable alternative resource for irrigation, which draws about 80 percent of the total water demand. The government has recently launched a program of implementation of new sewerage, wastewater treatment and reuse of treated wastewater in two major tourist areas; Limassol in the southern coast and Larnaca and Ayia Napa-Paralimni in the southeastern coast. It is expected that with the completion of these and other central collection and treatment plants in the cities and villages by the year 2012, the volume of treated wastewater will reach 25-30 MCM per year. The reclaimed water will be collected and used for irrigation after tertiary treatment. Since transmission costs will be high, most of the reclaimed water (about 55-60 percent) will most likely be used for urban and tourist resorts irrigation. A reclaimed water supply of about 10 MCM/day is conservatively estimated to be available for agricultural irrigation (Bazza, 2003; US-EPA, 2004).

Treatment plants in villages are considered as a basic instrument for agricultural, social and environmental policy of the country. The government covers 75-100 % of the cost of construction and operation of tertiary treatment plants, as well as the cost of treated wastewater distribution to farmers (Bazza, 2003)

Saline soils in Cyprus are limited. However secondary salinization due to the use of semisaline water for irrigation is common particularly under greenhouse production. To overcome the problem leaching is practiced during the growing season and more substantial leaching before planting (MEDAWARE, 2004).

Turkey

All the information on Turkey has been summarized from MEDAWARE (2004).

Water resources and demand

Although Turkey is situated in a large Mediterranean geographical location where climatic conditions are quite temperate, the diverse nature of landscape and in particular the existence of the mountains that run parallel to the coasts result in drastic regional differences in climatic conditions. While the coastal areas bear relatively mild climates, the inland Anatolian plateau has a continental climate with hot, dry summers and long lasting, cold winters with limited rainfall.

The average annual precipitation is 643 mm. Annual precipitation in the Aegean and Mediterranean coasts varies from 580 to 1300 mm, depending on location. The Black Sea coast receives the highest amount of rainfall (up to 2200 mm) and its eastern part is the only region of Turkey that receives rainfall throughout the whole year. The central dry area has precipitations of less than 400 mm per year.

Nominal renewable water resources have been estimated in 200,000 – 230,000 MCM per year, but the technically and economically usable surface and ground water potential would be limited to 110,000 MCM.

Present population is 78 million inhabitants and total annual water withdrawal is 42,000 MCM for the whole country (2000 data). Turkey has enough water at the national level, but the large territory and irregular distribution of rains in space and during the year create numerous problems of local water scarcity.

Table 8. Water demand in Turkey by sectors.

Year	Demand (10^6 m^3)	Sectoral Consumption		
		Domestic (MCM)	Irrigation (MCM)	Industrial (MCM)
1990	30.600	5.141	22.016	3.443
1992	31.600	5.195	22.939	3.466
1995	33.500	5.300	24.700	3.500
2000	42.000	6.400	31.500	4.100
2002	38.900	5.700	29.200	4.000

The SHW (General Directorate of State Hydraulic Works) has constructed a total area of 2,296,350 ha for irrigation, of which 10 % is operated by SHW himself and 70% by other end-user organizations (irrigation associations, village authorities, municipalities, etc.). The remaining 20% is not actually operational due to different problems.

Sewage treatment

Till late 1990’s, the National Bank of Provinces has been in charge of funding wastewater treatment plants within the framework of annual investment programmes according to instructions of the related municipalities. Those constructed plants were then transferred to the municipalities for operation. However, nowadays many associations (such as Greater Metropolitan Municipalities, Water and Sewerage Administrations, The Ministry of Tourism, Southeast Anatolian Project (SAP) Administration, The General Directorate of Special Protection Areas, and General Directorate of Massive Housing) deal with the investment of wastewater treatment plants. The Greater Metropolitan Municipalities especially those with high urban populations prefer to solve their wastewater treatment problems by utilizing foreign credits and by managing the investment period.

Between the years 1970-1980, 11 wastewater treatments plants were installed and operated by the Bank of Provinces (BoP). This number increased in the following years: 60 plants in 1980-1990, 82 plants till the end of 1998, and 118 plants till the end of 2001.

By 2001, a total number of 118 wastewater treatment plants were in operation with a total annual capacity of 2,550 MCM, but the actual amount of treated effluents was only 1,245 MCM which accounts to 50% of the total treatment capacity. 38% (468 MCM) of the treated effluents receive physical treatment, whereas 50% (618 MCM) receive biological treatment and 12% (159 MCM) advanced treatment.

The most common wastewater treatment type is the extended aeration of activated sludge system. Package units are popular in villages with a population < 1000. Secondary effluents are usually disinfected by the addition of chlorine.

Regulations

Turkey has not yet approved regulations on water reuse.

Reuse practice

Irrigation with wastewater has been estimated in 50 MCM/y in 2000. But the country has not a reuse policy and agricultural irrigation with wastewater is not conducted offically.

Wastewater agricultural irrigation is widely spread in South East Anatolia, mainly for the irrigation of vegetables. For example, in Siverek, located in South East Anatolia, domestic wastewater discharged into streams is being reused for agricultural applications on cotton, wheat and various vegetables including eggplants, peppers, tomatos, cabbage, carrots and spinach. The total area irrigated with wastewater is 165 ha and the consumption of irrigation water was 1.9 MCM in 2001.

Tourist villages and resorts, especially those along the Aegean and the Mediterranean coasts of the country, are building their own treatment facilities. Shortage of water resources and increased water demand by tourism in summer months forced these tourism centres to reuse their effluents. The major form of reuse is irrigation of gardens and parks.

Because of insufficient sewerage facilities and lack of satisfactory treatment, an enormous amount of domestic wastewater has been discharged into rivers. These discharged wastewater is indirectly used for irrigation. For example, in Trakya, located in North-West Anatolia, 1 560,620 m^3 per year of domestic wastewater are discharged into the river Evros and 9,000 ha of agricultural area are irrigated with water extracted from the polluted river.

Greece

Water resources

Greece has a population of about 11 million inhabitants and renewable freshwater resources are evaluated in about 70,000 MCM per year. Thus, water resources are abundant at the national level and the water stress index is very low. However, Greek geography is "complicated" with hundreds of islands, isolated peninsulas and valleys separated by a mountainous topography. Water scarcity at the local level is a common problem in numerous places within the country.

Water demand has conspicuously increased during the last 50 years due to development, increase in living standards and massive tourism.

Sewage treatment

About 65% of the population is connected to 350 centralised WWTP with a total capacity of over 1.45 MCM per day (~ 530 MCM per year) (Kamizoulis, 2003).

Regulations

No guidelines or criteria for wastewater reclamation and reuse have been yet adopted. A preliminary study is underway on the need for criteria for the reuse of treated wastewater. In this study, six basic categories of reuse (non-potable urban, agriculture, aquaculture industrial, environmental, and groundwater recharge) are considered (Angelakis et al., 2000; Kamizoulis, 2003).

Reuse practice

More than 80% of the treated effluents in Greece are produced in regions with deficient water balance. Thus, wastewater reuse in these areas would satisfy a real water demand. The distribution of treated domestic wastewater effluents in deficient water balance regions, as a function of the average distance from the agricultural land which is available for irrigation, have been analyzed: about 90% of the treated effluents are discharged from WWTP's which are located at a distance of less than 5 km from the available farmland. Therefore, the additional cost for transport to the irrigation fields is low Angelakis et al. (2000).

Presently, only few small reuse projects are actually running, most of them at a pilot level, but over 15 wastewater treatment plants are planning to reuse their effluents for agricultural irrigation. The major ones are listed in Table 9 (Kamizoulis et al., 2003).

Industrial reuse is negligible.

Table 9. WWTPs planning reuse in Greece (from Kamizoulis *et al.*, 2003).

Plant Name	**Flow m3/day**	**Uses**
Levadia	3,500	Irrigation of cotton
Amfisa	400	Olive tree irrigation
Palecastro	280	Storage, olive tree Irrigation
Chalkida	13,000	Landscape and Forestry irrigation
Karistos	1,450	Landscape and Forestry irrigation
Ierisos	1,200	Landscape and Forestry irrigation
Agios Konstantinos	200	Landscape and Forestry irrigation

Malta

Water resources

Malta has suffered from acute water stress for decades.

Scarcity of water was already highlighted in a report by Knights of St. John in 1524 *"…except for few springs in the middle of the Island, there was no running water nor even wells, the want of which the inhabitants supplied by cisterns*". A 16th century Knights decree required that *"…all houses were to have wells for collection of rainwater from roof-tops"* (Pizzuto, 2003).

The islands have a total area of almost 320 km^2 and a population of almost 400,000 inhabitants. Besides, Malta receives more than 1 million tourists per year. The renewable water resources (30 MCM per year of groundwater) hardly cover half of the water demand. Desalination of sea water by reverse osmosis closes the negative water balance.

Sewage treatment

Due to low water consumption per inhabitant, the raw sewage in Malta is strong (BOD_5 = 530 mg/L and SS = 445 mg/L) and has a high salinity (sodium and chloride) due to high levels of these ions in the domestic water supply.

The main sewage treatment plant (Sant Antnin) had a current capacity of 13,000 m^3/day of effluent, but it was increased to 26,000 m^3/d in the mid 1990s. The plant uses an activated sludge process followed by rapid sand filters (9 $m^3/m^2 \cdot h$). The effluent is then disinfected with gaseous chlorine (20 mg/L and contact time 30 min) and pumped into irrigation reservoirs with a free chlorine residual of 2 mg/L (Kamizoulis, 2003; Pizzuto, 2003).

Other three smaller sewage treatment plants are planned by the government (Pizzuto, 2003).

Regulations

There are not yet regulations for water reuse.

Reuse practice

Because agriculture is the main source of income, wastewater is practiced since the late XVII century (Angelakis et al., 1999).

Since 1983, the effluent of the Sant Antnin sewage treatment plant has been used for irrigation. The effluent is used to irrigate 600 ha of crops by furrow and spray irrigation. The effluent quality is suitable for unrestricted irrigation and is used to produce potatoes, tomatoes, broad and runner beans, green pepper, cabbages, cauliflower, lettuce, strawberries, clover, etc.

Despite the high salinity, there are no problems with crops. This is probably associated with high permeability of the calcareous soil. Soil monitoring has shown a salt accumulation in the top soil during the irrigation season followed by leaching to the groundwater with the winter rains (Kamizoulis, 2003).

Industrial reuse is limited to an industrial laundry.

Portugal

Water resources

Portugal has an almost Mediterranean climate with more than 70% of the annual rainfall during half of the year.

Renewable water resources are about 66,000 MCM per year, while water demand is only 12,000 MCM per year. With a population of about 10 million inhabitants, 80% of water demand is for agricultural irrigation (FAO-AQUASTAT, 2003).

Sewage treatment

According to a survey performed in 2000, sewerage coverage is only 55%, with only 36% of sewage receiving treatment (US-EPA, 2004), but this situation is presently changing quickly in order to comply with the requirements of the EU directives.

Regulations

Draft regulations are presently being discussed for approval (Marecos do Monte, personal communication, 2004)

Reuse practice

A survey carried out in 1998 assessed the actual practice of water reuse for irrigation in Portugal and showed that (Marecos de Monte, personal communication, 2004):

- 35 water reuse systems were identified over 27 municipalities out of 305 municipalities
- Most of the cases were of municipal wastewater reuse. Industrial wastewater was reused for irrigation only in 5 cases
- 5 cases out of 35 reused untreated wastewater
- Spray irrigation was the most used irrigation method, followed by drip irrigation, furrow irrigation and truck tanks
- Landscape irrigation was the main application
- Other applications were forage crops, vegetables, fruit trees and sport fields (golf courses and football grounds).

A new large WWTP (460,000 inh.) near Lisbon plans to irrigate 1,000 ha with tertiary treated wastewater. But at least 3 large projects in the area of Lisbon (Beirolas, Frielas, Costa do Estoril) are suffering of delays in their implementation (Marecos do Monte, personal communication, 2004).

Treated wastewater is a potential source of water for irrigation and should soon reach 580 MCM/yr, which is approximately twice as much as today. Even without storage, this amount could be enough to cover about 10% of the water needs for irrigation in a dry year. The use of treated wastewater for irrigation could significantly contribute to the agricultural development in the driest Portuguese provinces (Beja, Evora, Setubal, Lisboa and Santarem). Roughly, between 35,000 and 100,000 ha, depending on storage capacity could be irrigated with recycled water. Interest is also growing for the irrigation of golf courses (Angelakis, 2003), which is now implemented in the South of the country at an important scale.

An important research project on waste water reuse for irrigation was carried out by the Laboratorio Nacional de Engenharia Civil (LNEC) and the Laboratorio Quimico Agricola Rebelo da Silva (LQARS). The main objectives of the project were to assess and compare the effects of irrigation of various types of treated urban waste water versus the same crops irrigated with potable water and given commercial fertilizers, in order to provide experimental data to support the production of Portuguese guidelines for waste water reuse for irrigation. The main conclusions of the study were the following: primary and secondary effluents were found to be suitable for well drained soils and salinity-tolerant crops but unsuitable for sensitive crops; the nitrogen content of both effluents seem to enable the avoidance of the use of commercial fertilizers, as identical yields were obtained for the three treatments (primary and secondary effluents and control potable water); the facultative pond effluent appears to be of higher fertilizing capacity than primary and secondary effluents, since increased yields were obtained comparatively to the water irrigated crops (Angelakis et al., 2000).

ACKNOWLEDGEMENTS

The preparation of this chapter was possible thanks to the valuable collaboration of IWA colleagues around the Mediterranean Basin: Maria H. Marecos do Monte (Portugal), Giuseppe Cirelli and Salvatore Barbagallo (Italy), Lluís Sala (Spain), C. A. Kambanellas and Despo Fata (Cyprus), and Anton Pizzuto (Malta).

REFERENCES

Angelakis A., L. Bontoux, and V. Lazarova (2003) Challenges and prospectives for water recycling and reuse in EU countries. *Water Science and Technology: Water Supply* **3**(4): 59-68.

Angelakis, A., B. Durham, M.H.F. Marecos do Monte, M. Salgot, T. Wintgens, C. Thoeye, and T. Peitchev. 2005. Water Recycling and reuse in Eureau Countries: With Emphasis on Criteria Used. *EU1/2-05-WR-26(1),* draft report dated 16 February 2005.

Angelakis A., M. Marecos do Monte, and T. Asano (2000) Wastewater Reuse Practice in the Mediterranean Region. *In: Advanced Wastewater Treatment and Reuse. Design, Operation and Maintenance. Training material.* EW Leonardo da Vinci Programme, Chapter 9: pp.1-37.

Barbagallo S., Cirelli G. and Nurizzo C. (in press) Wastewater Reclamation and Reuse in Italy.

Bazza, M. (2003) Wastewater recycling and reuse in the Near East Region: experience and issues. *Water Science and Technology: Water Supply* 3(4): 33–50.

Crook J.; Mosher J and Casteine J (2005) – Status and Role of Water Reuse: an International View. *Report to the Global Water Research Coalition*, pre-publication version 3/2005, 133 pp.

Cyprus Water Development Program (2005) Official Website at http://www.moa.gov.cy/wdd/

Fatta D. and I. Skoula (2004) Evaluation of existing situation related to the operation of urban wastewater treatment plants and the effluent disposal practices with emphasis on the reuse in the agricultural production. *In: MEDAWARE program: Development of Tools and Guidelines for the Promotion of the Sustainable Urban Wastewater Treatment and Reuse in the Agricultural Production in the Mediterranean Countries.* Task 2, report March 2004, 126 pp.

Feigin, A., Ravina, I. and Shalhevet, J. (1991) Irrigation with Treated Sewage Effluent. Adv. Ser. Agr. Sci. 17, Springer-Verlag, Berlin.

Friedler, E. and Juanicó, M. (1996) Treatment and storage of wastewater for agricultural irrigation. *Water Irrig. Review* **16**(4), 26-30.

Ganoulis J (2003) Evaluating alternative strategies for wastewater recycling and reuse in the Mediterranean area. *Water Science and Technology: Water Supply* 3(4):11–19

Juanicó, M. and Dor, I. (Eds.) (1999) Reservoirs for Wastewater Storage and Reuse: Ecology, Performance and Engineering Design. Springer-Verlag, Environmental Science Series, Berlin, 394 pp.

Juanicó, M. (*in press)* Israel as a case Study. *In:* B. Jimenez and T. Tasano (Eds.) - Reuse International Survey: Common practices and current needs in the world. IWA Publishers, UK.

Kamizoulis, G.; Bahri A., Brissaud F and Angelakis A. (2003) Wastewater Recycling and Reuse Practices in the Mediterranean Region: recommended guidelines. *MED-REUNET, Case Studies.* www.med-reunet.com

MEDAWARE (2004-Drafts) Development of Tools and Guidelines for the Promotion of the Sustainable Urban Wastewater Treatment and Reuse in the Agricultural Production in the Mediterranean Countries. EU Programe MEDAWARE, Reports Task 1 A to F, and Task 2. Drafts kindly provided by Dr. Despo Fatta from the University of Cyprus.

Nurizzo C. (2003) Reclaimed water reuse in the Mediterranean region: some considerations on water resources, standards and bacterial re-growth phenomena. *Water Sci. Technol.* 3(4):317-324.

Pizzuto A. (2003) Case Study – Sewage Treatment Plant (Malta). Presentation to the Worshop on Integrated management of water resources, Izmir, Turkey, Sep. 2003.

Sala, L. and X. Millet (1997) Aspectos básicos de la reutilización de las aguas residuales regeneradas para el riego de campos de golf. *Consorci Costa Brava Publishers*, 126 pp.

Tsagarakis, K.P., P. Tsoumanis, D. Mara and A.N. Angelakis (2000) Wastewater Treatment and Reuse in Greece: Related Problems and Prospectives. *IWA, Biennial International Conference,* Paris, France.

US-EPA (2004) Guidelines for water reuse. *Report EPA/625/R-04/108*, 450 pp.

Weber, B. and Juanicó, M. (2004) Salt reduction in municipal sewage allocated for reuse: the outcome of a new policy in Israel. *Wat. Sci. Technol.* **50**(2):17–22.