9th EWA Brussels Conference
„Water – Investing Today for the Future“
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Brussels, Belgium

WATER AND WASTEWATER RECYCLING IN THE MEDITERRANEAN AREA

Alfieri POLLICE
IRSA CNR
Bari, Italy
Presentation outline

Water stress and reuse in Europe

Europe and Med-countries

Technological aspects of treated wastewater reuse

Regulatory aspects of wastewater recycling

EU funded RTD projects on reuse

(Case studies)
Water shortage in EU and most Med regions is due to:

- lack of natural water resources (also due to overexploitation),
- scarce or uneven rainfall (climate changes),
- development of local economies and population increase,
- improper water management by bulk users (e.g. agriculture),
- insufficient protection of resources from pollution.

Water stress in Europe

Water Stress Index = \[
\frac{\text{water withdrawal}}{\text{renewable freshwater resources}}
\]

Water Stress Index > 20% requires water management efforts.
Water stress in Europe
Water available vs. needs in EU

Average annual freshwater availability (1990-2010), determined with the hydrological model LISFLOOD© (JRC 2012)

Water demand for all sectors in 2005 (irrigation, livestock, industry & energy, households) (mm/year) (JRC 2012)
Water stress in Europe
Agriculture and vegetation water stress in EU

Areas where - parts of the year - water supply is not sufficient to meet **irrigation needs** (Mm³/year)(average 1990-2010) (JRC 2012)

Number of days per year with insufficient water for **vegetation growth** (~ soil moisture stress)(average 1990-2010) (JRC 2012)
Water reuse in Europe

Water use and reuse in EU countries by application

Legend:
- AGR: agricultural irrigation
- IND: industrial use
- ELE: electricity generation
- PWS: public water supply
- URB: urban and domestic uses
- GWR: groundwater recharge
- ECO: ecological/environmental enhancement

Source: AQUAREC 2006
Status of water reuse in Europe

Hochstrat (2011) (Data from EUREAU survey and AQUAREC, www.aquarec.org)
Applications are distributed mainly:
1. on coastal areas and islands in the semi-arid Mediterranean countries
2. in densely urbanised areas in wetter regions

Europe and the Mediterranean

Water use in Med Countries

Med area is not (only) Europe:
• 3 continents
• 21 countries
• Many diverse cultural groups

<table>
<thead>
<tr>
<th>Total population (1000 inh.)</th>
<th>Agricultural withdrawal (%)</th>
<th>Industrial withdrawal (%)</th>
<th>Municipal withdrawal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>45,638</td>
<td>60</td>
<td>22</td>
</tr>
<tr>
<td>France</td>
<td>62,445</td>
<td>13</td>
<td>69</td>
</tr>
<tr>
<td>Italy</td>
<td>60,920</td>
<td>48</td>
<td>33</td>
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<tr>
<td>Slovenia</td>
<td>2,024</td>
<td>54</td>
<td>82</td>
</tr>
<tr>
<td>Croatia</td>
<td>4,411</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Greece</td>
<td>11,327</td>
<td>89</td>
<td>2</td>
</tr>
<tr>
<td>Cyprus</td>
<td>1,090</td>
<td>87</td>
<td>3</td>
</tr>
<tr>
<td><strong>Tot / Avg</strong></td>
<td><strong>187,837</strong></td>
<td><strong>50</strong></td>
<td><strong>32</strong></td>
</tr>
<tr>
<td><strong>Asia:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>71,846</td>
<td>74</td>
<td>10</td>
</tr>
<tr>
<td>Syria</td>
<td>20,054</td>
<td>87</td>
<td>4</td>
</tr>
<tr>
<td>Lebanon</td>
<td>4,197</td>
<td>60</td>
<td>11</td>
</tr>
<tr>
<td>Palestine</td>
<td>3,931</td>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td>Israel</td>
<td>7,261</td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td><strong>Tot / Avg</strong></td>
<td><strong>107,289</strong></td>
<td><strong>65</strong></td>
<td><strong>8</strong></td>
</tr>
<tr>
<td><strong>Africa:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morocco</td>
<td>31,064</td>
<td>87</td>
<td>3</td>
</tr>
<tr>
<td>Algeria</td>
<td>32,339</td>
<td>65</td>
<td>13</td>
</tr>
<tr>
<td>Tunisia</td>
<td>9,937</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Lybia</td>
<td>5,659</td>
<td>83</td>
<td>3</td>
</tr>
<tr>
<td>Egypt</td>
<td>73,390</td>
<td>86</td>
<td>6</td>
</tr>
<tr>
<td><strong>Tot / Avg</strong></td>
<td><strong>152,389</strong></td>
<td><strong>81</strong></td>
<td><strong>6</strong></td>
</tr>
<tr>
<td><strong>TOT / AVG</strong></td>
<td><strong>447,515</strong></td>
<td><strong>65</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>
Mediterranean demographic trends until 2050

Population and GDP in Med countries in 2009

Source: UN World Population Prospects (2008)

Source: Plan Bleu 2012
Europe, the Med area, and water supply

Different priorities:

• Zones with sufficient water available, in quantity and quality;
• Zones with water quality issues;
• Zones with water quantity and quality issues.

General latitude-related criterion, but strong exceptions in coastal areas, large cities, etc.

Natural renewable water resources per capita
## Europe, the Med area, and water supply

Water use (in Mm³/yr) including reuse of treated wastewater in EU-Mediterranean countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total water withdrawal</th>
<th>Agric. Use</th>
<th>Treated wastewater</th>
<th>Wastewater reuse (2005)</th>
<th>Wastewater reuse (2025)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprus</td>
<td>270</td>
<td>182</td>
<td>17</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>France</td>
<td>32,600</td>
<td>2,800</td>
<td>7,000</td>
<td>15</td>
<td>120</td>
</tr>
<tr>
<td>Greece</td>
<td>8,150</td>
<td>6,900</td>
<td>700</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Italy</td>
<td>45,000</td>
<td>22,000</td>
<td>5,500</td>
<td>250</td>
<td>550</td>
</tr>
<tr>
<td>Malta</td>
<td>60</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Portugal</td>
<td>7,500</td>
<td>6,550</td>
<td>480</td>
<td>5</td>
<td>70</td>
</tr>
<tr>
<td>Spain</td>
<td>40,000</td>
<td>25,000</td>
<td>3,375</td>
<td>350</td>
<td>1350</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>133,580</strong></td>
<td><strong>63,444</strong></td>
<td><strong>17,082</strong></td>
<td><strong>631 (3.7%)</strong></td>
<td><strong>2250</strong></td>
</tr>
</tbody>
</table>

---

a These data relate only to the Government Controlled areas; b IFEN (2007); c FEN (2008); d APAT (2005) e Programa Nacional para o Uso Eficiente da Água (2002); f INSAAR (2009); g Versión Preliminar del Plan Nacional de Reutilización de Aguas (2010)
Water stress in Med-countries

Factors affecting water stress in Med countries:

1. Population concentration along the coastline (increasing coastal urbanization)

2. Seasonal water stress during warmer season due to simultaneous increase of:
   - Tourism fluxes,
   - Agricultural requirements,
   - Strongly uneven precipitations and higher temperatures (climate change),
   - Over-exploitation of natural resources.
Aridity index of Mediterranean watersheds

De Martonne index:
\[ I = \frac{P}{T+10} \]

- \( P \) = Avg annual precipitation
- \( T \) = Avg annual temperature

... and June, July, and August

Source: GWP and Plan Bleu (2012)
Possible strategies for limiting water stress

- Transfer of water from areas with higher abundance;
- Non conventional water sources:
  - Seawater or brackish water desalination,
  - Rainwater harvesting,
  - Cascade water use/Treated wastewater reuse (direct or indirect after replenishment of water bodies, SAT, MAR);
- Improved water management by balancing water demand and supply (Water Demand Management WDM).

Annual rainfall distribution in the Mediterranean Basin

TWWR in Europe and Med countries

In the Mediterranean, the main use of Treated Waste Water Reuse (TWWR) is agricultural irrigation, and it is quickly expanding because:

• **agriculture withdraws a significant share** of conventional water resources (average 65% in all Med-countries considered, and over 80% in southern and eastern Med-countries),

• **treated wastewater is a largely unexploited and highly available** water resource in Med-countries,

• in countries with limited sewerage facilities, irrigation with raw wastewater is an established practice, hence a **lower psychological rejection** concerns TWWR, that provides safer water with less health risks,

• **reclaimed water may have a significant fertilization potential**.
Possible obstacles to Treated Waste Water Reuse projects in Med area:

- Perceived complexity of TWWR (cross-sector issues concerning water, food, health and the environment) and need for some technical knowledge;
- Regulations are generally not adapted to local contexts;
- Inadequate tariff policy (heavily subsidized conventional water resources) and limited financial capacity;
- Competition for conventional water resources and need to define priorities (need for planning supply and demand over time and space);
- Risks of soil salinization, crops contamination, and pollution of water resources (need of monitoring procedures and some analytical capacity);
- Inadequate or incomplete sanitation coverage (esp. South-East Med);
- Public perception could be highly negative, causing rejection of projects.
Technological aspects

Reuse of treated wastewater in agriculture

**Opportunities**
- Continuous water supply;
- Safeguard of primary sources;
- Nutrients supply.

**Risks**
- Microbiological safety;
- Chronic effects on soils;
- Eutrofication of storage basins.

**Questions**
- Are costs sustainable?
- Are technologies adequate?
- Are limits and regulations representative of local situations?
- How stakeholders and final users can be involved?
Technological aspects

Reuse-related parameters and typical treatments

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Concerns</th>
<th>Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>Pipe clogging, Accumul. on soil</td>
<td>Clariflocculation</td>
</tr>
<tr>
<td>Microrganisms</td>
<td>Hygienic safety</td>
<td>Filtration (GMF)</td>
</tr>
<tr>
<td>Toxic compounds (metals/organics)</td>
<td>Accumulation in soil and crops</td>
<td>Membrane filtration</td>
</tr>
<tr>
<td>Nutrients (N, P)</td>
<td>Eutrophication of storage basins</td>
<td>Act. carbon adsorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clariflocculation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disinfection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Membrane filtration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biological treatments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ammonia stripping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemical precipitation</td>
</tr>
</tbody>
</table>

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Technological aspects

Municipal wastewater treatment alternatives

Conventional Activated Sludge (CAS)

Primary effluent

- anox (pre-denitro)
- aerobic (nitro)
- settling
- tertiary treatment
- disinfection

Membrane bioreactor (MBR)

- on-demand disinfection

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Technological aspects
Municipal wastewater treatment alternatives

Tertiary treatments:

a) COAG → FLOC → SED → FILTR → DISINF

b) POND → STABILIZ. POND → DISINF

c) WETLAND → POND → DISINF

d) micro FILTR → DISINF

e) ultra FILTR → DISINF

IRSA pilot activities: surface filtration as tertiary treatment or combined to biological treatments

WWTP upgrade:

f) Raw sewage → Pre-treatments → Primary settling → Activated sludge → ultra FILTR → DISINF
**Technological aspects**

Membrane systems for agricultural reuse of treated wastewater

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete SS removal and at least partial disinfection;</td>
<td>Need of pretreatments;</td>
</tr>
<tr>
<td>High and constant permeate quality;</td>
<td>Need of periodical membrane cleaning (maintenance);</td>
</tr>
<tr>
<td>No chemical reactions (thus no by-products);</td>
<td>Risk of membrane integrity loss;</td>
</tr>
<tr>
<td>Limited energy requirements (low-pressure processes, MF/UF).</td>
<td>Cost of installation (decreasing) and operation (with respect to natural systems)</td>
</tr>
</tbody>
</table>
Regulatory aspects

Three steps regulation process

Europe
- Competence to issue a framing legislation defining minimum requirements
- European Directive

Member States
- Enforcement of European Directives requires their transposition into national law
- National Law
  - Federal Law

Autonomous regions
- Possibility to regulate issues which were not addressed in national laws, option to adopt more stringent standards according to local situations
- Regional Law
Wastewater reuse relevant EU legislation

Definition of use related requirements

- Fresh Water Fish 78/659/EEC
- Shellfish Water 79/923/EEC
- Surface Water 75/440/EEC
- Bathing Water 76/160/EEC
- Drinking Water 80/778/EEC
- Ground Water 80/68/EEC
- Dangerous Substances 76/646/EEC

Protection of water quality

- Directives to be repealed latest by 2013
- Directives revised or under revision
- Possible future Directives

- Sewage Sludge 86/278/EEC
- Nitrates 91/676/EEC
- Pesticides 91/414/EEC

- UWWTD 91/271/EEC
- Envisaged revision of 86/278/EEC in 2004

- Soil Protection COM(2002) 179

- Wastewater Reuse

# Reuse regulations across Med countries

<table>
<thead>
<tr>
<th>Regulations in place</th>
<th>Year regulations adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe:</strong></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>yes; 1985, 2007</td>
</tr>
<tr>
<td>France</td>
<td>yes; 1999, 2003</td>
</tr>
<tr>
<td>Malta</td>
<td>yes; 1983, 2001</td>
</tr>
<tr>
<td>Italy</td>
<td>yes; 2003</td>
</tr>
<tr>
<td>Greece</td>
<td>yes; 2004, 2011</td>
</tr>
<tr>
<td>Cyprus</td>
<td>yes; 2005</td>
</tr>
<tr>
<td><strong>Asia:</strong></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>yes; considered</td>
</tr>
<tr>
<td>Syria</td>
<td>no; considered</td>
</tr>
<tr>
<td>Lebanon</td>
<td>no; Reuse for human use prohibited, reuse for crops considered</td>
</tr>
<tr>
<td>Palestine</td>
<td>yes; 2001</td>
</tr>
<tr>
<td>Israel</td>
<td>yes; 1959</td>
</tr>
<tr>
<td><strong>Africa:</strong></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>no; 1984, 1989 WHO, Martial law prohibits reuse</td>
</tr>
<tr>
<td>Libya</td>
<td>no</td>
</tr>
<tr>
<td>Tunisia</td>
<td>yes; 1980</td>
</tr>
<tr>
<td>Algeria</td>
<td>no; Reuse prohibited</td>
</tr>
<tr>
<td>Morocco</td>
<td>yes; 1995, WHO</td>
</tr>
</tbody>
</table>

Source: Kellis et al. 2013
EU funded R&D and Demo projects on Reuse

**FP5**

**Coretech** (2000/2003) - Development of cost-effective reclamation technologies for domestic wastewater and the appropriate agricultural use of the treated effluent under (semi-) arid climate conditions

**Wam Me** (2000/2003) - Water resources management under drought conditions: criteria and tools for conjunctive use of conventional and marginal waters in Mediterranean regions

**Poseidon** (2001/2004) - Assessment of technologies for the removal of pharmaceuticals and personal care products in sewage and drinking water facilities to improve the indirect potable water reuse


**Aquarec** (2003/2006) - Integrated Concepts for Reuse of Upgraded Wastewater

**FP6**

**Reclaim Water** (2005/2008) - Water reclamation technologies for safe artificial groundwater recharge

**Water Reuse** (2005/2010) - Sustainable waste water recycling technologies for irrigated land in NIS and southern European states

**Aquastress** (2006/2009) - Mitigation of water stress through new approaches integrating management, technical economic and institutional instruments

**FP7**

**AquaFit4Use** (2008/2012) - Water in industry, fit-for-use sustainable water use in chemical, paper, textile and food industry

**CB-WR-MED** (2010/2013) - Capacity building for direct water reuse in the Mediterranean area

**Water4Crops** (2012/2016) - Integrating bio-treated wastewater reuse with enhanced water use efficiency to support the Green Economy in Europe and India

**Demoware** (2013/2016 ?) - Innovation & demonstration for a competitive and innovative European water reuse sector
Case Studies: Israel

Shafdan (Tel Aviv)

- Tertiary treatment for sewage effluent (125 Mm³/yr) which is then used to replenish the groundwater table via seven infiltration basins (Soil Aquifer Treatment).
- Water from the aquifer is then pumped southward about 100 km and stored in reservoirs for irrigation of more than 4000 private farms (mostly market gardening for export).
- The project is part of a national policy on production of non-conventional water sources.

Technologies:

- Tertiary treatment with disc filters
- Various AOP combinations (UV+ozone)
- Online and offline heavy metal and organic pesticides toxicity alert.
- Parasites and bacterial real time PCR

Treated effluent quality:

- Suitable for unrestricted irrigation
- Complete (or maximum) removal of bacteria, parasites and viruses
- Micropollutants and salts removal
- Minimization of manganese dissolution during SAT by maximizing aerobic conditions.
Sabadell (Barcelona)

Secondary treated municipal effluent (plant capacity 25000 m³/d) is discharged into a river bed where it infiltrates (sand/gravel aquifer), and it is recovered downstream and UV disinfected.

New tertiary treatment with design capacity of 2500 m³/h (21,9 Mm³/yr) featuring flat-sheet membrane and UV and hypochlorite post-disinfection.

Regenerated wastewater is currently used for urban purposes in Sabadell, mainly street cleaning and public parks and gardens irrigation, but an ambitious wastewater reuse program is planned in the zone.
The plan is to serve various urban uses in the city, commercial areas and golf courses in the region.
Authorization for private garden irrigation is under review by the Catalan Water Agency. A separate distribution network has already been constructed.
Case Studies: Italy

Fasano (Apulia)

- No superficial water resources (streams, lakes), high salinity of groundwater due to over-exploitation (seawater intrusion);
- Scarce and unevenly distributed rainfall (500-600 mm/y);
- Agriculture vocated area (40% olive trees, 30% horticulture, 30% fruit trees and other);
- Municipal wastewater treatment plant (AS + disinfection) of 50,000 PE (max);
- Tertiary treatment plant of 8000 m$^3$/d (i.e. 2/3 of max potential);
- A 30 km distribution network brings treated wastewater to 51 users over an area of 1000 hectares.

Tertiary treatment
- Integrated basin of 6000 m$^3$ for equalization, treatment and accumulation;
- Plug-flow reactor with 3 sections: Pre-disinfection, clariflocculation, settling (plus possible post-disinfection);
- Pre-disinfection with sodium hypochlorite or peracetic acid + H$_2$O$_2$;
- Clariflocculation with alluminum chloride;
- Post-disinfection with sodium hypochlorite or UV with recirculation.
Case Studies: Cyprus

Limassol

- Limited water resources seriously jeopardized by rapid increase of urban and rural domestic supplies.
- Seawater intrusion in the water table due to overexploitation and competition for freshwater, especially during the dry season.
- Reclamation and reuse of treated wastewater has become a promising option for providing a reliable source of water to meet shortages and to cover water needs.

Treated wastewater produced at Limassol WWTP (3 Mm$^3$/yr) is used, directly or after accumulation into a reservoir, for irrigation of crops, green areas in hotels and for industrial use (cement factory). The main crops cultivated are fodder, olive trees, fruit trees (MEDAWARE project, 2003).

- Activated sludge followed by tertiary treatment (sand filtration and chlorination);
- Reclaimed effluent used for direct irrigation;
- Complains from farmers about water quality (microbial pollution, pipe clogging);
- Reasons: Overload of the WWTP, lack of trained staff;
- Proposed solution: Plant extension and SAT.
Key concepts

Priorities and quality requirements across Europe and Med countries:

Continental Europe: Higher quality standards, limited quantity issues, organic pollutants (POPs), pharmaceuticals, endocrine disruptors, etc..

Mediterranean Europe: Resource recovery for irrigation and MAR (contrast to salinization), nutrients, salinity, microbiology.

South-Eastern Mediterranean: Higher acceptance of lower quality resource, availability over the year, increase crop productivity, suitability of natural and simplified treatment.

Wastewater treatment for reuse should be considered as a production process where lower quality resources are raw materials, and the produced water is the final marketable product.

Different produced water qualities for different uses should be the base for the definition of quality standards, also considering the cost of treatment.
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Thanks for your attention

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Possible tools to tackle water stress include:

- **Water demand** management
  (water loss contrast, irrigation techniques, economic measures, training, etc.)

- **Water supply** increase
  (seawater desalination, wastewater reuse, rainwater harvesting etc.)
TWWR in Europe and Med-countries

On the contrary, success of TWWR projects require:

• Integrated, multi-disciplinary and multi-sectoral approach, concerted among stakeholders and coordinated with the relevant institutions;

• potential uses of TWW in relation to the quantity and quality of the wastewater resource need to be taken into account from the initial stages of project planning;

• Incorporating TWWR into an integrated water resources management (IWRM) policy.
Main water reclamation technologies and possible applications

• Natural systems (ponds, wetlands)
  Reuse type:
  – Recreational impoundments (no human contact), landscape, etc.
  – Restricted irrigation.

• Sand filtration and disinfection
  Reuse type:
  – Unrestricted irrigation.

• Membrane based systems (MBR, tertiary, etc.)
  Reuse type:
  – Urban applications, aquifer recharge and industrial applications requiring high quality water.
No EU regulation exists for water reuse, reclamation, or recycling. Regulatory measures by 2015?

The only reference to water reuse in EU directives is in Article 12 of the Urban Waste Water Treatment Directive (UWWTD 91/271/EEC) stating: “Treated wastewater shall be reused whenever appropriate.”, but the term “appropriate” is left un-defined, nor the concept is further developed.

Central concepts for water reuse policies
• potential hazards and risks associated with water reuse and their appropriate management
• balance between safety and cost as well as overall environmental impacts
FP7 InnoDemo «Demoware»

Water exploitation index (%) around year 2000

- 0–20 (low water stress)
- 20–40 (medium water stress)
- > 40 (severe water stress)
- Outside data coverage

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### Table 1. Water withdrawals in Mediterranean rim countries and pressure on the resource (2005–2010)

<table>
<thead>
<tr>
<th>Zones (whole countries)</th>
<th>Total withdrawal of renewable resources (km³/year)</th>
<th>Withdrawal by sector (volume and % of total)</th>
<th>Exploitation index of renewable natural water resources (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Drinking water</td>
<td>Irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>km³/year</td>
<td>%</td>
</tr>
<tr>
<td>North</td>
<td>120</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>East</td>
<td>60</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>South</td>
<td>74</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>254</strong></td>
<td><strong>41</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Source: Blinda, Plan Bleu (2011)
Source: Aquarec 2006

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Long-run average agricultural total factor productivity growth (1971–2008) (percent per year) (GWP 2013)
Reusing treated wastewater in the Mediterranean

In Italy, water purified at Milan's new San Rocco purification plant using ultra-violet treatment is being used for irrigation. The project has reduced the amount of untreated effluent flowing into the natural environment, it keeps farms in production, and it is producing satisfactory sanitary conditions – which did not exist prior to the project. All costs are covered by the sewage charge collected from the people of Milan. The project retains the complex hydraulic organisation which has existed since the Roman era.

In Tunisia, treated effluent is used to water golf courses in Hammamet. Two private golf courses use the town's treated wastewater after tertiary treatment in aerated lagoons. This avoids pumping groundwater from an over-exploited aquifer. Moreover, the reuse of treated wastewater avoids the discharge of water from the purification station into the sea near tourist beaches. This PPP has created 170 jobs and helps to make Hammamet attractive as a tourist destination. Some investment and operating costs are met by the authorities who consider that this public investment contributes to tourism.

Source: AFD (2011)
Olive mill wastewater (OMW) production in Mediterranean countries is about 10-12 million m3/year and its disposal is one of the major environmental concerns related to olive tree cultivation. Since OMW are considered as a source of nutrients, the direct application of OMW to bare soil has been proposed as a low cost alternative method to OMW treatment (Di Giovacchino et al., 2002). Lopez et al. (1996) reported that the application of high volumes of OMW on bare soil for 3 years increased the fertility of the soil in the 0-50 cm layer promoting minor changes in the chemical properties below this layer. The use of the appropriate dosage (80-320 m3/ha) can improve soil fertility (mostly potassium) with no negative effects on soil properties (Morisot and Tournier, 1986).

Research suggests that OMW can be considered as a useful, low cost amendment and fertilizer and the land application of OMW is an environmentally friendly and cost effective method of management for small to medium olive mills. OMW does not contain human pathogens and hence, no chlorination is needed. OMW application is allowed under certain circumstances in Italy, Spain and Portugal. There is a need for a regulation that imposes European standards in this field and possibly guidance for all olive producing countries in Mediterranean region.
Barriers to water reuse implementation

• Financing is the first and utmost problem
• Inconsistent or inadequate regulations /guidelines which lead to delays and misjudgements
• Need for better institutional arrangements
• A larger educational effort and stakeholder involvement is needed
• Technical issues exist, but can be managed
• Il riutilizzo delle acque a fini irrigui sarà elemento di interesse e potrà essere considerato un processo produttivo autonomo, la cui materia prima è costituita dalle acque reflue e il cui prodotto finale è una risorsa idrica alternativa a quelle convenzionali da immettere sul mercato.

*NB Common issues of constraint highlighted by the water utilities in a survey carried out within the AQUAREC project. The full workshop outcome report can be now downloaded from the project website: www.aquarec.org*
Credits:
N. Condom, M. Lefebvre, L. Vandome (2012) Treated wastewater reuse in the Mediterranean: Lessons learned and tools for project development. Blue Plan Papers 11, PLAN BLEU UNEP/MAP Regional Activity Centre

In EU about 25% of natural freshwater is used for agriculture (up to 80% in southern Europe).
Public water supply (acqueduct) is 20% of water used in Europe, and 25% of it is used to flush the toilets.
Public water supply can be made more effective (up to 50% of drinking water is lost in some EU Member States). (EEA 2012)

Average need for a country to sustain agricultural production is 750 m3 per capita per year (WHO, 2006).
Seven countries in the Mediterranean have less than 750 m3 per capita per year (Malta, Palestine, Israel, Egypt, Libya, Tunisia, and Algeria).
Another five countries have less than 1000 m3 per capita per year (“water stressed”: Syria, Cyprus, Lebanon, Egypt and Morocco).
Almost two thirds (12/21) of the Mediterranean countries have no long term sustainable water resources (Kellis et al. 2013).