

INNOVA-MED CONFERENCE “ Water Reclamation and Reuse”  
8 - 9 October 2009, Girona, Spain



**WATER REUSE IN SPAIN: DATA OVERVIEW  
AND COSTS ESTIMATION OF SUITABLE  
TREATMENT TRAINS**

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**Presentation**

- 1. Some aspects have enhanced the development of water reuse in Spain**
- 2. Spanish Reuse Database. Development and Main Results**
- 3. Reuse regulation. Royal Decree 1620/2007**
- 4. Proposal of treatment trains to meet legal requirements. General estimated cost of investment and operational are including.**

## 1. Introduction

- ❑ **The need of water**
- ❑ **Treated effluents**
  - ❑ Directive 91/271/EEC
  - ❑ Water Framework Directive
  - ❑ Others: Bathing Water Directive; Programmes for Pollution Monitoring or priority or emerging pollutants
- ❑ **The development of regeneration technologies**
- ❑ **Reuse regulation development**

### The enforcement of Directives and other regulations:

- National Sanitation and Purification Plan (1995-2005)
- National Plan for Water Quality, Sanitation and Purification (2007-2015)
- Royal Decree 1620/2007 water reuse regulation
- State Water Reuse Plan
- Programa A.G.U.A. and River Basin District Plans or Autonomous Region Reuse Programs

- ✓ Water treatment plants: 2,533 (> 5.000 h-e)
- ✓ Treating volume: 3,370 Hm<sup>3</sup> per year
- ✓ Treated volume for reuse (2015): 1.200 Hm<sup>3</sup>

(Source: The Ministry of the Environment, 2007)

## 2. Spanish Reuse Database

- ❖ **The requester:** Ministry of Environment (2005-2008)
- ❖ **Aim:** Gather the main information about water reuse in Spain in order to make a first approach
- ❖ **Main stages:**
  - Database design
  - fieldwork collection of data
  - checking and storage of data
  - integration of this Database in Geographic Information System (GIS).
- ❖ **Final report:** delivered to the requester in 2008

1 Database design to obtain a reliable overview of reuse in Spain

4 integration of this Database in GIS compatible with the geographic information available at CEDEX

**Development RDB**

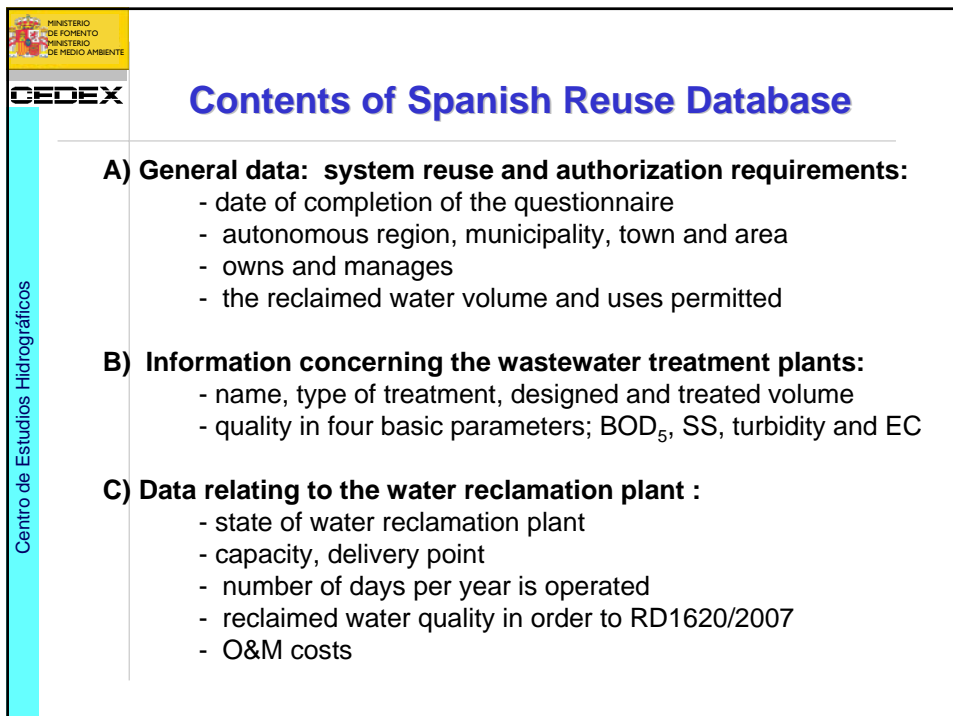
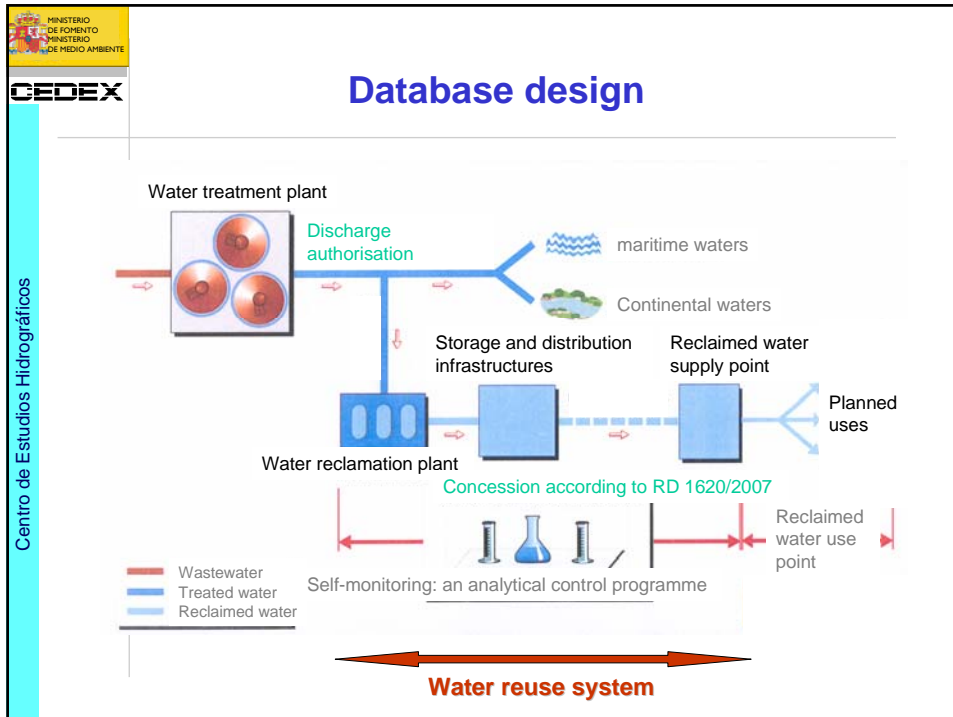
**Views from ArcGIS maps**

Tab-questionnaire used for data input to database

3 checking and storage of data.

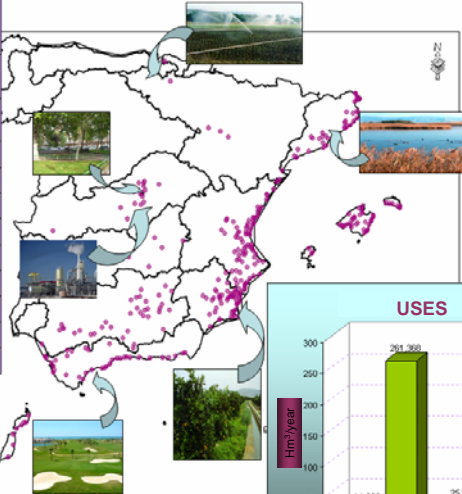
2 fieldwork collection of data  
- Basin departments  
- Autonomous Communities

5. Web applications is developing for updating records

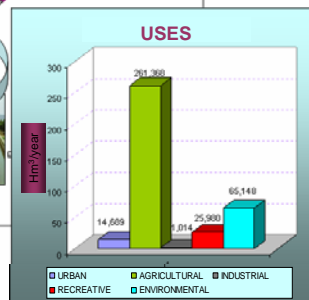


## State of Water Reuse in Spain

| ZONES                | Hm <sup>3</sup> /year |
|----------------------|-----------------------|
| Comunidad Valenciana | 148,66                |
| Comunidad de Murcia  | 84,52                 |
| Islas Canarias       | 17,8                  |
| Islas Baleares       | 28,24                 |
| Cataluña             | 44,16                 |
| Andalucía            | 24,21                 |
| Pais Vasco           | 12                    |
| Aragón               | 0,17                  |
| Castilla la Mancha   | 2,96                  |
| Madrid               | 5,48                  |
| <b>TOTAL</b>         | <b>368,2</b>          |

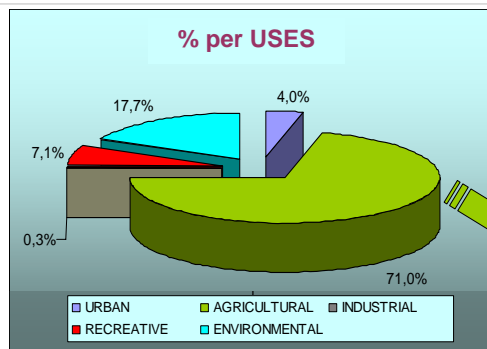


- N° reuse systems 322
- 10,6% of the total treated wastewater
- The volume of reclaimed water was 447.34 Hm<sup>3</sup> in 2008 according to the Ministry of Environmental



Locations and volume per year of water reuse broken down by regions and uses (2007)

## Percentages over total water reuse volume by uses

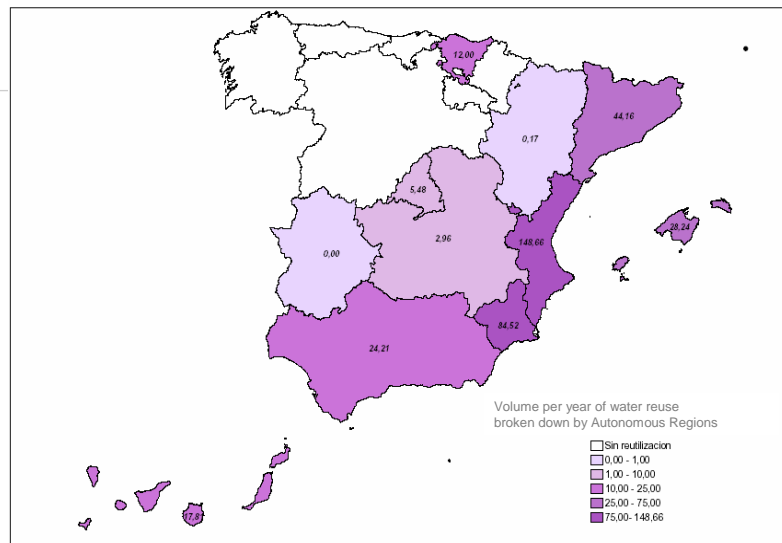


Reuse Database (CEDEX).  
R. Iglesias, 2007

▪ it is observed agricultural irrigation is the most frequent use, although the percentage of environmental or urban use are increasing recently.

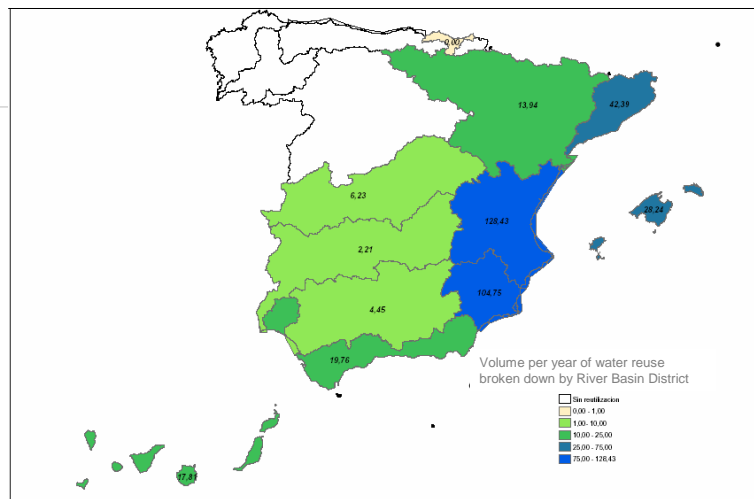
- Irrigation of crops
- Watering of urban green areas
- Irrigation of golf courses
- Recharge of aquifers

| Agricultural use           |                |
|----------------------------|----------------|
| ANDALUCIA                  | 13,847         |
| ARAGON                     | 0,000          |
| BALEARES                   | 19,035         |
| CANARIAS                   | 17,800         |
| CASTILLA-LA MANCHA         | 2,230          |
| CATALUÑA                   | 7,913          |
| VALENCIA                   | 113,517        |
| EXTREMADURA                | 0,000          |
| MADRID                     | 0,000          |
| MURCIA                     | 83,598         |
| PAIS VASCO                 | 3,429          |
| <b>Hm<sup>3</sup>/year</b> | <b>261,368</b> |



Reuse Database (CEDEX).R. Iglesias, 2007

▪ There are an important Autonomous Region Reuse Programs and specific rules to reuse.



Reuse Database (CEDEX).R. Iglesias, 2007

▪ The future of water reuse is essentially focused on the coastal areas of the Mediterranean and South-Atlantic Arc, and the Balearic and Canary Islands where it is strategic non-conventional resource

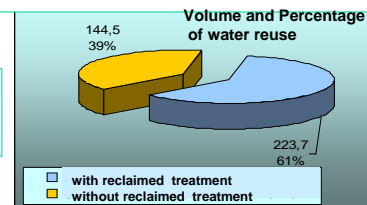
## Reuse treatment trains

| TREATMENT PROCESSES         | Nº WRP     | %           |
|-----------------------------|------------|-------------|
| <i>Without desalination</i> | <b>133</b> | <b>89,3</b> |
| <b>D</b>                    | <b>18</b>  | <b>12,0</b> |
| <b>F + D</b>                | <b>58</b>  | <b>39,0</b> |
| <b>F-Q + F + D</b>          | <b>28</b>  | <b>18,9</b> |
| <b>F-Q + F + M</b>          | <b>9</b>   | <b>6,0</b>  |
| <b>M (MBR)</b>              | <b>2</b>   | <b>1,4</b>  |
| <b>S N</b>                  | <b>18</b>  | <b>12,0</b> |
| <i>With desalination</i>    | <b>16</b>  | <b>10,7</b> |
| <b>F+ EDR + D</b>           | <b>4</b>   | <b>2,6</b>  |
| <b>F-Q + F + EDR + D</b>    | <b>2</b>   | <b>1,4</b>  |
| <b>M+ OI</b>                | <b>3</b>   | <b>2,0</b>  |
| <b>F+ M+ OI</b>             | <b>4</b>   | <b>2,6</b>  |
| <b>F-Q + F + OI</b>         | <b>2</b>   | <b>1,4</b>  |
| <b>F-Q + F + M + OI</b>     | <b>1</b>   | <b>0,7</b>  |
| <b>TOTAL</b>                | <b>149</b> | <b>100</b>  |

**LEGEND:** F = Filtration; P/C = Physical-chemical with settling; M: Filtration with Membranes; NS = Natural Systems; D = Disinfection; EDR= Electro-dialysis reversal; RO: Reverse Osmosis; MBR: Membrane Bioreactor.







Reuse Database (CEDEX).R. Iglesias, 2007


- ✓ 149 water reclamation plants operating
- ✓ 12% of these plants have only a disinfection treatment
- ✓ Only 61% of the total volume reused in Spain has suitable reclaimed water treatment
- ✓ 39 % volume reused in irrigation is treated water.
- ✓ 52% disinfection treatments are with hypochlorite.
- ✓ Systems with desalination processes represent 13% of the total water reclamation plants.
- ✓ Physical-chemical treatment via settling then sand filtration followed by disinfection, has growth recently



## 3. Treated Wastewater Reuse Regulations

- ❑ **At the EU level**
  - ❑ It is not a Directive
  - ❑ Directive 91/271/EEC concerning urban waste-water treatment
- ❑ **At the national level**
  - ❑ Royal Decree 1/2001: the Government shall establish the basic requisites for water reuse
  - ❑ The Regulation on Public Water Domain (Royal Decree 849/1986): defines the requisites and steps for obtaining a concession for water reuse
  - ❑ Royal Decree 1620/2007 of December 7th, which lays down the legal regime for the reuse of treated wastewater, establishes both the basic requisites for water reuse, and the necessary procedures to obtain the concessions and authorizations

| <br><b>CEDEX</b> |  | <b>Royal Decree 1620/2007.</b><br>Maximum allowed values in 4 parameters: nematodes; E.coli; SS and Turbidity  |  |  |  |   |
|---|--|--|--|--|--|---|
| Centro de Estudios Hidrográficos  |  | URBAN USES<br>(2)  | AGRICULTURAL<br>(3)  | INDUSTRIAL<br>(3)  | RECREATIONAL<br>(2)  | ENVIRONMENTAL<br>(4)  |
|   |  |  <p>1.1 Residential:<br/>a) Private garden watering.<br/>b) Discharge of bathroom appliances</p> <p>1.2 Urban services:<br/>a) Watering of urban green areas (parks, sports grounds, etc.)<br/>b) Hosing down streets<br/>c) Fire-fighting systems<br/>d) Industrial car wash</p> |  <p>2.1. a) Irrigation of fresh food crops direct contact of regenerated water with edible parts</p> <p>2.2a) systems not avoiding direct contact of regenerated water with edible parts.<br/>b) Irrigation of pastureland for milk or meat-producing animals<br/>c) Aquaculture</p> <p>2.3 a) Localized irrigation of ligneous crops<br/>b) ornamental flowers</p> |  <p>3.1 a) Process and cleaning water except in food industry<br/>b) Other industrial uses</p> <p>3.2 a) Refrigeration towers and evaporation condensers</p> <div style="background-color: #008080; color: white; padding: 5px;"> <p><b>Forbidden uses</b></p> <ul style="list-style-type: none"> <li>❖ drinking water, except catastrophe</li> <li>❖ hospitals</li> <li>❖ molluscs in aquaculture</li> <li>❖ bath water</li> <li>❖ Ponds, bodies of water and running water with public access</li> </ul> </div> |  <p>4.1. a) Irrigation of golf courses</p> <p>4.2. a) Ponds, bodies of water and running water with no public access</p> |  <p>5.1. a) Recharge of aquifers by localized seepage through the soil</p> <p>5.2. a) Recharge of aquifers by direct injection</p> <p>5.3. a) Irrigation of forests, green zones and similar areas with no public access<br/>b) Forestry</p> <p>5.4. a) Other environmental uses (maintenance of wetlands, minimum flows and similar uses)</p> |

| <br><b>CEDEX</b> |   | <b>4. Technologies and Systems for Water Reclamation according to Royal Decree 1620/2007</b> |
|---|---|--|
| Centro de Estudios Hidrográficos  | <p>➤ <b>Current situation</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> It necessary to adapt an important part of the reuse systems</li> <li><input type="checkbox"/> Royal Decree 1620/2007 sets a 2-year deadline to comply with the requisites</li> <li><input type="checkbox"/> The development of programs for planned reuse of wastewater has spurred MARM to study technology issues and important factors in the selections of treatment processes for water reuse</li> </ul> <p>➤ <b>A proposal of regeneration treatments to meet legal requirements</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> During 2008, Department of Wastewater Treatments, Reclamation and Reuse of CEDEX was working on the treatment trains efficiency to meet different applications criteria regulated by Royal Decree 1620/2007 as to estimate costs</li> </ul> |  |
|   | <p><b>Based on</b></p> <ul style="list-style-type: none"> <li>- running water reclamation plants set up in Spain</li> <li>- the provision of multiple barriers</li> </ul>   |  |



**Quality groups according to the bacteriological limits established on the RD 1620/2007**

| APPLICATIONS  |   | Quality | Escherichia CFU/100 ml  | Nematodes eggs/10 L | Legionella spp. 100 CFU/L |
|---|---|---------|---|---------------------|---------------------------|
| •Industrial 3.2 a)  | • Refrigeration towers and evaporation condensers.  | A       | Absence   | Absence             | Absence                   |
| •Residential 1.1 a) y b)  | • Private garden watering. Discharge of bathroom appliances.  |         | Absence   | 1                   | 100                       |
| •Direct Recharge 5.2 a)   | • Recharge of aquifers by direct injection.   |         | Absence   | 1                   | No limit set              |
| •Urban 1.2 a), b), c), d)<br>•Agricultural 2.1 a)<br>•Recreational 4.1 a) | •Watering of urban green areas<br>•Hosing down streets. Fire-fighting systems.<br>•Industrial car wash. Irrigation with contact<br>•Irrigation of golf courses.   | B       | < 100 -200  | < 1                 | < 100                     |
| •Agricultural 2.2 a), b) y c)<br>•Industrial 3.1 c)                       | •Irrigation of crops for human consumption not avoiding direct contact of regenerated water with edible parts.<br>•Irrigation of pastureland for milk or meat-producing animals. Aquaculture<br>•Process and cleaning water for use in food industry.   | C       | < 1.000   | < 1                 | No limit set              |
| •Environmental 5.1 a)   | •Recharge of aquifers by localized seepage through the soil   |         | < 1.000   | No limit set        | No limit set              |
| •Agricultural 2.3 a), b) y c)<br>•Industrial 3.1 a) y b)                  | •Localized irrigation of ligneous crops impeding contact of regenerated water with food for human consumption.<br>•Irrigation of ornamental flowers, greenhouses and nurseries with no direct contact of regenerated water with crops.<br>•Process and cleaning water except in food industry | D       | < 10.000  | < 1                 | < 100                     |
| •Recreational 4.2 a)  | •Ponds, bodies of water and running water with no public access   |         |   |                     |                           |
| •Environmental 5.3 a) y b)  | •Irrigation of forests, green zones and similar areas with no public access   | E       | No limit set  | No limit set        | No limit set              |
| •Environmental 5.4 a)   | •Maintenance of wetlands, minimum flows and similar uses  | F       | The minimum quality required is studied on a case by case basis |                     |                           |

**Treatment processes flow diagram (1)**

| Quality | Type | Treatment train without desalination   |
|---------|------|--|
| A       | 1    | Chemical precipitation <sup>[1]</sup> , <b>filtration with membranes</b> <sup>[2]</sup> and <b>Disinfection</b> (residual chlorine may be needed in distribution system)<br>Type 2 can achieve quality A about E. coli, Legionella spp and intestinal nematodes standards but it is difficult to achieve turbidity limit that sets in 1-2 NTU.<br>Recharge of aquifers by direct injection is being used treatment train 5a <sup>[3]</sup> |
| B       | 2    | <b>Chemical precipitation, depth filtration and disinfection</b> (ultraviolet radiation together with chlorination) ; residual chlorine may be needed in distribution system   |
| C       | 3    | <b>Filtration and disinfection</b> (tendency to use ultraviolet radiation followed by residual chlorine)   |
| D       |      |  |
| E       | 4    | <b>Filtration</b> <sup>[4]</sup>   |
| F       | -    | It is studied on a case by case.   |

[1] Physical-chemical treatment with a lamella settling system. With regular concentrations of constituents in treated wastewater which are meeting RD 11/1995 requirements [13], this unit operation can be omitted.

[2] Cases studied have ultrafiltration.

[3] All treatment trains in Spain include RO to remove nutrients and trace constituents.

[4] With regular treated wastewater quality standards but it is recommended any surface or depth filtration for distribution system management.

## Treatment processes flow diagram (2)

| Quality    | Type | Treatment train with desalination   |
|------------|------|---|
| A-F        | 5a   | Chemical precipitation <sup>1</sup> , Filtration, Filtration with membranes <sup>2</sup> , RO desalination and residual chlorine.                                       |
| B, C, D, E | 5b   | Chemical precipitation <sup>1</sup> , Filtration <sup>3</sup> , EDR desalination and Disinfection (tendency to use ultraviolet radiation followed by residual chlorine) |

- <sup>1</sup> Physical-chemical treatment with a lamella settling system.
- <sup>2</sup> Typical process flow diagrams incorporating membranes before RO as protective barrier.
- <sup>3</sup> Physical-chemical treatment with a lamella settling system.
- <sup>4</sup> Double depth filtration with continuous washing is being used.

## Establishment and Operation Cost of Selected Treatment Trains

| Treatment train     | Costs                                       |   |
|---------------------|---|---|
|                     | Establishment                               | Operation                               |
|                     | €/(m <sup>3</sup> <sub>designed</sub> /day) | €/(m <sup>3</sup> <sub>produced</sub> ) |
| Type 1              | 164 - 351                                   | 0,14 - 0,20                             |
| Type 2 <sup>1</sup> | 27 - 47                                     | <b>0,06 - 0,09</b>                      |
| Type 3              | 9 - 22                                      | 0,04 - 0,07 <sup>2</sup>                |
| Type 4              | 5 - 11                                      | 0,04 - 0,07                             |
| Type 5.a            | 259 - 458                                   | <b>0,35 - 0,45<sup>3</sup></b>          |
| Type 5.b            | 248 - 405                                   | 0,35 - 0,45 <sup>4</sup>                |

- <sup>1</sup> This treatment train is used for industrial applications 3.1a), b) and c) due to E. coli and Turbidity requirements.
- <sup>2</sup> Disinfection means €0.005 per m<sup>3</sup> produced so this unit process is not seen in the displayed value.
- <sup>3</sup> Cases where physical-chemical treatment operation can be left out, cost may be ranging from €0.30 to €0.40 per m<sup>3</sup> produced.
- <sup>4</sup> Cases where physical-chemical treatment operation can be left out, cost may be ranging from €0.30 to €0.40 per m<sup>3</sup> produced.

**INNOVA-MED CONFERENCE**

*"Innovative processes and practices for wastewater treatment and re-use in the Mediterranean region"*

**SESSION 3: WATER RECLAMATION AND REUSE**

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ESTIMATION OF SUITABLE TREATMENT TRAINS**

**Thank you for your attention**

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