

I CONFERENCIA INTERNACIONAL DE
LA ASOCIACIÓN ESPAÑOLA DE REUTILIZACIÓN SOSTENIBLE DEL AGUA
Madrid, 19-20 Oct 2010

WATER REUSE IN PORTUGAL: REGULATIONS AND PRACTICE

Helena MARECOS do MONTE

Instituto Superior de Engenharia de Lisboa

1950-062 Lisboa, Portugal



WATER CONSERVATION

- **Water conservation** is a principle of paramount importance in **sustainable water resources management**.
- **Water availability** varies widely according to geographic location and seasons.
- **Water demand** for human activities is not constant:
 - Continuous demand growth due to demography, urbanisation, socio-economic development;
 - Seasonal demand peaks due to agriculture and tourism.
- Situations of unbalance.
- **Pollution** decreases water availability.

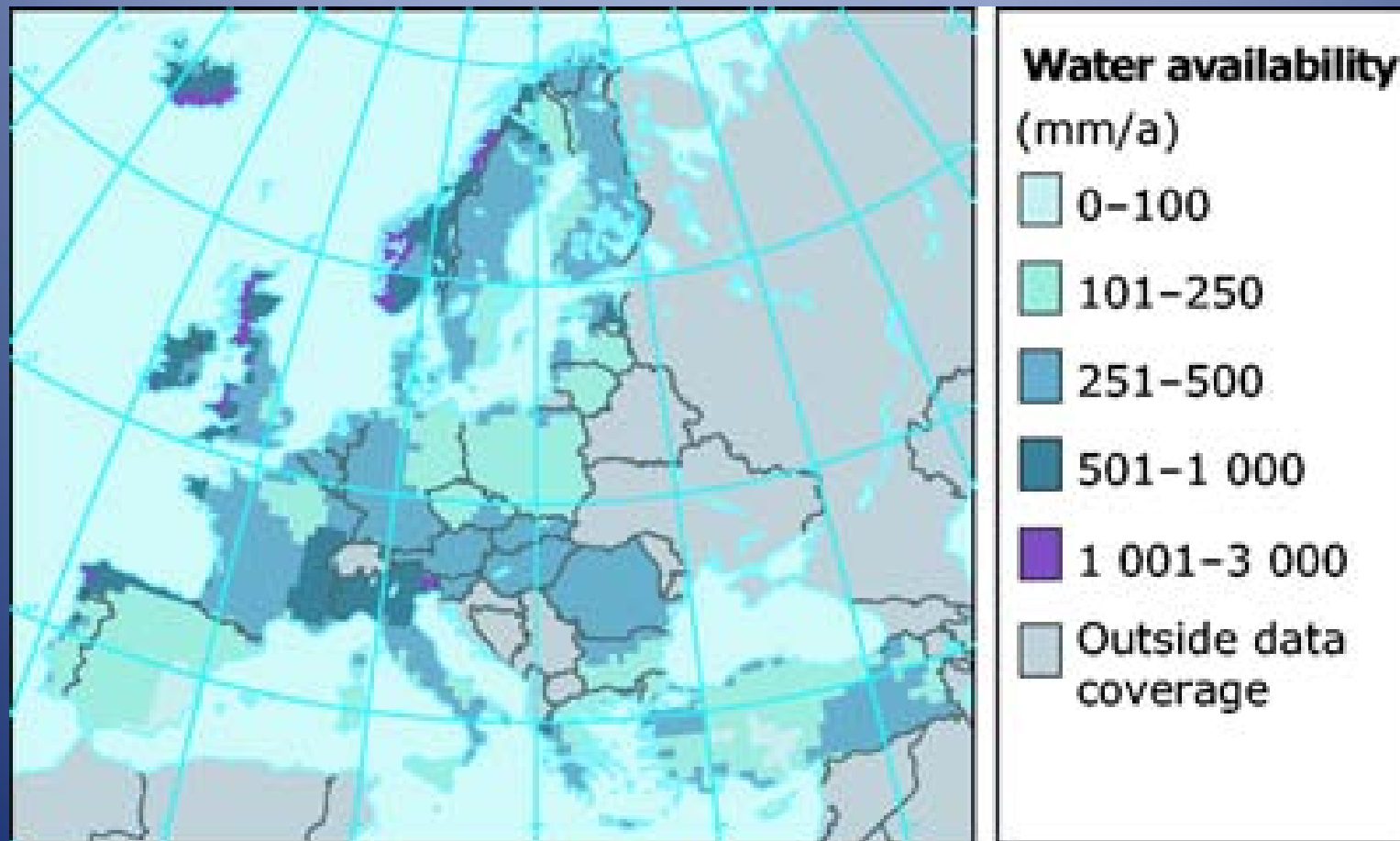


WATER CONSERVATION VS WATER REUSE

- **Climate change** tends to decrease available water in Portugal:
 - Droughts – decrease water quantity.
 - Floods - decrease water quality.
- The need for sustainable water management => the need to implement **efficient use of water** => several strategies.
 - **Reuse of treated wastewater** is an important strategy.

WATER RESOURCES IN PORTUGAL

Water availability in Europe



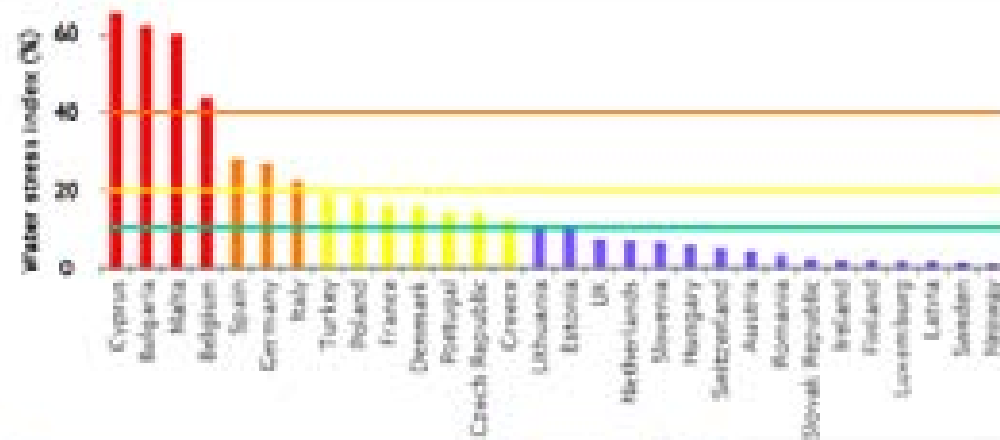
Source: EEA

WATER STRESS INDEX IN EUROPE

• Total abstraction/ annual renewable water resources:

- < 19%
- > 40%

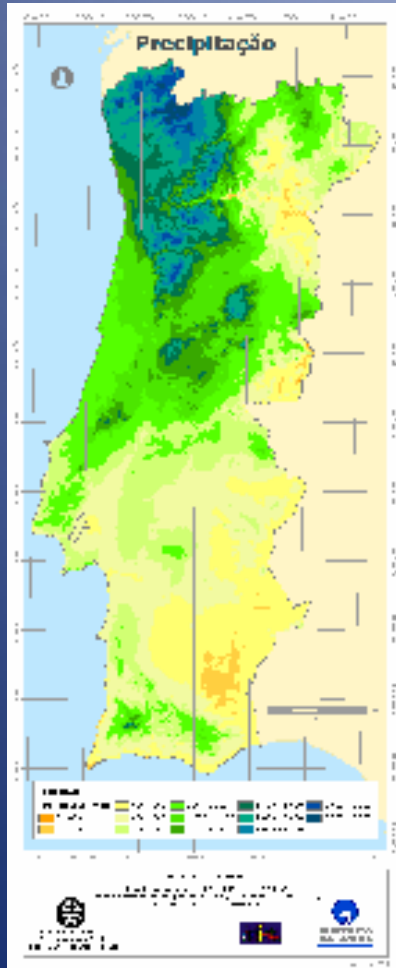
Water stress index



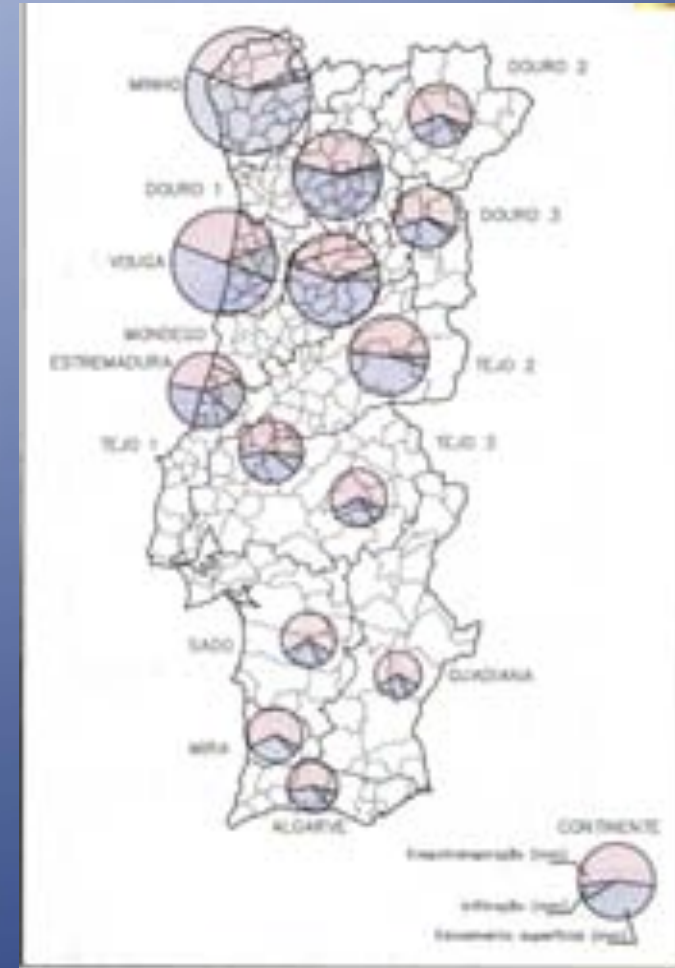
Source: AQUADOC, 2006 / Haskett et al, 2006
(based on data of EEA and national state of the environment reports)



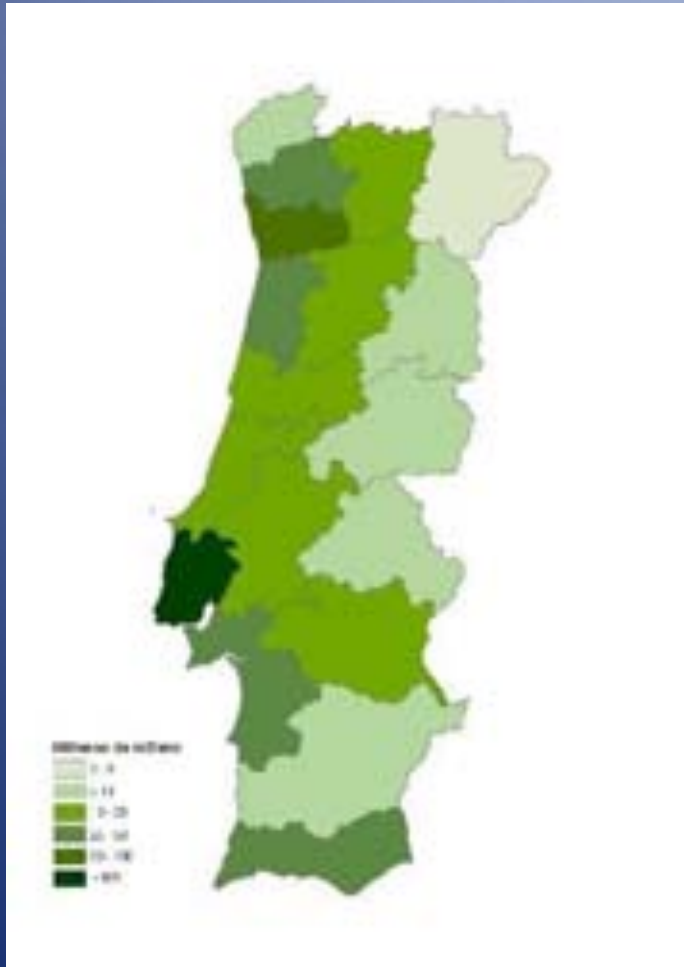
Portugal: Hydrological balance



- 40 % of water flows from Spain
- 57,5% of Portugal mainland experiences water deficit
- Droughts
- Climate changes tend to aggravate the situation mainly in southern regions
- Development can no longer be based on abstraction of water from easily accesible rivers and less deep aquifers.



Treated wastewater in Portugal



- Presently > 70% of the Portuguese population is equipped with WWTP.
- Goal of PEAASAR II:
90% of the population in 2013.
- ≥ 500 million m³/year of treated UWW.
- Part of this water may be considered a source for new uses.

THE STRATEGIC FRAMEWORK

FOR **WATER REUSE** IN PORTUGAL

What does PEAASAR II states?

- It is a **national objective** to reach **$\geq 10\%$ of treated WW reused by 2013**
 - (Operational objective 2)
- Reuse for non potable uses within WWTP is already very common.
- Higher potential for water reuse in the southern half part of Portugal (due to its geographic and socio-economic features).
- Higher potential for large WW systems.
- High potential for golf courses.



WHAT DOES PNUEA STATE?

Sectoral water demand	Million m ³ /year
Urban supply	570
Agriculture	6 550
Industry	385
Total	7500

- Total inefficiencies = 3100 m³/year
- **Measure 04** (applicable to public urban systems) : **reuse of treated WW.**

If PEAASAR II goals are reached:

570 million m³/year x 0,9 x 10% = 50 million m³/ano



WATER REUSE IN PORTUGAL

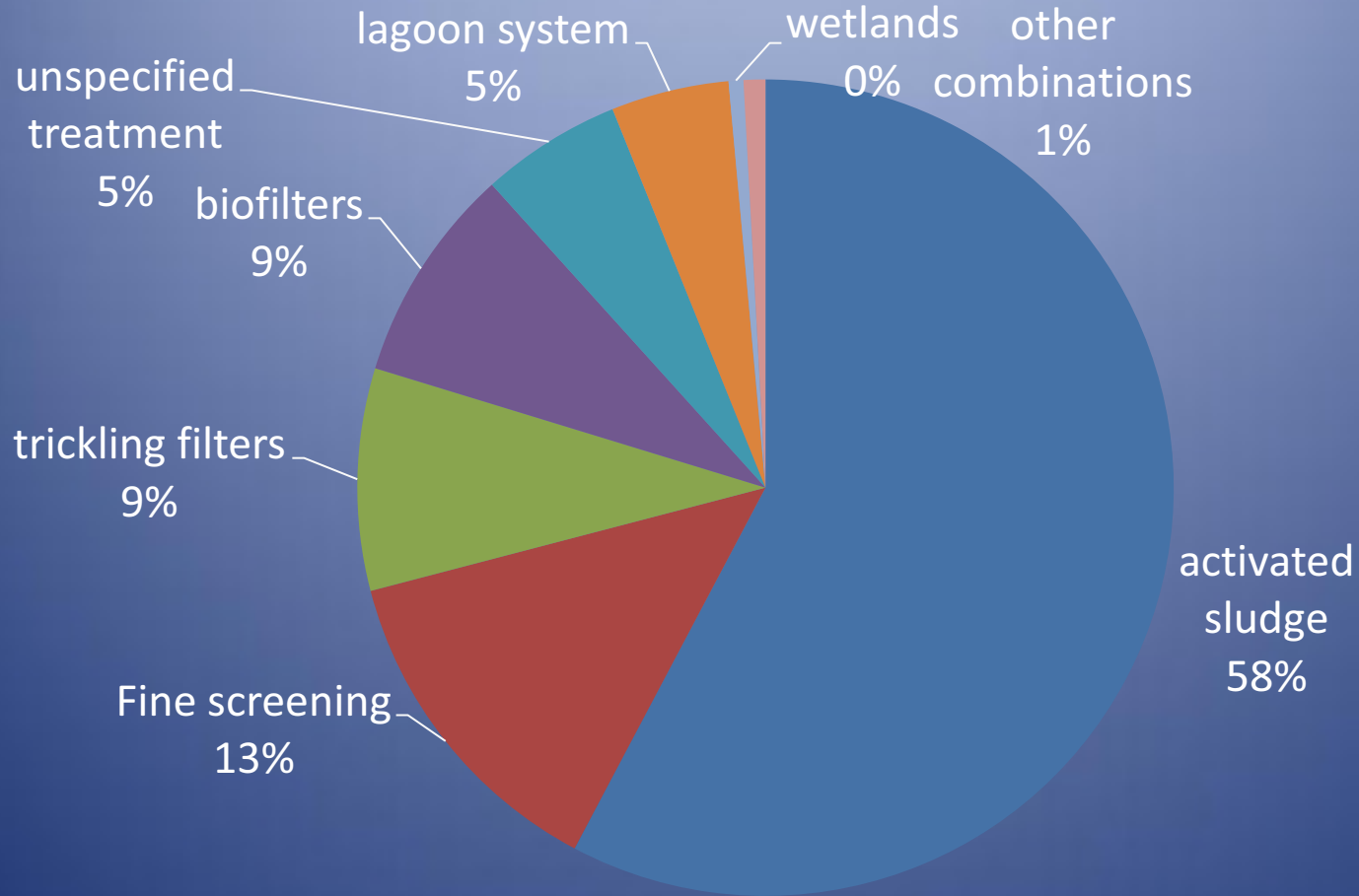
PRACTICE

Ongoing and planned projects



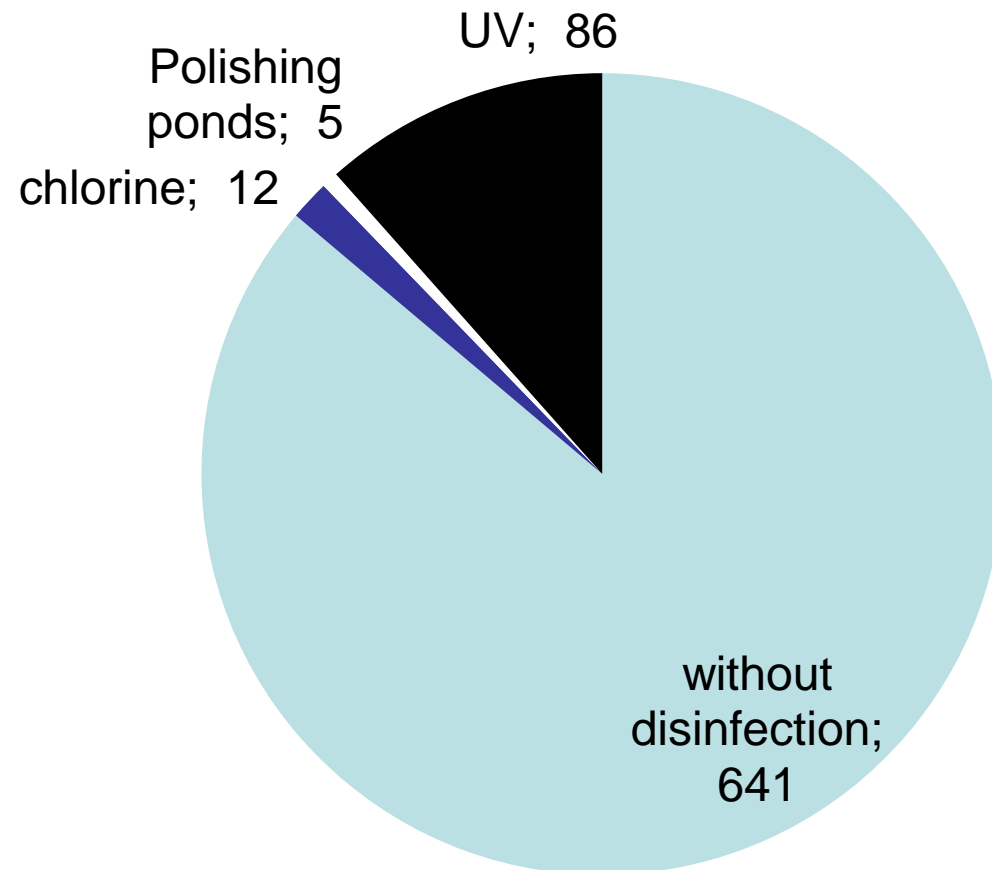
1. Landscape and agricultural irrigation, urban non-potable uses at Águas do **Oeste**
2. **Mafra** – irrigation of urban leisure areas, other uses as dust control in civil works (SIMTEJO)
3. Building acclimatization, toilet uses and landscape irrigation – **Frielas** WWTP (SIMTEJO)
4. Landscape irrigation in **Lisbon** front – Alcântara WWTP (SIMTEJO)
5. Agricultural irrigation - Foz do Lizandro WWTP (SIMTEJO)
6. Landscape irrigation in **Cascais** area – Guia WWTP (SANEST)
7. Alentejo
8. Landscape irrigation and golf courses – several WWTP (Águas do **Algarve**)

TYPE OF WASTEWATER TREATMENT



% of TWW volume (2009 - 391 millions m³)

TYPE OF WASTEWATER TREATMENT - disinfection



Location of WWTP in the Aguas do Oeste region





Potential applications for water reuse identified in the Oest district

Public users

- Landscape irrigation
- Urban cleaning
- Car and several equipment cleaning
- Toilet flushing
- Fire protection
- Other

Private users

- Industry
- Toilet flushing
- Agricultural irrigation
- Civil construction



WWTP producing water for reuse

Municipality	WWTP
Alcobaça	Alcobaça / Fervença, Benedita, Pataias/ Alpedriz, Pedra do Ouro, São Martinho do Porto and Vale de Paredes
Arruda dos Vinhos	Arruda dos Vinhos
Óbidos	Carregal, Casalinho, Charneca, Gaieiras and Óbidos
Lourinhã	Miragaia and Zambujeira
Peniche	Atouguia da Baleia, Bufarda, Paço and Serra d'El Rei
Sobral de Monte Agraço	Gosundeira, Ponte de Monfalim and Sobral de Monte Agraço
Torres Vedras	Dois Portos, Maceira, Maxial, Silveira, Torres Vedras, Turcifal/Freiria and Runa

POTENCIAL DEMAND FOR TREATED WW REUSE IN ÁGUAS DO OESTE DISTRICT (10³m³/year)

Municipality	Toilet flushing	Industry	Landscape irrigation	Agricultural irrigation	Urban cleaning		Total
					Streets	Cars and solid waste containers	
Alcobaça	750,8	75,9	1 896,0	-	330,5	2,2	3 055,4
Arruda dos Vinhos	77,2	3,8	63,8	550,2	20,1	0,5	715,6
Lourinhã	290,2	3,9	334,5	731,3	144,3	1,0	1 505,2
Óbidos	81,0	1,2	67,2	1 362,7	37,8	0,8	1 550,7
Peniche	372,0	15,6	305,9	377,4	70,8	1,5	1 143,2
Sobral de Monte Agraço	123,8	24,7	415,6	-	56,1	0,8	621,1
Torres Vedras	859,5	14,8	2 843,3	195,7	321,4	2,9	4 237,7
TOTAL	2 554,5	139,9	5 926,3	3 217,1	981,0	9,7	12 828,9
%	19.9	1.1	46.2.	25.1	7.7	0.08	100.0

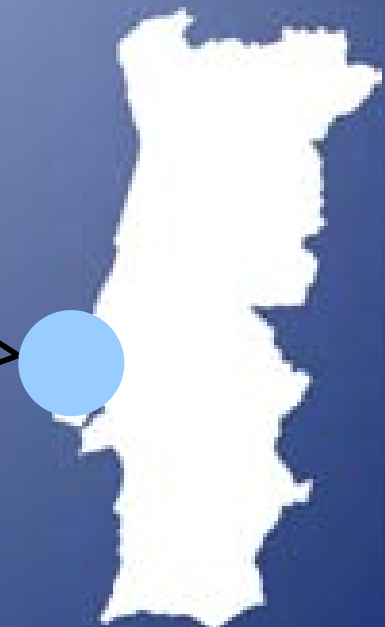
1 500 000 hab.eq (2005)



Municipalities:

- Lisboa
- Loures
- V. F. Xira
- Amadora
- Mafra
- Odivelas

2002 - 2043



POTENCIAL LISBOA AREA APLICATION

- **Agricultural irrigation:** commercial nurseries and crop irrigation;
- **Landscape irrigation:** cemeteries, golf courses, industrial park, public park, roadway medians and roadside plantings;
- **Industry:** Cooling water, fire protection, heavy construction, process water;
- **Non potable urban uses:** air conditioning, commercial car wash and laundries, decorative fountains, fire protection, municipal urban services, toilet flushing, sewer flushing;
- **Recreation/environmental uses:** artificial lakes, wetlands

WATER REUSE in 3 WWTP in LISBON



Beirolas/Lisboa WWTP (SIMTEJO)– landscape irrigation and service water in the WWTP



- Dry weather flow:
54.500 m³/day

Effluent quality:

- BOD : 25 mg/L
- COD : 125 mg/L
- TSS : 35 mg/L
- FC : 200 NMP / 100 mL

Chelas/Lisboa WWTP (SIMTEJO)– landscape irrigation and service water in the WWTP



- Dry weather flow: 52.500 m³/day

Effluent quality:

- BOD : 25 mg/L
- COD : 125 mg/L
- TSS : 35 mg/L
- FC :200 NMP / 100 mL

CHELAS WWTP



Dry weather flow:

38.719 m³/day

Internal reclaimed water used :

2191 m³/day

Street cleaning:

17 m³/day (1 year experience)



Reclaimed water

BOD : < 25 mg/L

COD : <125 mg/L

TSS : < 35 mg/L

FC effluent: < 0 NMP / 100 mL

L

Chelas WWTP - ongoing project

Chelas Valley/ Marvila
Landscape and
agricultural irrigation

- Quarters of:
 - Lóios,
 - Flamenga,
 - Armador,
 - Condado,
 - Amendoeiras
- Belavista Golfe,
- Belavista urban park.



Alcântara/Lisboa WWTP (SIMTEJO)– landscape irrigation and service water in the WWTP

- Dry weather flow:
181.000 m³/day

Effluent quality:

- BOD : 25 mg/L
- COD : 125 mg/L
- TSS : 35 mg/L
- FC : 2000 NMP / 100 mL



LISBON DOWNTOWN (ALCANTARA – TERREIRO DO PAÇO)

ONGOING PROJECT

- Pilot project that consists in a reclaimed water pipe from Alcantara WWTP to downtown center Terreiro do Paço).
- Main goal applications: Landscape irrigation, street cleaning ,combined sewer flushing and service water in sewer pumping stations
- Cost synergy with new sewer installation



Alcântara/Lisboa WWTP – Pipe Alcântara –Terreiro do Paço



Alcântara/Lisboa WWTP – Pipe Alcântara –Terreiro do Paço

EXAMPLE OF SYNERGY INSTALATION



Mafra WWTP (SIMTEJO)– landscape irrigation, other uses as dust control in civil works



Dry weather flow: 1.709 m³/day

Internal Reclaimed water used : 200 m³/day

Reclaimed water delivery to municipality for landscape park night irrigation
413 m³/day

MALVEIRA WWTP

Dry weather flow

3.509 m³/day

Internal Reclaimed water used :

203 m³/day



ERICEIRA WWTP

Dry weather flow

2.115 m³/day

Internal Reclaimed water used :

133 m³/day



FRIELAS WWTP



Dry weather flow:

48 735 m³/day

Internal use in the WWTP :

720 m³/day

Reclaimed water delivery to IKEA Loures for cooling in air conditioning:

3 200 m³/day (summer)

1 280 m³/day (winter)



FRIELAS WWTP - CONSTRUCTED WETLANDS IN LOURES

- Create a polishing constructed wetland for Frielas WWTP effluent.
- The reclaimed water has potential for agricultural irrigation



RURAL TOURISM WINERY

(VILA GALÉ - BEJA)

- Secondary treated wastewater from tourism facilities, including wine and olive oil industry;
-
- Treated wastewater mixed with groundwater in a storage reservoir;
- Applied in the vineyard through drip irrigation. No direct discharge in the river system;
- Established monitoring program for irrigation water.



HIGH WAY SERVICE AREAS – A2 –

ALCÁCER DO SAL (BEJA)



- Tertiary treated WW used for landscape irrigation .
- Secondary treated WW is discharged in watercourses.
- Storage capacity available for disinfected effluent used in areas where human contact is offbeat.
- Watering schedules (few users)

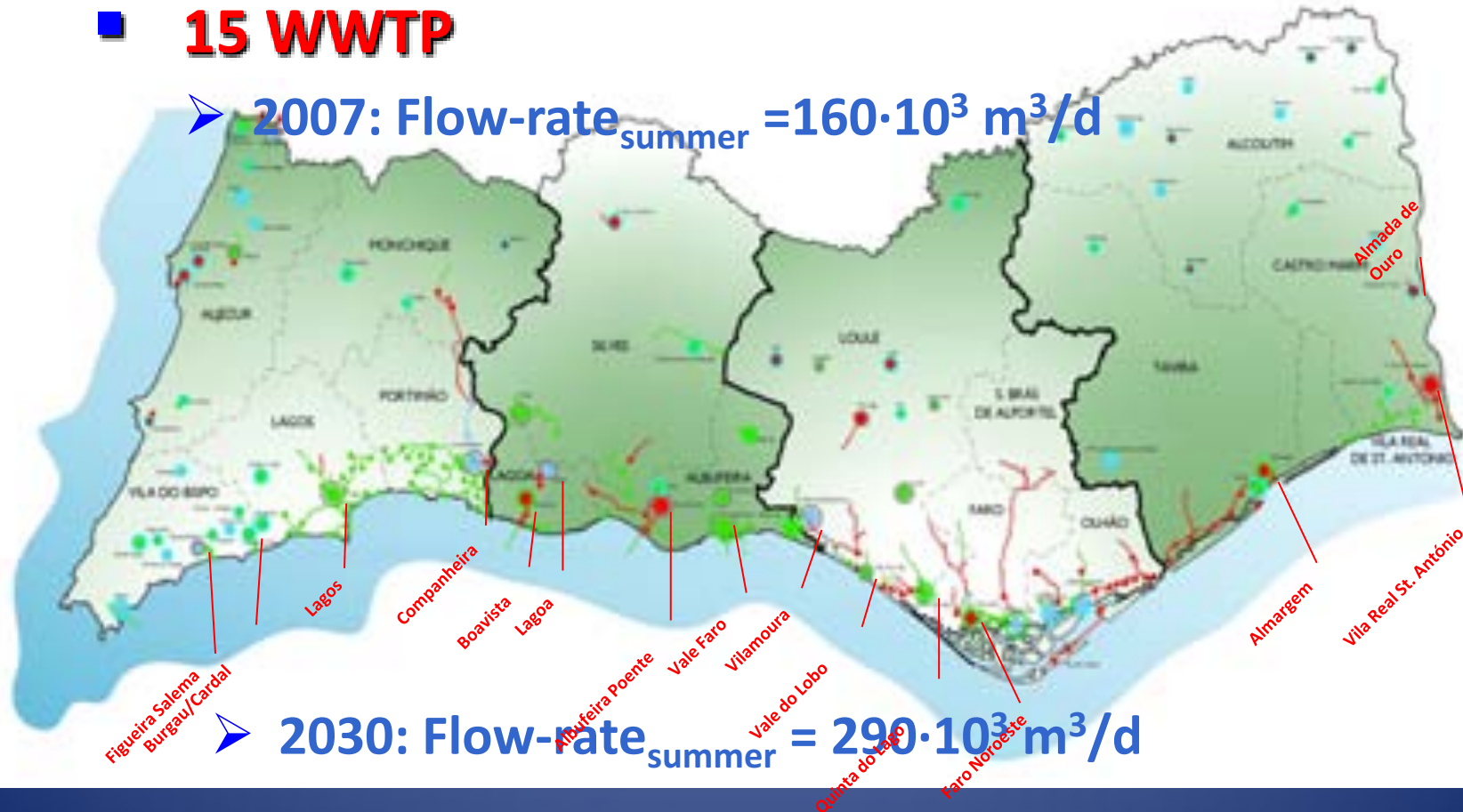
WATER REUSE PROJECTS BEFORE ÁGUAS DO ALGARVE

- 1994 ... 2010
 - Reuse of the effluent from Armação de Pera WWTP for the irrigation of Sagados golf
 - Disinfection treatment : sand filtration and chlorination
- 1999 onwards
 - Reuse of the effluent from Quinta do Lago WWTP for irrigation of S. Lourenço golf course and landscape irrigation in Quinta do Lago.

WWTP SELECTED FOR RREUSE

■ 15 WWTP

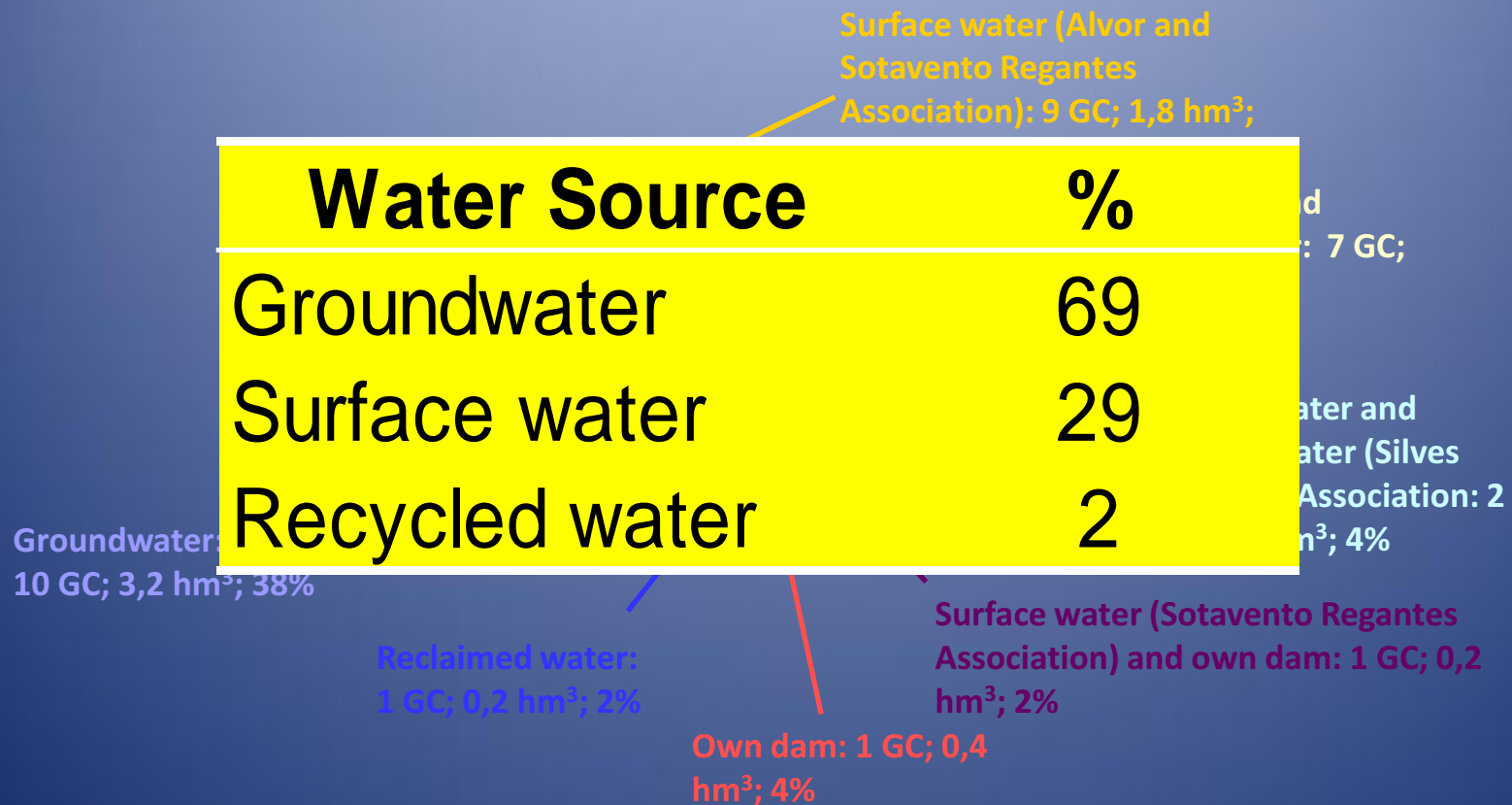
➤ 2007: Flow-rate_{summer} = $160 \cdot 10^3 \text{ m}^3/\text{d}$



➤ 2030: Flow-rate_{summer} = $290 \cdot 10^3 \text{ m}^3/\text{d}$

WATER SOURCES AND WATER IRRIGATION DEMAND

- Annual water irrigation demand: 8,7 hm³ (31 GC = 513 holes; 28,5 GC 18 holes)



WATER DEMAND FOR GOLF COURSES IRRIGATION

■ At present:

➤ 8,7 hm³/year (31 GC = 513 holes)



120.000 hab. eq.

➤ GC Maximum daily flow rate : 2.500 m³/d

■ Near future:

➤ More 19 GC = 341 holes; 5,7 hm³



80.000 hab. eq.

➤ Total = 14.4 hm³/year



200.000 hab. eq.



ASSESSMENT OF TWW QUALITY FOR REUSE IN IRRIGATION

EFFECTS ON GRASS AND SOILS

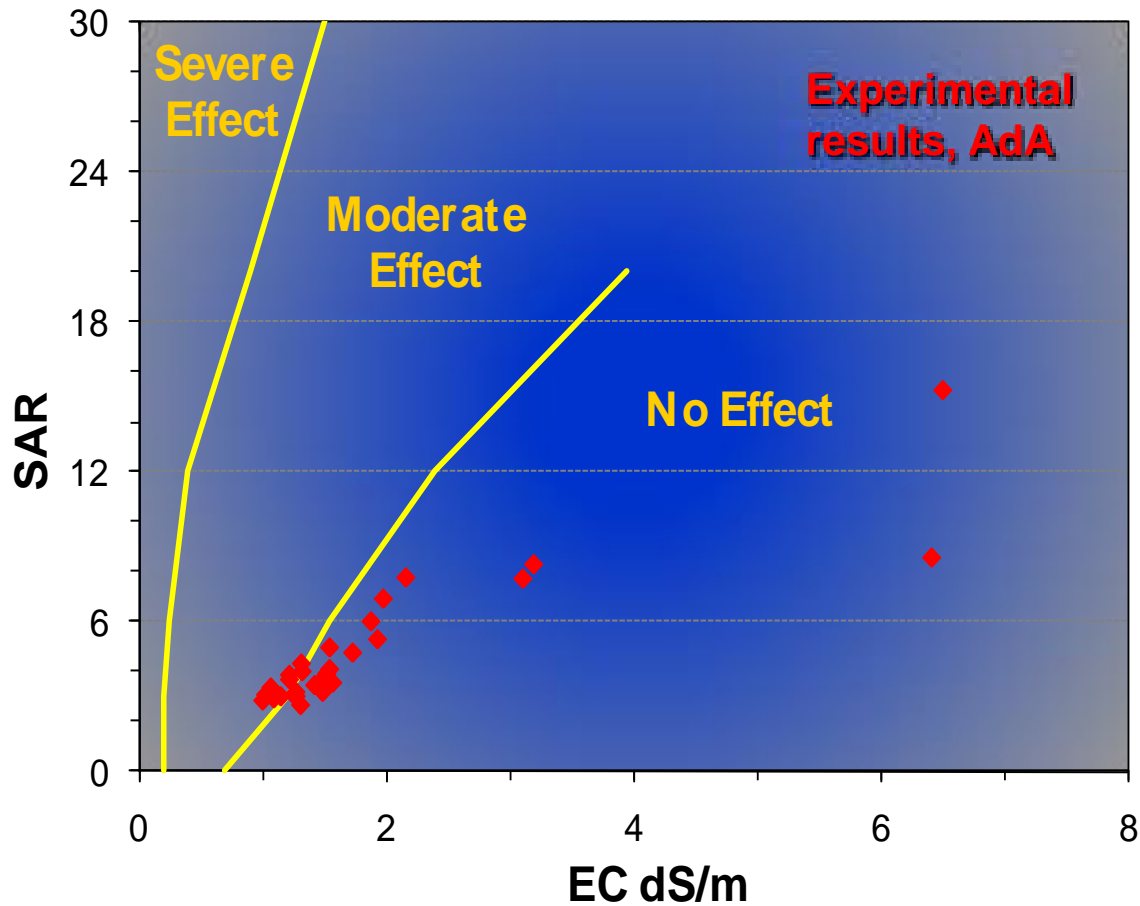
	Parameter	Vilamoura WWTP				Almargem WWTP				Legislation	
		Low tide		High tide		Low tide		High tide		VMR	VMA
		Value	Effect	Value	Effect	Value	Effect	Value	Effect		
Effect on the grass	Salinity (TDS) (mg/l)	629	LM	631	LM	1045	LM	1673	LM	640	--
	Conductivity (Ec) (dS/m)	1,2	LM	1,2	LM	1,9	LM	3,1	H	1	--
	Chloride (mg/l)	163	LM	165	LM	267	LM	511	H	70,0	--
	Boron (mg/l)	0,22	N	0,14	N	0,23	N	0,35	N	0,3	3,75
	Sodium (mg/l)	130	LM	108	LM	200	LM	390	LM	--	--
	SAR	3,7	LM	3,0	N	5,3	LM	7,7	N	8,0	--
	Adjusted SAR (2)	4,7	LM	3,8	LM	6,5	LM	9,6	H	--	--
Effect on soils	Relationship SAR↔Ec	--	N	--	N	--	N	--	N	--	--
	Relationship SAR Adjusted↔Ec	--	N	--	LM	--	N	--	LM	--	--
	Residual sodium RSC	2,5	M	1,7	LM	3,3	M	-1,4	LM	--	--

Effects: Null (N); Light-Moderate (LM); High (H)

Generally speaking, the treated wastewater is less saline than many of the groundwater currently used for irrigation.

ASSESSMENT OF TWW QUALITY FOR REUSE IN IRRIGATION

RISK OF LOSS OF PERMEABILITY SOILS DUE TO THE INTERFACE BETWEEN CONDUCTIVITY –SAR (Ayers e Westcot, 1994; Harivandi, 2004)



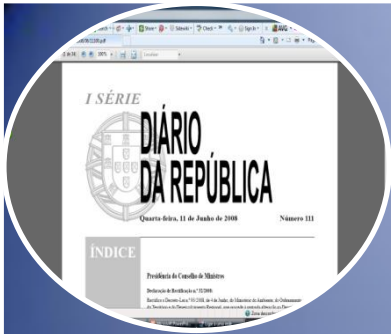
BALANCE

TREATED WW AVAILABILITY / WATER IRRIGATION DEMAND

- Seasonality !



PORTUGUESE REGULATIONS ON
WATER REUSE



LEGAL FRAMEWORK

- **Water Act nº 58 /2005**

- **1st Art.** "... to promote a sustainable water use, based on a long-term protection of water resources ..."

- **Decree-Law 226-A/2007 - Water Uses**

- **44th Art.** "The use of public waters for gardens irrigation, other public spaces, and golf courses shall be, whenever possible, supplement by other water sources, including the use of urban wastewater properly treated for the purpose or reuse water runoff resulting from irrigation of the field itself. "
- **57th Art.** "Treated waste water should be reused whenever possible or appropriate, ..."

- **Decree-Law 236/98 - Standards, criteria and water quality objectives**

- **58th Art.** "The use of wastewater for agricultural irrigation and forest is subject to licensing by the ARH and depends on the agreement of the Health Authority and Regional Agricultural Administration."

–
"The use of wastewater for watering public gardens is also subject to previous ARH approval, with the agreement of the Health Authority."

- **Decree-Law 152/97 - Treatment of urban wastewater**

- **11th Art.** "The treated wastewater and sludge should be reused whenever possible or appropriate."

Portuguese standard on treated wastewater reuse for irrigation NP 4434

- Agronomic quality
 - FAO
 - DL 236/98 - Annex XVI
- Microbiologic quality – public health
 - WHO -1973, 1989, 2006
- NP 4434:2005



NP 4434 presents:

- Requirements for treated wastewater quality * for irrigation
- Criteria for irrigation methods and equipment
- Procedures for irrigation operation
- Procedures to ensure environmental protection
- Procedures for environmental monitoring

* Industrial wastewater and livestock slurries are excluded from NP 4434 scope.

Crop categories

Category A Vegetables to be eaten raw.

Category B Public parks and gardens and sport fields, forest with easy public access.

Category C Vegetables to be eaten cooked, forage crops, vinyards and orchards.

Category D Cereals (excluding rice), Vegetables and other crops to be used as raw material in industry, e.g. textile, extraction of oils and vegetal essences, forest crops, lawns not easily accessed by people or with controled access.

Crops to be watered with TWW

- Permission to irrigate crops of categories A, B, C e D depends on the wastewater treatment level..
- Vegetables to be eaten raw can only be watered with TWW through subsurface irrigation or drip irrigaton.
- Vegetables to be eaten raw whose eadible parts are close to the watered soil are not to be irrigated with TWW.

Characteristics of irrigation site

- **Soil chemical characteristics**
 - Only soils whose heavy metals content exceeds VMA for soils receiving sludge are to be excluded from irrigation with TWW.
- **Topography**
 - Slope < 20%, function of irrigation method.
- **Hydrogeologic vulnerability**
- **Distance to houses and water sources**

Minimization of environmental impacts and public health risks

- **Risks to be controled:**
 - Surface and groundwater contamination due to TWW infiltration and runoff;
 - contact of people and animals with plants and soil watered with TWW;
 - Contamination of plants and soil and water bodies out of the irrigation site by water drops carried by the wind;
 - Inalation by people and animals of aerosols originated by spray irrigation.

Procedure for the minimization of environmental impacts and public health risks

- **Irrigation**

- Signalling
- Attention to cross connection between irrigation water pipes and drinking water pipes
- Irrigation at night/or out of public access period
- Spray irrigation – portable anemometer
- Individual protection equipment for irrigation operators
- Pasture - access to animals forbidden during the week following the irrigation
- Orchards – close irrigation 2 weeks prior harvesting



ATENÇÃO!

ZONA DE REGA COM
ÁGUAS RESIDUAIS
TRATADAS

ÁGUA NÃO POTÁVEL

Procedure for the minimization of environmental impacts and public health risks

- Barriers for protection of surrounding area
 - Spray irrigation – protection by a curtain
 - Drainage (surface and subsurface)
 - Protection strips of non irrigated areas (2 m), with natural wild vegetation

Control and monitoring of the irrigation field

• Background

- Nutrient (N, P e K) carried with TWW should not exceed the crop needs ;
- the amount of heavy metals annually applied on soil should not exceed the maximum values in NP 4434;

Control documents

- Analyses of TWW used for irrigation
 - Responsibility _ WWTP operator company
 - Records of the Volum of TWW applied for irrigation
 - Record of the mass of nutrients and heavy metals applied on soil by TWW;
 - Calculation
- $$M = V \times C$$
- Fertilisation Plan concerning the global area.

FERTILIZATION PLAN

- Soil analyses /or Leeves analyses
- Calculation sheet for the amount of nutrients to be applied
- Fertilization programme - calendar
- Fertilization sessions - records

Monitoring of TWW reuse system

- **Treated wastewater**
 - Responsibility: WWTP or the organisation responsible for effluent storage.
 - Frequency according to water characteristics variability.
 - Weekly : pH, salinity (conductivity), NO_3 , N-NH_4 , PO_4 .
- **Soil**
 - Annual analysis
- **Water bodies**
 - Piezometers – ensuring that groundwater is sampled up to 1 m in farmed areas and 1,8 m in forest.

Portuguese Guidelines on Wastewater Reuse

- Published in **January 2010** by:
ERSAR - Portuguese Regulator Authority for Water and Sanitation Services
- **Authors:**
 - **Helena Marecos do Monte**
High Engineering Institute of Lisbon (ISEL)
 - **António Albuquerque**
Beira Interior University (UBI)
- **Objective:**
 - to provide the public with a supporting tool for the implementation of reclaimed wastewater reuse projects.



Target public

The Guide on Wastewater Reuse addresses to every professional in the water industry, particularly to:

- manager organizations of public urban wastewater systems and drinking water supply systems,
- river basin region managers,
- public health authorities,
- tourism operators
- and other public and private organizations interested in the implementation of wastewater reuse projects.



Guide contents

➤ Organization

This Guide focus on the **wastewater quality aspects that affect the several reuse applications** – irrigation, non-potable urban environmental and recreation applications, etc. .

The **legal and institutional issues** related to water reuse projects' implementation, the **economic and financial viability** aspects , **public participation and acceptance** of water reuse projects are also approached in this Guide .

PART I – INTRODUCTION AND FUNDAMENTAL CONCEPTS

Introduction. Health and environmental effects associated with quality characteristics of reclaimed wastewater. Water reuse applications. Quality criteria for reclaimed wastewater reuse.

CAP 1

CAP 2

CAP 3

CAP 4

PART II – STRATEGY TO IMPLEMENT RECLAIMED WASTEWATER REUSE SYSTEMS

The legal and institutional framework of water reuse. Methodology for implementation of reclaimed wastewater reuse systems. Engineering issues. Economic issues. Public participation...

CAP 5

CAP 6

CAP 7

CAP 8

CAP 9

BIBLIOGRAPHY

GLOSSÁRIY

ANNEXES

Guidelines can be downloaded at:

- <http://www.ersar.pt>
- <http://www.ersar.pt/website/ViewContent.aspx?FolderPath=%5cRoot%5cContents%5cSitio%5cMenuPrincipal%5cDocumentacao&SubFolderPath=%5cRoot%5cContents%5cSitio%5cMenuPrincipal%5cDocumentacao%5cPublicacoesIRAR&BookCategoryID=1&BookTypeID=1&Section=MenuPrincipal>

hmarecos@dec.isel.pt

Thank You

A decorative graphic featuring the words "Thank You" in a pink, cursive font. The text is surrounded by a green vine with several leaves and two pink flowers, one of which is fully bloomed with a yellow center.