TECHNICAL AND ECONOMIC EVALUATION OF WATER REUSE FROM WASTEWATER TREATMENTS PLANTS

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Introduction

- Water is a constrained natural resource and, in many areas of the planet, water shortage is considered to be one of the most important issues to be resolved.
- Today the problem of limited water recourses has become crucial due to the intense character of the water shortage.
- Many infrastructure projects have been planned and / or constructed in the islands to solve the problem (especially desalination plants, water ground reservoirs, dams) .

The water shortage problem…

- In Greece accordingly, and more specifically in the Aegean Islands, water demand and supply is a difficult problem that needs to be assessed and has either a temporal character (appears only in summer months) or a permanent one in extreme cases (through out the year).

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Background of the work

- Therefore, the limited water resources problem had led to the exploitation of alternative water supply methods and techniques in all the ranges of end uses.
- Amongst them, most commonly applied is the seawater desalination and, more recently, the reclamation and reuse of wastewater.
- Till date agricultural irrigation seems to be the most common use of treated municipal wastewater
- Furthermore, Greece presents a very good application example of reclamation and reuse of wastewater case, since about 80% of Greek wastewater effluents are produced in regions with deficit water balance

Scope of the work

- The aim of the present work is the techno-economic evaluation of the conversion of a WWTP from secondary to tertiary treatment, calculating
  - the investment required and
  - the potential benefit from the water selling to various interested users.
- *The results of the work include an idea on the areas where such an investment would be more promising in terms of water demand*

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Greek Water River Basin Districts (RBDs)

Greece is divided into 14 RBDs with the most problematic in terms of water balance deficiencies being East Peloponnese, Sterea Hellas, Thessaly and the district of Aegean Islands.

Source: (Koutsoyiannis and Andreadakis, 2008)

Deficiencies observed in RBDs

→ Up to today the problem is mainly faced by the transportation of assorted resources from neighbouring RBDs, but this does not pose any sustainable vision for its long-term resolution.

The profile of irrigation water demand may match satisfactorily with the availability of waste water from the corresponding local plants.

a/a	Greek RBDs	Water (de-) efficient
1	West Peloponnese	Surplus
2	North Peloponnese	Surplus
3	East Peloponnese	Deficient
4	West Sterea Hellas	Surplus
5	Epirus	Surplus
6	Attica	Marginal surplus
7	East Sterea Hellas	Deficient
8	Thessaly	Deficient
9	West Macedonia	Surplus
10	Central Macedonia	Marginal surplus
11	East Macedonia	Surplus
12	Thrace	Surplus
13	Crete	Marginal deficient
14	Aegean islands	Deficient

Source: (Koutsoyiannis and Andreadakis, 2008)

Hydrological balance in Greece 1/2

- Over the past 50 years, water demand has increased tremendously
- Total permanent population is aprox.11,000,000 inhabitants (Census 2001), with water consumption need of about 200liters/day whilst the tourists spend about 300liters/day
- *In 2006, annual water consumption was estimated approximately at 8,243hm^3 (YPAN, 2006)…*

Hydrological water balance in Greece 2/2

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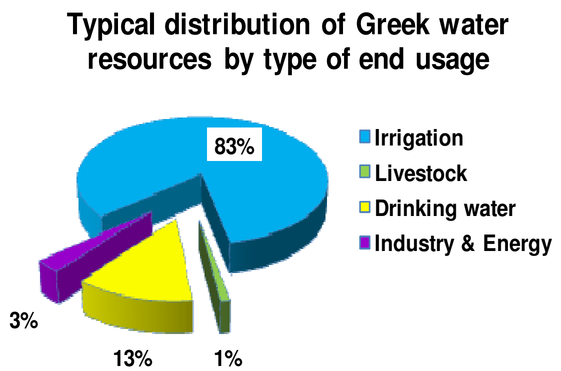
…from which almost 83% is meant for irrigation purposes, 1% for livestock, 13% for drinking purposes and the remaining 3% is consumed in industrial and energy applications



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Present situation of WWTPs in Greece

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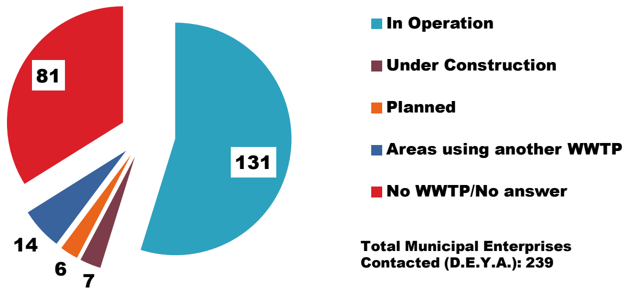
Present situation of WWTPs in Greece



Source: Optimisation of Production Systems Laboratory

In Greece, the population that needs to be served is estimated about 12,4 millions of p.e. (Ypan, 2006), whilst the total population equivalent of the country is approximately 15.2 millions p.e.

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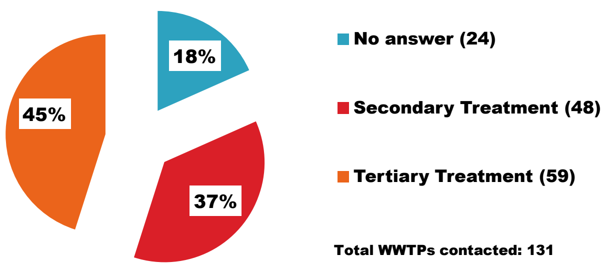
Stage of wastewater treatment of WWTPs in Greece



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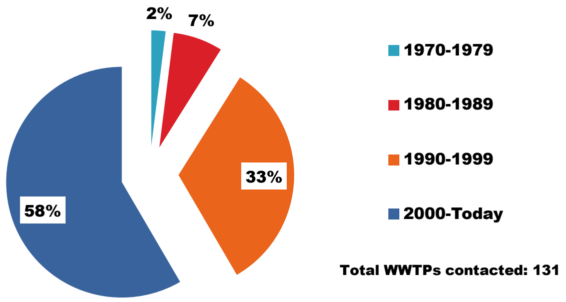
Construction - expanded year of WWTPs in Greece



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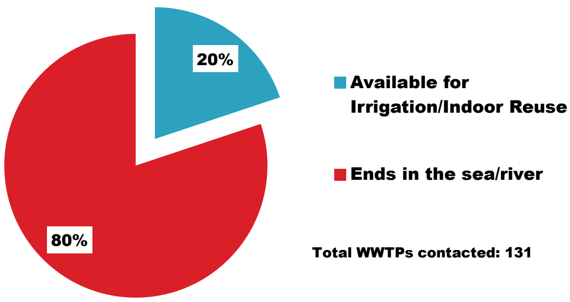
Water use of WWTPs in Greece after treatment



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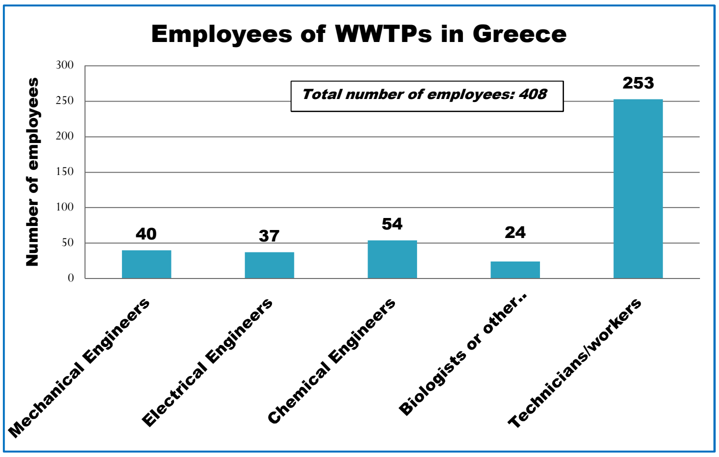
Present situation of WWTPs in Greece



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The largest WWPTs in land of Greece according equal population

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Techno-economic economic evaluation of WWTTP with water reuse

Case study considerations- specifications:

- Typical WWTP -operating in an agricultural area
- Plant conversion from secondary to tertiary treatment
- Recycled water will be used for irrigation purposes in the area

Geographical identity –water demand profile:

- Area: Serres (East Macedonia)
- Water needs: 17,200m^3/day
- Irrigation needs: 11,000m^3/day.

Problem dimensions:

- Settlement serving about 100,000 p.e
- Initial capital investment is estimated to 12,500,000€ (2010)
- Specific cost of the tertiary treatment and disinfection 4,000,000€
- (Table 5). The plant is situated in Serres (East Macedonia), where total

Design parameters – characteristics of the proposed plant

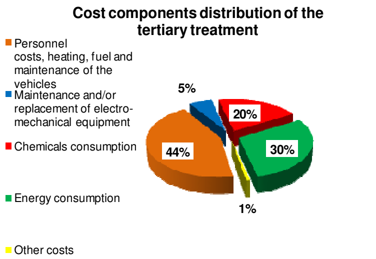
A/A	INPUT CHARACTERISTICS	UNIT	VALUES
1	Popul. Equivalent	p.e.	100,000
2	Max. daily supply	m^3/d	32,000
3	Hourly waste peak	m^3/h	1,458
4	Hourly design peak	m^3/h	1,762
5	Input from underground water	m^3/d	7,300
6	Volatile solids	kg/d	8,000
7	Average daily supply	m^3/d	15,000
8	BOD_5	mg/l	402
9	Total N	mg/l	80
10	Total NP	mg/l	16

Wastewater characteristics for the designed plant (Asimakis *et al*., 2009)

POLLUTION PAPAMETER	VALUE
BOD_5 (mg/l)	≤ 10
Volatile Susp. Solids (mg/l)	≤ 10
Total Nitrogen (TKN) (mg/l)	≤ 15
Ammonium nitrogen ($N\text{-}NH_4$) (mg/l)	< 2
Residual chlorine (mg/l)	≤ 0.50

Effluent specification (Asimakis *et al.*, 2009)

Cost components of proposed plant



Cost components distribution of the tertiary treatment

Cost components of the tertiary treatment	Cost (k€)
Personnel costs, heating, fuel and maintenance of the vehicles	175
Maintenance and/or replacement of electro-mechanical equipment	22
Chemicals consumption	80
Energy consumption	120
Other costs	3
Total	**400**

Cost components of the tertiary treatment

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Results 1/2

Year	Operational Cost per year (in k€)					Total tertiary treatment cost (in k€)
	Personnel and Overhead costs (increase 4% per year)	Energy costs (increase 3% per year)	Maintenance (increase 5% per year)	Chemicals (increase 3% per year)	Other expenses (increase 5% per year)	
2012	175	120	22	80	3	400
2013	182	124	23	82	3	414
2014	189	127	24	85	3	429
2015	197	131	25	87	3	444
2016	205	135	27	90	4	460
2017	213	139	28	93	4	477
2018	221	143	29	96	4	494
2019	230	148	31	98	4	511
2020	239	152	33	101	4	530
2021	249	157	34	104	5	549

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Results 2/2

Annual WWTP income for a selling price of 2 €/m^3 for various percentages of water recycle (in k€)

Percentage of water recycled and sold	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
5%	402	410	420	430	430	443	452	461	470	480
10%	800	820	840	850	870	887	904	920	940	960
15%	1,200	1,229	1,250	1,280	1,300	1,330	1,360	1,380	1,400	1,440
20%	1,600	1,640	1,670	1,700	1,740	1,770	1,800	1,840	1,880	1,920

Economic analysis of the investment (NPV & IRR) for 20% recycle percentage

Water selling price (€/m^3)	NPV (k€)	IRR		Water selling price (€/m^3)	NPV (k€)	IRR
1.3	-509	5.45%		1.6	889	12.12%
1.4	-43	7.79%		1.7	1,355	14.16%
1.5	423	10.01%		1.8	1,821	16.13%

Conclusions

- In the present study the possibilities of water reuse from wastewater treatment plants have been investigated
- For this purpose an economic model for the evaluation of the feasibility of converting a wastewater treatment plant from secondary to tertiary treatment has been developed
- The results showed that the investment is profitable for a water selling price >1.5€/m^3
- This price is acceptable since:

  2.0 €/m^3 <the price for transported water<10.0 €/m^3

Certainly this positive financial result is in addition to all other benefits of the investment, i.e development of a new water supply source and wastewater effluents minimization

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Thank you for your attention