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Wastewater reuse in Apulia: between dream and reality

Antonio Lopez

Water Research Institute

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Agricultural wastewater reuse in Apulia: between Dream and Reality

Antonio Lopez

ECI – WBTR
13 June 2014
Otranto - Italy
PRELIMNAY STATEMENT:
From a technical standpoint wastewater reuse is not a challenge anymore.

Singapore:

NEWater Project - Bottled Reverse Osmosis Drinking Water from blended MWW

(since 2001)
Water Reuse
Main Drivers and Trends

**Drivers**

- Water shortage
- More stringent regulations
- Social & Political & Market pressure

**Trends**

- New Standards
- New Analytical Methods
- New Treatment and Management
Wastewater reuse
-Types of reuse-

- IRRIGATION
- INDUSTRY
- GROUNDWATER RECHARGE
- NON POTABLE CIVIC USES (washing: roads, building, vehicles; feeding: cooling, heating, fire-fighting systems; washing toilets)
- DRINKING PURPOSES
Water reuse in EU Countries

Diversification of types of reuse

- Irrigation
- Landscape irrigation (golf courses)
- Grey water recycling
- Indirect potable reuse
- Industrial reuse

Canary Islands
Balearic Islands
Cyprus
Rainfall distribution in ITALY: average values (mm) in the period 1960-2010
Rainfalls trends in Apulia during the period 1970-2010
(Ten years average values measured at some rainfall stations)
### Inflows and Outflows average yearly values of the main Italian regional water basins (1965-2005)

<table>
<thead>
<tr>
<th>Main regional water basins</th>
<th>INFLOWS</th>
<th>OUTFLOWS</th>
<th>OUTFLOWS COEFFICIENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>$10^9$ m$^3$</td>
<td>mm</td>
</tr>
<tr>
<td>Po</td>
<td>1070</td>
<td>71.8</td>
<td>670</td>
</tr>
<tr>
<td>Veneto</td>
<td>1160</td>
<td>42.8</td>
<td>810</td>
</tr>
<tr>
<td>Liguria</td>
<td>1340</td>
<td>6.4</td>
<td>990</td>
</tr>
<tr>
<td>Romagna + Marche</td>
<td>940</td>
<td>20.6</td>
<td>460</td>
</tr>
<tr>
<td>Toscana</td>
<td>1010</td>
<td>20.9</td>
<td>470</td>
</tr>
<tr>
<td>Lazio</td>
<td>1020</td>
<td>24.1</td>
<td>440</td>
</tr>
<tr>
<td>Abruzzo + Molise</td>
<td>900</td>
<td>11.9</td>
<td>490</td>
</tr>
<tr>
<td>Campania</td>
<td>1200</td>
<td>23.2</td>
<td>670</td>
</tr>
<tr>
<td>Puglia (APULIA)</td>
<td>660</td>
<td>13.2</td>
<td>150</td>
</tr>
<tr>
<td>Basilicata</td>
<td>800</td>
<td>7.9</td>
<td>200</td>
</tr>
<tr>
<td>Calabria</td>
<td>1170</td>
<td>16.1</td>
<td>560</td>
</tr>
<tr>
<td>Sicilia</td>
<td>730</td>
<td>18.8</td>
<td>190</td>
</tr>
<tr>
<td>Sardegna</td>
<td>780</td>
<td>18.3</td>
<td>250</td>
</tr>
<tr>
<td>ITALY</td>
<td>990</td>
<td>296.0</td>
<td>510</td>
</tr>
</tbody>
</table>

**APULIA**
Population: 4,500,000 M
Area: 19,000 km$^2$
Coasts length: 800 km
Orography of Apulia
Hydrography of Apulia
Yearly sectorial water needs in Apulia

**INDUSTRY**
(142 Mmc)

**AGRICULTURE**
(812 Mmc)

**POTABLE**
(546 Mmc)

TOTAL=1500 Mmc

- **55%** coming from regional groundwater [~ 200,000 wells]
- **45%** coming from out of Region sources (11% from springs and 34% from superficial water bodies)

**Sectorial water-sources contribution (%)**

**POTABLE**
- Sup.W. 54%
- Regional G.W. 23%
- Springs 23%

**INDUSTRY**
- Sup.W. 15%
- Springs 26%
- Regional G.W. 59%

**AGRICULTURE**
- Sup.W. 24%
- Regional G.W. 75%
- Springs 1%
### Water needs in Apulia

- **Regional (R) and Extra-regional (E) sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Requirement (Mm³/y)</th>
<th>Regional (%)</th>
<th>Extra-regional (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>812</td>
<td>78</td>
<td>22</td>
</tr>
<tr>
<td>Industry</td>
<td>142</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>Potable</td>
<td>546</td>
<td>24</td>
<td>76</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1500</td>
<td>55</td>
<td>45</td>
</tr>
</tbody>
</table>

- **Regional groundwater (55%)** [~ 200,000 wells]
- **Springs from Campania Region (11%)**
- **Superficial water from bordering Regions (34%)**
In Apulia potable needs are satisfied by the Apulian Aqueduct (AQP): the largest in Europe – the third in the World

250 (municipalities served)
4,000,000 (inhabitants)

SERVICES PROVIDED - water: treatment, supply and distribution - wastewater: collection and treatment

20,000 Km² (territory served)
20,000 Km (distribution pipelines)
550,000,000 m³/y (distributed water)

23% Regional GW
77% Bordering Regions
Land use in Apulia
(Regional Total Area: 19,000 km$^2$)

KEY
12,500  AGRICULTURAL LAND USE
2,900   OTHER LAND USES
3,600   IRRIGATED CROPPING
Groundwater withdrawals for irrigation purposes in Apulia (mm/y)
Electrical conductivity ($\mu$S/cm) in Apulian groundwater
Apulian areas affected by groundwater overexploitation
About the problem of sewage in Apulia with focus on biological treatment
Municipal WW Treatment Plants distribution in Apulia
Total amount (Mm$^3$/y) of municipal wastewater treated in Apulia

Provinces:
- Bari
- Brindisi
- Foggia
- Lecce
- Taranto

Total: 238 Mm$^3$/y
The Apulian Water Protection Master Plan

"Piano di Tutela delle Acque (PTA)"

(definitively issued on 20th/October/2009)

**Aim:**

assessing the quality state of regional water resources and planning the implementation of the necessary measures for preventing their qualitative-quantitative worsening
Apulian PTA goals: **IMPLEMENTING MWW REUSE**

Volumes of reusable municipal wastewater in Apulia according to the PTA

1st phase

- **VOLUMES REUSABLE FROM THE POLISHING TREATMENT PLANTS ALREADY**
- EXITING or
- UNDER CONSTRUCTION or
- FINANCED

<table>
<thead>
<tr>
<th>POTENZIALITA' DISPONIBILE</th>
<th>PROVINCIA</th>
<th>POTENZIALITA'</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARI</td>
<td>mc/anno</td>
<td>22.690.000</td>
</tr>
<tr>
<td>BRINDISI</td>
<td>mc/anno</td>
<td>4.480.000</td>
</tr>
<tr>
<td>FOGGIA</td>
<td>mc/anno</td>
<td>12.090.000</td>
</tr>
<tr>
<td>LECCE</td>
<td>mc/anno</td>
<td>12.080.000</td>
</tr>
<tr>
<td>TARANTO</td>
<td>mc/anno</td>
<td>41.058.000</td>
</tr>
<tr>
<td><strong>TOTALE</strong></td>
<td><strong>mc/anno</strong></td>
<td><strong>92.398.000</strong></td>
</tr>
</tbody>
</table>

2nd phase

- **VOLUMES THAT COULD BE REUSED WHEN ALL THE SUITABLE APULIAN WASTEWATER TREATMENT PLANTS WILL BE EQUIPPED WITH A POLISHING STEP**

<table>
<thead>
<tr>
<th>POTENZIALITA' TOTALE</th>
<th>PROVINCIA</th>
<th>POTENZIALITA'</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARI</td>
<td>mc/anno</td>
<td>42.473.510</td>
</tr>
<tr>
<td>BRINDISI</td>
<td>mc/anno</td>
<td>9.392.619</td>
</tr>
<tr>
<td>FOGGIA</td>
<td>mc/anno</td>
<td>16.780.644</td>
</tr>
<tr>
<td>LECCE</td>
<td>mc/anno</td>
<td>29.752.337</td>
</tr>
<tr>
<td>TARANTO</td>
<td>mc/anno</td>
<td>49.219.631</td>
</tr>
<tr>
<td><strong>TOTALE</strong></td>
<td><strong>mc/anno</strong></td>
<td><strong>147.618.741</strong></td>
</tr>
</tbody>
</table>

**92 Mm³/y**

**147 Mm³/y**

NOTE THAT THIS IS JUST THE VOLUME PRESENTLY REQUIRED BY THE WHOLE APULIAN INDUSTRIAL SECTOR
Main quality parameters fixed by the in force Italian Law (D.M.185/03) for agricultural reuse of municipal wastewater. (*) exceptions valid in Apulia.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6-9.5</td>
<td>Total Phosphorus (mg/L)</td>
<td>10</td>
</tr>
<tr>
<td>Coarse solids (mg/L)</td>
<td>absent</td>
<td>Total Nitrogen (mg/L)</td>
<td>35</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>10</td>
<td>Grease and Oil (mg/L)</td>
<td>10</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>100</td>
<td>Aldehydes (mg/L)</td>
<td>0.5</td>
</tr>
<tr>
<td>BOD₅ (mg/L)</td>
<td>20</td>
<td>Surfactants</td>
<td>0.5</td>
</tr>
<tr>
<td>Boron (mg/L)</td>
<td>1.0- (2.0)*</td>
<td>Chlorinated Pesticides</td>
<td>0.0001</td>
</tr>
<tr>
<td>Chlorides (mg/L)</td>
<td>250-(500)*</td>
<td>Escherichia coli (CFU/100ml)</td>
<td>10</td>
</tr>
<tr>
<td>Sulphates (mg/L)</td>
<td>500</td>
<td>Salmonella (CFU/100ml)</td>
<td>absent</td>
</tr>
<tr>
<td>Electrical Conductivity (μS/cm)</td>
<td>3,000</td>
<td>Sodium Adsorption Ratio</td>
<td>10</td>
</tr>
</tbody>
</table>

Notes: In addition to Boron even Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Si, Th, V, Zn, THM, CN, SO₃⁺, Benzene, Benzo(a)pyrene plus other organics are considered in the D.M.
Common treatment schemes used to achieve different water quality objectives for agricultural irrigation

**Industrial crops, forest**  
Example: Mexico City (45 m³/s)  
100% of irrigation needs  
(WHO: <1 helm.eg/L; <1000 FC/100 ml)

**Industrial crops, forest**  
Israel (60 mg BOD/L ; 50 mgSS/L)

**Industrial crops, forest**  
Pasture, cooked vegetables, fruits  
Australia (<3000 and <750 FC/100 ml)  
California (<23 TC/100 ml)  
EPA, US (<200 FC /100 ml)  
South Africa (<1000 FC/100 ml)  
Catalonia (<1000 FC/100 ml)

**Pasture, cooked vegetables, fruits**  
Vegetables eaten raw  
Canaries Island (<2.2 TC/100 ml)  
Israel (<2.2 FC/100 ml)  
California (<2.2 FC/100 ml)  
Florida (<1 FC/100 ml)  
Arizona (<1 FC/100 ml)  
Italy  
virus < 1 PFU/40L
Conventional polishing treatment train used to achieve the quality standards fixed for agricultural reuse of municipal wastewater

Secondary effluent → Rapid mix → flocculation → sedimentation → filtration → disinfection → storage → reuse

Membrane ultrafiltration
Membrane Filtration pilot plant at CERIGNOLA (FG)

- [Zee Weed 250]

- Total membrane surface area **23.5 m²**

- Ext. **1.9 mm**
- Int. **1.0 mm**
- Pores: **0.03 μm**

- Material: Polyethylene
- Surface: Hydrophilic
Municipal wastewater membrane filtration at CERIGNOLA plant: some performances

TOTAL SUSPENDED SOLIDS

P-PO$_4$

N-NH$_4$

days

mg/L

mgN-NH$_4$/L

mgP-PO$_4$/L

influent
effluent

influent
effluent

influent
effluent

days

mgN-NH$_4$/L

mgP-PO$_4$/L

influent
effluent

influent
effluent

influent
effluent

influent
effluent

influent
effluent

influent
effluent

days
Wastewater Membrane Filtration: Costs Estimation

Costs Estimation Table:

<table>
<thead>
<tr>
<th>Flow rate (m³/d)</th>
<th>O&amp;M costs (€/m³)</th>
<th>Capital costs (€)</th>
<th>Total costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.8</td>
<td>0.00</td>
<td>16.80</td>
<td>16.800</td>
</tr>
<tr>
<td>168</td>
<td>0.05</td>
<td>168</td>
<td>1680</td>
</tr>
<tr>
<td>1680</td>
<td>0.10</td>
<td>1680</td>
<td>16800</td>
</tr>
<tr>
<td>16800</td>
<td>0.15</td>
<td>16800</td>
<td>168000</td>
</tr>
</tbody>
</table>

- **O&M costs**:
  - Membrane replacement
  - Labour
  - Energy
  - Spare parts
  - Chemicals (membrane cleaning)

- **Equivalent Inhabitants**:
  - 50
  - 500
  - 5000
  - 50000

**Graphical Representation**:

- **Costs** (€/m³) vs. **Flow rate (m³/d)**
- **Equivalent Inhabitants** vs. **Flow rate (m³/d)**
Groundwater Extraction costs in Apulia
Field of fennels irrigated with membrane filtered municipal wastewater at CERIGNOLA (FG)

Long-term effects on crops and soil have been investigated at the University of Bari by the Department of Science of Vegetable Production
Technological and process innovations for agricultural reuse of municipal and agro-food industry wastewater for sustainable management of water resources

(Acronym: In.Te.R.R.A)

Project Duration: 42 months
Starting date: June 2011
Funds: 6 Mio €

Main Objective: In.Te.R.R.A. is aimed at studing, sperimenting and proposing innovative and sustainable strategies, technological as well as managerial to favor a more diffuse implementation, at regional and national level, of agriculture wastewater reuse.
Partners and Locations

**ACADEMIC**
- Università degli Studi di Bari – Dipartimento di Scienze Agro-Ambientali e Territoriali (DiSAAT)
- Università degli Studi di Foggia – Dipartimento di Scienze Agro-ambientali, Chimica e Difesa vegetale Foggia
- Università del Salento - Dipartimento di Scienze e Tecnologie Biologiche e Ambientali - Lecce
- Consiglio Nazionale delle Ricerche – Istituto di Ricerca sulle Acque (IRSA) di Bari
- Consiglio per la Ricerca e la Sperimentazione in Agricoltura – Unità di ricerca per i sistemi colturali degli ambienti caldo-aridi (CRA-SCA) - Bari
- Politecnico di Bari – Dipartimento di Ingegneria delle Acque e di Chimica - Bari
- Istituto Agronomico Mediterraneo di Bari - Valenzano (BA)

**INDUSTRIAL**
- AQUASOIL srl - Fasano
- INTESIS srl - Bari
- BIOTEC srl - Molfetta (BA)
- FIORDELISI srl - Stornarella (FG)
- SERECO srl - Noci (BA)
- ECOPIMPIANTI SUD srl - Brindisi
- ELETTROMECCANICA CMC srl - Foggia
Expected Results

• technical and economical optimization of WW treatment systems through process-simplification avoiding the removal of substances useful for crops and soil.

• defining new guidelines for reusing wastewater with different microbial contents according to different crops and agronomic practices with the aim to support a revision of the current in force too severe regulations.

• evaluating the effectiveness of cheap and rapid tests for assessing the eco-toxicity of soils and waters.

• developing low-cost sensors for continuous monitoring of wastewater quality and remote data acquisition.

• development of participatory approaches and information and involvement methodologies for stakeholders (farmers, plant managers, institutions and consumers) aimed at a shared water resource management.

• Life Cycle Assessment of different methodologies of wastewater management
Regional Law 21 October 2008 n.27
"Includes the polishing step among the SII (Integrated Water Services) and its costs into the SII tariff"

Regional Regulation R.R. 18 April 2012
"Norms and provisions for reusing treated wastewater"
APULIA REGION’s INVESTMENTS TO FAVOUR WW REUSE

APQ 11 marzo 2003
“TUTELA DELLE ACQUE E GESTIONE INTEGRATA DELLE RISORSE IDRICHE” MEF, MATTM, MPAF, MIT, REGIONE all.D) interventi prioritari per il riutilizzo delle acque reflue depurate

16 INTERVENTI
€ 45.786.134,96

POR PUGLIA 2000/2006 - MISURA 1.2 - Azione B)
“Affinamento e riuso delle acque reflue depurate”

14 INTERVENTI
€ 38.171.080,89

PO FESR 2007/2013 – Azione 2.1.2 – Attuazione misure del PTA finalizzate a garantire il raggiungimento/mantenimento degli obiettivi di qualità per i corpi idrici, nonché per la tutela qual-quantitativa degli stessi

3 INTERVENTI
€ 11.716.517,42

96 Milioni
and after all these efforts what is the present status of agricultural wastewater reuse in Apulia?
The Scream - Eduard Munch (1983)
Polishing plants actually in operation
- December 2013 data -

Tot Mm3 planned in the PTA:
147 Mm³/y

Ostuni
59,167/450,000
Gallipoli
181,958/2,800,000
Corsano
156,000/450,000
San Pancrazio Salentino
0/600,000
Trinitapoli
0/630,000

年年分布精制m³/年
年年潜在可恢复m³

TOT 347,115/4,930,000 (~7%)
After many years spent discussing and «fighting», since several years Apulia Region defined a solid framework of plans and rules, technical as well as financial, aimed at promoting wastewater reuse.

Nevertheless in a region chronically featured by water resources scarcity such apparently «logic» option is far to be actually implemented.

It's our task to remove real and HIDDEN obstacles.

THE DISCUSSION SEEMS JUST OPENED!
La Primavera (Allegory of Spring) - Alessandro Filipepi detto il Botticelli (1482)

THE FASANO WWTP !
THANKS
FOR YOUR ATTENTION