Life cycle assessment of a full scale case study on agricultural reuse of treated agro-industrial wastewater

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LIFE CYCLE ASSESSMENT OF A FULL SCALE CASE STUDY ON AGRICULTURAL REUSE OF TREATED AGRO-INDUSTRIAL WASTEWATER

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Wastewater and Biosolids Treatment and Reuse: Bridging Modeling and Experimental Studies
12 June 2014 – Otranto (Italy)
THE CASE STUDY

Production of dehydrated vegetables
# THE CASE STUDY

Production of dehydrated vegetables

## Wastewater produced (2013 year average)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>1017±310 mg/L</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>28±8 mgN/L</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>6±3mgP/L</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>240±85 mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>5.6±0.7</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>2.6±1.0 mS/cm</td>
</tr>
<tr>
<td>Escherichia Coli</td>
<td>6,E+06 UFC/100mL</td>
</tr>
</tbody>
</table>

## WWTP effluent (year average)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>41±24 mg/L</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>4±2 mgN/L</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.4±0.3 mgP/L</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>29±21 mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>6.2±0.6</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>2.6±0.7 mS/cm</td>
</tr>
<tr>
<td>Escherichia Coli</td>
<td>2,E+04 UFC/100mL</td>
</tr>
</tbody>
</table>

WWTP (4500 P.E.)

- irrigation
- + tertiary treatment
- discharge

Environm. impacts

+ discharge

Escherichia Coli
What is LCA?
LCA is the “compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle” (ISO 14040)

the total system of unit processes involved in the life cycle of a product (or service)
LIFE CYCLE ASSESSMENT METHODOLOGY

GOAL AND SCOPE DEFINITION

INVENTORY ANALYSIS

IMPACT ASSESSMENT

INTERPRETATION
Assessment of environmental impacts of scenarios A and B
SCENARIOS CONSIDERED

scenario A: irrigation with well water
scenario B: irrigation with tertiary treated WW

Conventional primary + secondary treatment

Tertiary treatment

360m³/day

WASTEWATER produced by industrial activities

Sludge disposal

20%

80%

WELL WATER

IRRIGATION

Sludge disposal

80%

20%

treated wastewater

DISCHARGE
Conventional primary + secondary treatment

WASTEWATER produced by industrial activities

Sludge disposal

Tertiary treatment

scenario A: irrigation with well water
scenario B: irrigation with tertiary treated WW

BOUNDARIES
scenario A: irrigation with well water

scenario B: irrigation with tertiary treated WW

WASTEWATER produced by industrial activities

Conventional primary + secondary treatment

Tertiary treatment

Sludge disposal

WELL WATER

IRRIGATION

FUNCTIONAL UNIT

127 m³

27 m³

108 m³

8 m³

100 m³

100 m³

FUNCTIONAL UNIT

treated wastewater

DISCHARGE
TERTIARY TREATMENT - DESCRIPTION

scenario B: irrigation with tertiary treated WW

Tertiary treatment
TERTIARY TREATMENT - DESCRIPTION

**Scenario B: Irrigation with tertiary treated WW**

- **Sand Filtration**
  - Chlorination: 0.2mgNaClO/L
  - 30’ backwashing every 8h operation

- **Membrane UF**
  - Hollow Fiber Membranes (pore size 0.05µm)
  - 30” backwashing every 45’ operation
  - Weekly chemical cleaning
  - Membrane Ultrafiltration

- **Reservoirs**
- **UV Radiation**
  - 6 UV-C lamps (300W each)
  - Backwashings

**ΔP**
- 1-2bar
- 0.5-1bar
TERTIARY TREATMENT - REQUIREMENTS

scenario B: irrigation with tertiary treated WW

REAGENTS: for chlorination, for chemical cleaning (fresh water, NaClO, NaOH)

EQUIPMENT: reservoirs, sand, membranes, pumps, valves, UV lamps, PLC, devices
## INVENTORY - INPUT/OUTPUT LIST

<table>
<thead>
<tr>
<th>INPUT</th>
<th>scenario A</th>
<th>scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater (m³)</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td>Energy requirements (kWh)</td>
<td>310</td>
<td>321</td>
</tr>
<tr>
<td>Well water (m³)</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Fresh water(^{(1)}) (m³)</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>NaOH (g)</td>
<td>0</td>
<td>18.9</td>
</tr>
<tr>
<td>NaClO (g)</td>
<td>0</td>
<td>40.5</td>
</tr>
<tr>
<td>Sand (kg)</td>
<td>0</td>
<td>0.37 (^{(2)})</td>
</tr>
<tr>
<td>Flocculating agents (m³)</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

### OUTPUT

<table>
<thead>
<tr>
<th>scenario A</th>
<th>scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary treated WW, used for irrigation (m³)</td>
<td>0</td>
</tr>
<tr>
<td>Secondary treated WW, discharged (m³)</td>
<td>127</td>
</tr>
<tr>
<td>Thickened sludge disposal (kg)</td>
<td>300</td>
</tr>
</tbody>
</table>

Equipments (membrane etc) have a lifespan > 3 years → not considered

\(^{(1)}\) condensation water

\(^{(2)}\) sand replacement every 8 months operation
IMPACT ASSESSMENT

Abiotic Depletion
Abiotic Depletion Fossil
Acidiphication Potential
Eutrophication Potential
Freshwater Aquatic Ecotoxicity Potential
Global Warming Potential
Human Toxicity Potential
Marine Aquatic Ecotoxicity Potential
Ozone Layer Depletion Potential
Photo. Ozone Creation Potential
Terrestrial Ecotoxicity Potential
Ecotoxicity
Human Ecotoxicity, cancer
Human Ecotoxicity, non-cancer
Energy Use

Hp: Italian energetic mix, European market
IMPACT ASSESSMENT of SCENARIO B

- Abiotic Depletion
- Abiotic Depletion Fossil
- Acidiphication Potential
- Eutrophication Potential
- Freshwater Aquatic Ecotoxicity Potential
- Global Warming Potential
- Human Toxicity Potential
- Marine Aquatic Ecotoxicity Potential
- Ozone Layer Depletion Potential
- Photo. Ozone Creation Potential
- Terrestrial Ecotoxicity Potential
- Ecotoxicity
- Human Ecotoxicity, cancer
- Human Ecotoxicity, non-cancer
- Energy Use

Energy | Others
**CONCLUSIONS**

<table>
<thead>
<tr>
<th>Scenario A: irrigation with well water</th>
<th>Scenario B: irrigation with tertiary treated WW</th>
</tr>
</thead>
</table>

- +++ Eutrophication Potential
- ++ Abiotic Depletion
- ++ Ozone Layer Depletion Potential
- + all others
- Membrane chemical washing
- To reduce impacts, optimize the process

Fresh water consumption? No impacts, because water is considered a non-limited resource in LCA.

It’s not true in the specific case study (Apulia region) and in most Mediterranean areas.

It's not true in the specific case study (Apulia region) and in most Mediterranean areas.
Thanks for your attention

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www.pon-interra.it
TERTIARY TREATMENT – TSS REMOVAL

Scenario B: irrigation with tertiary treated WW

- Chlorination: 0.2 mg NaClO/L
- Backwashings: 29 ± 21 mg TSS/L
- Membrane ultrafiltration: <5 mg TSS/L
- Backwashing reservoirs: <5 mg TSS/L
- UV radiation
- Reservoir
- Sand filtration
- 15 ± 11 mg TSS/L
- Reservoir
- Irrigation
TERTIARY TREATMENT – E.coli REMOVAL

- sand filtration
- membrane ultrafiltration
- chlorination 0.2mgNaClO/L
- backwashings
- UV radiation
- reservoir
- backwashing reservoirs

scenario B: irrigation with tertiary treated WW

10^4 CFU/100mL

0 CFU/100mL

IRRIGATION