LIFE Zero Waste Water: exploring the joint management of bio-waste and wastewater

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INTRODUCTION

Our Research Team

Chemical Engineering
Water and Environmental Eng.

Urban wastewater can be fully treated **anaerobically** with AnMBR plants
WWTPs can become WRRFs with net energy production
Current WWTP facilities by plant size and type of process (Spain)

a) PE > 50.000
b) 50.000 > PE > 20.000
c) 20.000 > PE > 5.000
d) PE < 5.000

< 50.000 PE are mostly aerobic based

- Energy demand
- GHG emissions

Source: CEDEX, 2013
INTRODUCTION

Carbon foot-print of WWTP in the Region of Valencia

- 91% GHG emissions associated to energy consumption

- Fossil fuel consumption
- \( \text{N}_2\text{O} \rightarrow \text{N/DN process} \)
- \( \text{CH}_4 \rightarrow \text{Anaerobic w/o CH}_4 \text{ capture} \)

Source: EPSAR (2016), Period 2010-2015
We need a shift towards more sustainable technologies

**Anaerobic Membrane BioReactor (AnMBR)**

- Anaerobic treatment can be used in small WWTP (aerobic water treatment can be avoided)

**BENEFITS:**

**IMPACT REDUCTION**
- Low energy demand
- Low GHG emissions
- Low sludge productions

**RECYCLING & VALORIZATION**
- High quality water (ultra-filtered, pathogen free, nutrient rich effluent)
- Organic matter → Biogas / Biomethane
- Nutrients & compostable sludge

AnMBRs allow **decentralisation**, which facilitates recycling of water and nutrients.
AnMBR applied to low strength UWW

First study at pilot plant scale located in Valencia (Spain) in 2008

Reaction volume
2.2 m$^3$

2 membrane tanks
PURON®, KMS ultrafiltration
31 m$^2$ filtration area/module

Design flow-rate
25 m$^3$/d

Influent characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Media ± SD$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST (mg SS-l$^{-1}$)</td>
<td>186 ± 61</td>
</tr>
<tr>
<td>SSV (mg SS-l$^{-1}$)</td>
<td>150 ± 54</td>
</tr>
<tr>
<td>DQO$_T$ (mg DQO-l$^{-1}$)</td>
<td>388 ± 95</td>
</tr>
<tr>
<td>DQO$_S$ (mg DQO-l$^{-1}$)</td>
<td>79 ± 25</td>
</tr>
<tr>
<td>AGV (mg DQO-l$^{-1}$)</td>
<td>11 ± 7</td>
</tr>
<tr>
<td>S-SO$_4$ (mg S-l$^{-1}$)</td>
<td>99 ± 18</td>
</tr>
<tr>
<td>N-NH$_4$ (mg N-l$^{-1}$)</td>
<td>27,0 ± 8,1</td>
</tr>
<tr>
<td>P-PO$_4$ (mg P-l$^{-1}$)</td>
<td>2,7 ± 0,9</td>
</tr>
<tr>
<td>Alk. (mg CaCO$_3$-l$^{-1}$)</td>
<td>292,5 ± 37,2</td>
</tr>
</tbody>
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AnMBR applied to low strength UWW

Case study of industrial prototype (Alcázar de San Juan WWTP) in 2014

3 membrane tanks  0.8 m³/tank (0.7 + 0.1)

PURON®, KMS, Ultrafiltration (0.03 µm)

41 m² filtration area/module

Anaerobic reactor  40 m³ (35 + 5)

Design flow-rate  60 m³/d

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With the contribution of the LIFE Programme of the European Commission
### AnMBR applied to low strength UWW

**Case study of industrial prototype (Alcázar de San Juan WWTP)**

#### Energy demand (technology comparison)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Energy Consumption (kWh/m³)</th>
<th>Energy Recovery (kWh/m³)</th>
<th>Net Energy Consumption (kWh/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAS w/o energy recovery</td>
<td>0.42</td>
<td>-</td>
<td>0.42</td>
</tr>
<tr>
<td>CAS with energy recovery</td>
<td>0.44</td>
<td>0.16</td>
<td>0.28</td>
</tr>
<tr>
<td>AeMBR w/o energy recovery</td>
<td>0.50</td>
<td>-</td>
<td>0.50</td>
</tr>
<tr>
<td>AeMBR with energy recovery</td>
<td>0.54</td>
<td>0.13</td>
<td>0.41</td>
</tr>
<tr>
<td>AnMBR with energy recovery</td>
<td>0.59</td>
<td>0.65</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

↑ organic matter (COD) in the influent  ➔  ↑ benefits
**LIFE ZERO WASTE WATER**

**Integrated management** of Urban Wastewater (UWW) and the Organic Fraction of Municipal Solid Waste (OFMSW) for populations of **less than 50,000 inhabitants**

**PROJECT LOCATION**: Valdebebas WWTP, Madrid (Spain)

**BUDGET INFO**:
- Total amount: **2,464,520 €**
- % EC Co-funding: **55%**

**DURATION**: Start: **01/09/2020** - End: **31/08/2024**

**PROJECT’S IMPLEMENTORS**:
- Aqualia
- Canal de Isabel II
- Simbiente
- USC
- Universitat de València
- VWM Solutions
Different integration options to be analysed in the project

Gravity driven transport

Only food waste is treated

Domestic food waste disposers

Big producers

Selective collection system

Resource Recovery Facility

Anaerobic MBR

Wet grinding and pulping

Inert fraction

Wet grinding and pulping

Separation

Energy

Reusable water
The AnMBR Plant

Anaerobic digester and 3 types of membrane modules

- **Gasometer**: 60 m³
- **Anaerobic reactor**: 100 m³

**3 membrane tanks**: 0.8 m³/tank (0.7 + 0.1)
- Tank A: PURON®, KMS, 41 m² filtration area (0.03 µm)
- Tank B: ZENmbr2-S, LITREE, 40 m² filtration area (0.02 µm)
- Tank C: IMMEM®, POLYMEM, 40 m² filtration area (0.03 µm)

**Design flows:**
- 50 m³/d UWW
- 125 kg/d OFMSW
- (~ 300 PE with 70% PF)
The LIFE ZWW project concept

Circular economy in the urban sanitation sector

- Food products
- Bio methane
- Fertigation
- Compost - fertilizers
- Water Resources Recovery Facilities (WRRF)
- Integrated Sanitation System (UWW + OFMSW)

Urban space

Rural space

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Management of the OFMSW in the EU

Bio-waste “capture rate” (BW collected as a share of BW generated)

Source: European Environment Agency, 2020

Increased business opportunity for FWDs

Source: European Environment Agency, 2020

- It is crucial for bio-waste recycling (high quality compost, less inert/toxic materials)

So far, door-to-door and street containers are the most extended systems

But, for many cities, it is not easy to implement in few years:

- It requires careful planning, design, and citizen engagement.
- Achieving high bio-waste quality and “capture rates” can take many years, even with awareness campaigns.
- Impurities can be reduced, but can still exceed 15% in street containers.

Separate collection is now being implemented is Spain by legal requirements, but in most cases it is inefficient and expensive for citizens.

The combination of FWDs with AnMBR-based RRFs can promote effective bio-waste recycling.
Use of FWDs with AnMBR systems

Advantages for MSW management: citizen engagement

- FWDs simplify the separation of bio-waste to citizens at home:
  - No special bin is required for organic waste separation.
  - The use of compostable/plastic bags is avoided.
  - The **effort of citizens** is significantly reduced.
  - Easy solutions enhance engagement and BW capture rates.

- Citizen engagement relies on FWD installation (Penetration Factor).
  - A high PF means less organics in the mixed waste street container.

- Less OM will end up in a landfill.

Source: Insinkerator®
Use of FWDs with AnMBR systems

**Advantages for MSW management: road transport reduction**

- Significant reduction in collection and transport requirements:
  - On demand collection can be applied
  - It reduces **cost** and **environmental impact** of MSW collection
  - Reduction in truck traffic, noise, air pollution, etc.

High collection frequency required (warm climates)
CONCLUSIONS

Main benefits of the solution proposed in the LIFE ZWW project:

- It promotes Circular Economy in urban sanitation at the local level.
- It allows anaerobic treatments being implemented in small and decentralised WWTPs.
- It allows a fast increase of bio-waste capture rates (only FWD installation required)
- FWDS ensure the quality of bio-waste, avoiding improper materials.
- Once the AnMBR plant is built, PF can rise without additional membrane upgrades.
- The more bio-waste, the greater the benefits (biogas, nutrients, compost...)

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TAKE HOME MESSAGE

- The AnMBR system enables a paradigm shift in urban sanitation:
  
  “More OM in the influent means more benefits”

- The integrated sanitation system facilitates MSW management and increases the benefits of RRFs.

Integrated sanitation system
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10th International Conference on Sustainable Solid Waste Management