Option analysis for sludge management in the context of UWWTD compliance efforts in Croatia

Damjan Nemec
OUTLINE:

1. Croatia: overview of status and practices
2. Dubrovnik case study
3. Analysis of adopted solutions throughout Croatia
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COUNTRY OVERVIEW

• **Demographics:**
  - Current census: 4.3 mio
  - Trend: noticeable decline
    - Natural growth rate negative
    - Strong migrations out of the country

• **Economy:**
  - GDP per capita: ~12,000 EUR (60% of EU average)
  - Dominated by services sector (70%)
  - Industry (25%), agriculture (5%)

• **Administrative division:**
  - 20 + 1 Counties
  - 428 Municipalities
• **UWWTD context:**

  • Around 280 agglomerations larger than 2,000 PE.

### Agglomeration size range (PE)

<table>
<thead>
<tr>
<th>Agglomeration size range (PE)</th>
<th>No. (2014)</th>
<th>Catchment area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black sea</td>
<td></td>
<td>Adriatic sea</td>
</tr>
<tr>
<td>over 150.000</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>50.000 - 150.000</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>15.000 - 50.000</td>
<td>43</td>
<td>19</td>
</tr>
<tr>
<td>10.000 - 15.000</td>
<td>28</td>
<td>11</td>
</tr>
<tr>
<td>2.000 - 10.000</td>
<td>190</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>281</td>
<td>119</td>
</tr>
</tbody>
</table>

### Size of Agglomeration (PE)

<table>
<thead>
<tr>
<th>Recipient sensitivity</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Sea (sensitive)</td>
<td></td>
</tr>
<tr>
<td>Secondary treatment</td>
<td>2.000 – 10.000</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>10.000 – 15.000</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>15.000 – 50.000</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>50.000 – 150.000</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>&gt; 150.000</td>
</tr>
<tr>
<td>Adriatic Sea (sensitive)</td>
<td></td>
</tr>
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<td>50.000 – 150.000</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>&gt; 150.000</td>
</tr>
<tr>
<td>Adriatic Sea (normal)</td>
<td></td>
</tr>
<tr>
<td>Appropriate treatment</td>
<td>2.000 – 10.000</td>
</tr>
<tr>
<td>Secondary treatment</td>
<td>10.000 – 15.000</td>
</tr>
<tr>
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</tr>
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<td>&gt; 150.000</td>
</tr>
</tbody>
</table>

- **31.12.2023**
- **31.12.2020**
- **31.12.2018**
- **31.12.2018**
SLUDGE MANAGEMENT (TREATMENT & DISPOSAL)

• **General strategy:**
  
  • No general strategy exists on the governmental level
  • Responsibility delegated on to the local level
  • Solution has to be Environmentally Acceptable and Economically Affordable

• **Options given:**
  
  • Disposal on landfills
  • Reuse (compost, construction material)
  • Thermal treatment (incineration)
  • Disposal on land
SLUDGE MANAGEMENT (TREATMENT & DISPOSAL)

• **Landfilling:**
  - As of 2017 landfilling substances containing over 35% of dry solids is no longer allowed

• **Recycling:**
  - Composting
  - Use as construction material (certain limitations are given)

• **Thermal treatment:**
  - Mono-incineration plant planned in Zagreb
  - Incineration in coal powered thermal power plant (Plomin)
  - Incineration in cement factories: Holcim (Koromačno), Nexe (Našice), Cemex (Split)
  - Incineration outside of the country not prohibited
  - Pyrolysis not considered
SLUDGE MANAGEMENT (TREATMENT & DISPOSAL)

• **Application on land:**
  • Only treated and stabilised sludge allowed to be deposited (1.66 tDM/ha/y)
  • Limit values for heavy metals and organics stricter than compared to EU Directives
  • Furthermore, it is forbidden to deposit on:
    • Water protection zones and along the coast
    • On Karst areas (about 50% of Croatia!)
  • Regular monitoring required!
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PROJECT LOCATION
TOURISM !!!
PROJECTED LOAD OF THE WWTP

Economy  At the end of the project period

Jan       Feb      Mar      Apr      May      Jun       Jul       Aug       Sep      Oct       Nov      Dec

At the end of the project period

73,000 PE
POSSIBLE LOCATIONS FOR WWTP
OPTION A : EXISTING WWTP LAPAD

Advanced Activated Sludge process required : limited options for sludge
POSSIBLE LOCATIONS FOR WWTP
OPTION B: ALTERNATIVE LOCATION OF WWTP KOMOLAC

Convectional Activated Sludge process: Anaerobic Digestion of sludge possible
Manner of final disposal dictates the required treatment of sludge before that
OPTION 0 : DIRECT TRANSPORT OF DEWATERED SLUDGE TO FINAL DISPOSAL

- Sludge quantities:
  - After stabilisation (?) and dewatering as part of the WWTP
    - Without AD: ~6.800 t/y. (16-22 t/d) @ 20% DM (~1.400 t/y. DM)
    - With AD: ~2.900 t/y. (7-10 t/d) @ 28% DM (~800 t/y. DM)

- Disposal (assumption – from 2023 onward)
  - Incineration in the vicinity of the city of Split
  - Transport via the future Pelješac bridge (230 km)
  - Cost of disposal: 95 EUR/t

- Costs:
  - **CAPEX:** 0,00 mio EUR
  - O&M: 0,00-0,00 mio EUR/y.
  - Transport 0,12-0,26 mio EUR/y.
  - Final disposal 0,27-0,64 mio EUR/y.
  - **OPEX (total):** 0,39-0,91 mio EUR/y.
• Sludge quantities:
  • After stabilisation (?) and dewatering as part of the WWTP
    • Without AD: ~1.500 t/y. (3-5 t/d) @ 90% DM (~1.400 t/y. DM)
    • With AD: ~900 t/y. (2-3 t/d) @ 90% DM (~800 t/y. DM)

• Disposal (assumption – from 2023 onward)
  • Incineration in the vicinity of the city of Split
  • Transport via the future Pelješac bridge (230 km)
  • Cost of disposal: 95 EUR/t

• Costs:
  • CAPEX: 2,50-4,10 mio EUR
  • O&M: 0,11-0,49 mio EUR/y.
  • Transport 0,04-0,06 mio EUR/y.
  • Final disposal 0,09-0,14 mio EUR/y.
  • OPEX (total): 0,24-0,69 mio EUR/y.
OPTION 2: SOLAR DRYING OF SLUDGE & TRANSPORT TO FINAL DISPOSAL

• Sludge quantities:
  • After stabilisation (?) and dewatering as part of the WWTP
    • Without AD: ~1.800 t/Y. (4-6 t/d) @ 75% DM (~1.400 t/y. DM)
    • With AD: ~1.100 t/Y. (3-4 t/d) @ 75% DM (~800 t/y. DM)

• Disposal (assumption – from 2023 onward)
  • Incineration in the vicinity of the city of Split
  • Transport via the future Pelješac bridge (230 km)
  • Cost of disposal: 95 EUR/t

• Costs:
  • CAPEX: 1,62-2,57 mio EUR
  • O&M: 0,05-0,09 mio EUR/y.
  • Transport 0,04-0,10 mio EUR/y.
  • Final disposal 0,10-0,17 mio EUR/y.
  • OPEX (total): 0,19-0,36 mio EUR/y.
OPTION 3: COMPOSTING DEWATERED SLUDGE AND USE AS LANDFILL COVER

• Sludge quantities:
  • After stabilisation (?) and dewatering as part of the WWTP
    • Without AD: ~6.800 t/y. (16-22 t/d) @ 20% DM (~1.400 t/y. DM)
    • With AD: ~2.900 t/y. (7-10 t/d) @ 28% DM (~800 t/y. DM)

• Disposal (assumption – from 2023 onward)
  • Used as landfill cover
  • For remediation of the closed one and later for the new one
  • Cost of disposal: 0 EUR/t

• Costs:
  • CAPEX: 1,89-2,84 mio EUR
  • O&M: 0,16-0,22 mio EUR/y.
  • Transport 0,03-0,05 mio EUR/y.
  • Final disposal 0,00-0,00 mio EUR/y.
  • OPEX (total): 0,19-0,27 mio EUR/y.
• Sludge quantities:
  • After stabilisation (?) and dewatering as part of the WWTP
    • Without AD: \(~6.800 \text{ t/y.} \ (16-22 \text{ t/d}) \ @ 20\% \text{ DM} \) \ (~1.400 \text{ t/y. DM})
    • With AD: \(~2.900 \text{ t/y.} \ (7-10 \text{ t/d}) \ @ 28\% \text{ DM} \) \ (~800 \text{ t/y. DM})

• Disposal (assumption – from 2023 onward)
  • Handing over to Regional MSW management centre
  • Use biologically stabilised material as landfill cover
  • Cost of treatment and final disposal: 51 EUR/t

• Costs:
  • \textbf{CAPEX:} \ 0,00 \text{ mio EUR}
  • O&M: \ 0,00-0,00 \text{ mio EUR/y.}
  • Transport \ 0,05-0,11 \text{ mio EUR/y.}
  • Final disposal \ 0,15-0,35 \text{ mio EUR/y.}
  • \textbf{OPEX (total):} \ 0,20-0,46 \text{ mio EUR/y.}
OPTION 5 : **PYROLYSIS OF DEWATERED SLUDGE**

- **Sludge quantities:**
  - No stabilisation (!) just dewatering as part of the WWTP
    - Without AD: \(~6.800 \text{ t/y.} \ (16-22 \text{ t/d}) \ @ \ 20\% \text{ DM}\) \( (~1.400 \text{ t/y. \ DM}) \)
  - Two options in terms of location: 1. as part of the WWTP, 2. as part of the Regional MSW MC

- **Disposal (assumption – from 2023 onward):**
  - Phosphorous rich „ash“ as leftover
  - Will be landfilled, if not used as biofertiliser.
  - Cost of disposal: 40 EUR/t

- **Costs:**
  - **CAPEX:** \(2,94-3,18 \text{ mio EUR}\)
  - O&M: \(0,23-0,23 \text{ mio EUR/y.}\)
  - Transport \(0,01-0,11 \text{ mio EUR/y.}\)
  - Final disposal \(0,02-0,02 \text{ mio EUR/y.}\)
  - **OPEX (total):** \(0,26-0,37 \text{ mio EUR/y.}\)
• **WWTP at existing location without AD of sludge**

• **Solar drying to 75% DM** at another (MSW handling) site some 15 km away

• Allows the option of:
  • **partial (solar) drying of sludge** (45% to 55% DM)...
  • ...followed by a **composting process**.

• Processes does not require external materials although it can be added
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ANALYSIS OF ADOPTED SOLUTIONS THROUGHOUT CROATIA

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<th>Total tDM/y</th>
</tr>
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<tr>
<td>5.000 – 15.000</td>
<td>12</td>
<td>145,300</td>
<td>2,870</td>
</tr>
<tr>
<td>15.000 – 50.000</td>
<td>21</td>
<td>683,000</td>
<td>10,740</td>
</tr>
<tr>
<td>50.000 – 150.000</td>
<td>18</td>
<td>1,532,000</td>
<td>18,510</td>
</tr>
<tr>
<td>150.000 – 500.000</td>
<td>3</td>
<td>645,000</td>
<td>9,430</td>
</tr>
<tr>
<td>over 500.000</td>
<td>1</td>
<td>1,000,000</td>
<td>14,240</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>4,005,300</td>
<td>55,790</td>
</tr>
</tbody>
</table>

In terms of final disposal method:
- For incineration (64%)
- For deposition on land (23%)
- Other / undefined (13%)

For incineration (64%)
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<tr>
<td><strong>Total</strong></td>
<td>55</td>
<td>4,005,300</td>
<td>55,790</td>
</tr>
</tbody>
</table>

In terms of sludge treatment method:
- Direct to incineration (27%)
- Solar drying (23%)
- Thermal drying (16%)
- Other / undefined (13%)
- Sludge reed beds (14%)
- Composting (5%)
- Direct on land (3%)
FINAL THOUGHTS FOR CHOOSING AN APPROPRIATE SLUDGE ROUTE

• Adapt your solution to local specifics
  • Evaluate quantity and quality of sludge
  • Consider possible disposal options and final locations
  • Take advantage of available resources (e.g. sunlight; source of (waste) heat...)

• Try to keep your options open (for the future)
  • It’s not always possible to predict future needs and developments
  • Example: solar drying as a pre-step:
    • Incineration (power and/or heat recovery)
    • Composting (recycling of nutrients)
    • Pyrolysis (recovery of phosphorous)

• There should exist at least a general governmental strategy
  • General guidelines for development of solutions AND legislation!
  • Development of at least basic infrastructure
FINAL THOUGHTS FOR CHOOSING AN APPROPRIATE SLUDGE ROUTE

Start looking at sludge as a (national) resource rather than a problem!

Start searching for wealth extraction options rather than fastest/cheapest disposal routes!
Thank you for your attention!

Damjan Nemec
More Information

For info or further questions on this seminar and the activities of the JASPERS Networking Platform, please contact the JASPERS Networking and Competence Centre at the following email:

jaspersnetwork@eib.org

JASPERS Networking Platform:  www.jaspersnetwork.org

JASPERS Website:  jaspers.eib.org