Influence of sludge characteristics on pressure-driven electro-dewatering of stabilized sewage sludge

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Summary

1. Introduction to EDW
2. Aim of the study
3. Materials and methods
4. Results of EDW tests
5. Influence of sludge characteristics on EDW
6. Conclusions and future research

Acknowledgements and contacts
Pressure-driven EDW of sludge

Mahmoud et al. 2010. Water Research, 44(8), 2381.

Electrophoresis

\[ \nu_{eo} = \frac{\varepsilon \zeta}{4\pi \mu} \nabla \phi \]

Electro-osmosis

\[ \dot{Q} = \frac{\varepsilon \zeta}{4\pi \mu} A \cdot \nabla \phi \]

Electromigration
Background

Lab-scale PD-EDW lead to:

✓ Higher **DS content** than mechanical dewatering
  ▪ Lower sludge disposal costs
  ▪ Sludge may self-sustain incineration

✓ Lower **energy consumption** than thermal drying

✓ Inactivation mechanism of **bacteria**

**However:**

× **Few full-scale** EDW applications

× **Difficult prediction** of EDW efficiency on different sludge samples

× **Corrosion** of the anode
Aim of the study

AIMS:
- Assess feasibility of PD-EDW on sludge from different WWTPs
- Evaluate the effects of sludge characteristics on PD-EDW

QUESTIONS:
- What DS content may be reached by PD-EDW?
- Could polyelectrolyte dosage be reduced?
- VD/DS ratio, CST, zeta potential and conductivity could affect the efficiency of PD-EDW?
Experimental plan

Laboratory testing

- Characterization of the sewage sludge samples
- Polyelectrolyte dosage by jar test
- Pressure-driven EDW tests
Lab-scale device

- Cylindrical glass vessel (h=176 mm, Ø=80 mm)
- Double effect cylinder SMC-CP96 (200 mm stroke)
- DC power supply (30 V-5 A)
- Anode: DSA – Ti MMO
- Cathode: stainless steel mesh (AISI 304)
- Cloth: PTT (polytrimethyleneterephthalate)
Experimental conditions

Three steps for the pressure-driven EDW tests:

• Centrifugation at the lab (RCG = 1789 g) \[ t_{\text{CFG}} = 5 \text{ min} \]
• Mechanical pressure (p = 300 kPa):
  \[ t_p = 10 \text{ min} \]
• Mechanical pressure (p = 300 kPa) + electric potential @ 15 V
  \[ t_v = 25 \text{ min} \]

Total duration of the test \[ t_{\text{tot}} = 40 \text{ min} \]
## Sludge samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stabilisation</th>
<th>Polymer dosage</th>
<th>DS$_i$</th>
<th>VS/DS</th>
<th>pH</th>
<th>Conductivity</th>
<th>CST</th>
<th>Zeta potential</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>g/kg$_{DS}$</td>
<td>%</td>
<td>%</td>
<td>-</td>
<td>mS/cm</td>
<td>s</td>
<td>mV</td>
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<td>1-A</td>
<td>Aerobic</td>
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<td>2.0</td>
<td>68.3</td>
<td>7.5</td>
<td>1.34</td>
<td>32.0</td>
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<td>102.3</td>
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</tr>
</tbody>
</table>

*Polyamidic and high cationic (Tillflock CL-1480)*
Efficiency of the pressure-driven EDW

E.C. = Specific electrical energy consumption

E.C. = 52.4 ± 3.37 Wh/kgH₂O
E.C. = 62.2 ± 1.93 Wh/kgH₂O
E.C. = 55.3 ± 4.06 Wh/kgH₂O
E.C. = 76.4 ± 14.07 Wh/kgH₂O
Electrical behaviour

1. Current ↑ at the end of EDW tests

2. Sludge conductivity ↑

3. Local temperature ↑
Influence of sludge characteristics on the pressure-driven stage

Aerobically stabilised sludge:

- \( \frac{VS}{DS} \uparrow \rightarrow CST \downarrow \)
- \( \frac{VS}{DS} \uparrow \rightarrow \Delta DS_{p-i} \downarrow \)
- \( CST \uparrow \rightarrow \text{Dewatering Rate} \uparrow \)
Influence of sludge characteristics on the EDW stage

Sludge 2 and 3 may reach considerably higher DS content by increasing the tests duration.

Current ↑  →  Dewatering Rate ↑

ζ ↑  →  Dewatering Rate ↓

\[
\vec{v}_{eo} = \frac{\varepsilon\zeta}{4\pi\mu} \nabla \Phi
\]

\[
\vec{Q} = \frac{\varepsilon\zeta}{4\pi\mu} A \cdot \nabla \Phi
\]
Conclusions – 1/3

**Efficiency:**

- **Aerobically stabilised sludge** showed a maximum DS increase of 2.6 to 14.1% if compared with real plant data.

- **Anaerobically digested sludge** did not show a significant improvement if compared with real plant data.

- Electric energy consumption was $61.6 \pm 11.65 \text{ Wh/kg}_{H2O}$, less than 1/5 of the equivalent primary energy for thermal drying.
Conclusions – 2/3

**Polymer dosage:**

- The polyelectrolyte addition improves dewatering during the sole application of pressure, so that the EDW phase can act on a drier cake.

- The dose of polyelectrolyte should be carefully chosen.

- The dosage of polyelectrolyte should be better investigated for the application of EDW on an industrial scale.
Conclusions – 3/3

**Sludge characteristics:**

- **VS/DS ratio** affects the *pressure-driven stage* of the unconditioned *aerobically stabilised samples*.

- **CST** is a good predictor of PD dewaterability.

- Low *zeta potential values* reduce the effect of the *EDW* process and may slow down the dewatering rate.
Future research

➢ **Economic assessment of EDW:**
  - Polymer dosage
  - Energy consumptions
  - Sludge disposal costs

➢ **Study of corrosion resistant materials for the anode**

➢ **Prototyping a full-scale EDW machine**
Acknowledgements

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http://cordis.europa.eu/project/rcn/191799_it.html
www.sludgetreat.eu

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- X2 Solutions (Modena, I)
Thank you for your attention

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