Workshop on good practices and experience in sludge management

Characterising the Problem

6th June 2018, Warsaw
Oh no! Not that picture again

**Sludge Treatment Processes**

- **Digestion**
  - Aerobic digestion
  - Anaerobic digestion: - Mesophilic - Thermophilic

- **Composting**
  - Sludge only
  - Co-composting

- **Wet oxidation**

- **Incineration (with energy recovery)**
  - Raw sludge
  - Digested sludge
- **Co-incineration (waste)**

- **Pyrolysis**
- **Gasification**

- **Solar drying**

- **Drying beds**

- **Reed beds**

- **Thermal drying**
  - Digested sludge drying
  - Raw sludge drying

- **Chemical conversion**
  - - Pyrolysis
  - - Gasification
  - - Wet oxidation

**Products**

- **Digested liquid**
- **Digested cake**

**Uses**

- **Use on land**
  - Agriculture: - Food crops - Commercial crops (energy & material)
  - Land reclamation: - Landfill capping - Landscaping
  - Forestry - Plantations

- **Fuel**
  - - Cement kilns
  - - Heat/power plants

**Key**

- Liquid/thickened sludge
- Dewatered sludge cake/solids
- Dried sludge
- Ash or residue
  - Biogas, Syngas or usable heat produced
  - Potential for power production

**Note:** The following treatment–use routes are used but are not best practice:
- Use of raw or limed sludge in agriculture
- Disposal of dewatered or dried sludge to landfill
Waste Water Sources

- Domestic
- Commercial
  - Restaurants, shops …
- Institutional
  - Hospitals, schools
- Industrial
  - Small and Medium Sized Enterprises (SMEs)
  - Larger Industries (Industrial Emissions Directive)
- Rainwater
- Infiltration
- Septic tank sludge
- Sludge from other treatment
Waste Water

Constituents
- Macro solids (solid waste)
- Inert – sand, grit
- Organic particulate
- Organic dissolved
- Inorganic
  - Salts
  - Metals
- Microbiological
- “Chemical” – pharmaceutical

Properties
- Odour – foul
- Colour - brown

Domestic wastewater - undiluted

<table>
<thead>
<tr>
<th></th>
<th>g/c/d</th>
<th>mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>60</td>
<td>480</td>
</tr>
<tr>
<td>COD</td>
<td>120</td>
<td>960</td>
</tr>
<tr>
<td>SS</td>
<td>70</td>
<td>560</td>
</tr>
<tr>
<td>N</td>
<td>11</td>
<td>88</td>
</tr>
<tr>
<td>P</td>
<td>1.8</td>
<td>14</td>
</tr>
</tbody>
</table>
Waste Water Treatment

### Processes
- Mechanical
- Physical
- Biological
- Chemical
- Ultraviolet

### Resources
- Infrastructure
  - Depreciation
  - Maintenance
- Operation
  - Electricity
  - Chemicals
  - Personnel
  - **SLUDGE DISPOSAL**

### Types
- Attached growth
- Suspended growth (Activated Sludge)
- Membrane Filtration
Pretreatment

- Screenings
  - Landfill
- Grit and Sand
  - Re-use/landfill
- Scum / Grease (FOG)
Main Processes

- Secondary Sludge (mixed)
  - Microbiological growth
  - Brown
  - Flocculent
  - Without debris
  - Homogeneous
  - Earthy odour (good condition)
  - Readily digestible

- Primary Sludge
  - Sedimentation (physical)
  - Grey
  - Slimy
  - Debris
  - Non-homogeneous
  - Extremely offensive odour
  - Readily digestible
Thickening Sludge

• Draught sludge
  • Pumped from tanks
  • 0.5 – 1% Dry solids
  • Large volume

• Thickening
  • Reduce volume
  • 4 – 6% Dry Solids
  • < 20% volume
  • Still pumpable

• Versions
  • Sedimentation (down)
  • Flotation (up)
## Sludge Generation

<table>
<thead>
<tr>
<th></th>
<th>Specific Production</th>
<th>Settled Solids Content</th>
<th>Volatile Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g TSS/p.e./d</td>
<td>% DM</td>
<td>% of TS</td>
</tr>
<tr>
<td><strong>Primary Sludge (raw)</strong></td>
<td>45</td>
<td>2.5 – 7</td>
<td>60 – 75</td>
</tr>
<tr>
<td><strong>Secondary sludge (raw)</strong></td>
<td>25</td>
<td>1 – 3</td>
<td>45 – 55</td>
</tr>
<tr>
<td><strong>Trickling Filters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Secondary sludge (raw)</strong></td>
<td>35</td>
<td>0.5 – 1.5</td>
<td>65 – 75</td>
</tr>
<tr>
<td><strong>Activated sludge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aerobically stabilized (mixture)</strong></td>
<td>50 - 55</td>
<td>1.5 – 4</td>
<td>40 – 65</td>
</tr>
<tr>
<td><strong>Anaerobically stabilized (mixture)</strong></td>
<td>50</td>
<td>0.8 – 2.5</td>
<td>40 – 55</td>
</tr>
</tbody>
</table>
# Chemical Characteristics

## Sludge at 30% Dry solids

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>DWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>7.7</td>
</tr>
<tr>
<td>Dry solids</td>
<td>%</td>
<td>30</td>
</tr>
<tr>
<td>Water</td>
<td>%</td>
<td>70</td>
</tr>
<tr>
<td>Carbon</td>
<td>%</td>
<td>33 - 50</td>
</tr>
<tr>
<td>Oxygen</td>
<td>%</td>
<td>10 - 20</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>%</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>%</td>
<td>2 - 6</td>
</tr>
<tr>
<td>Sulphur</td>
<td>%</td>
<td>0.5 – 1.5</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>g/kg</td>
<td>2 - 55</td>
</tr>
<tr>
<td>Metals</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thermal Characteristics (1)

• Calorific Values
  • High (Gross) Heating Value
    • From water free material
  • Lower (Net) Heating Value
    • From “actual” material

• Tanner Triangle (waste)
  • Combustible >25%
  • Moisture <50%
  • Ash (inert) <60%
## Thermal Characteristics (2)

<table>
<thead>
<tr>
<th>MJ/kg</th>
<th>~HHV / GCV</th>
<th>~LHV / NCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Coal</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Wood (dry)</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Lignite</td>
<td>14</td>
<td>*</td>
</tr>
</tbody>
</table>

### EN 15359:2011 Solid Recovered Fuel – Specifications and classes

| SRF/RDF (1)           | >25        |
| SRF/RDF (2)           | >20        |
| SRF/RDF (3)           | >15        |
| SRF/RDF (4)           | >10        |
| SRF/RDF (5)           | >3         |

### United Utilities (United Kingdom: Liverpool & Manchester)

| Sludge – Undigested   | 17         | *          |
| Sludge – Digested     | 12         | *          |
| Sludge – Digested with ferric | 9        | *          |
NCV versus Moisture

\[
NCV = GCV \left(1 - \frac{w}{100}\right) - 2.447 \frac{w}{100} - 2.447 \frac{h}{100} \times 9.01 \left(1 - \frac{w}{100}\right)
\]

where,
NCV: net calorific value in MJ/kg fuel (wet basis)
GCV: gross calorific value in MJ/kg fuel (dry basis)
w: water content of fuel as percentage of weight
h: concentration of hydrogen as percentage of weight (dry basis).

1. Conversion to water basis
2. Energy to vaporize water in the sludge
3. Energy to vaporize water generated by combustion of hydrogen
   - Theory – need to get below 50% moisture to sustain combustion
   - Practice – aim to get to 35% moisture
### Water, water everywhere

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Solids Content</th>
<th>Further Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw Sludge</strong></td>
<td><a href="#">~1% Dry solids</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thickening</strong></td>
<td><strong>Removal of non-bonded water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thickened Sludge</strong></td>
<td><a href="#">5% Dry Solids</a></td>
<td></td>
<td><strong>Transport</strong></td>
</tr>
<tr>
<td><strong>Dewatering</strong></td>
<td><strong>Bonded &amp; Capillary water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dewatered Sludge</strong></td>
<td><a href="#">25% Dry Solids</a></td>
<td></td>
<td><strong>Incineration</strong> Additional Fuel Required</td>
</tr>
<tr>
<td><strong>Solar / Moderate Thermal Drying</strong></td>
<td><strong>Cell water (1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dried Sludge</strong></td>
<td><a href="#">70% Dry Solids</a></td>
<td></td>
<td><strong>Co-incineration</strong> Substitute Fuel</td>
</tr>
<tr>
<td><strong>Solar Assisted / Strong Thermal Drying</strong></td>
<td><strong>Cell water (2)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Desiccated Sludge</strong></td>
<td><a href="#">95% Dry Solids</a></td>
<td></td>
<td><strong>Energetic User</strong></td>
</tr>
</tbody>
</table>
## Microbiological Organisms

<table>
<thead>
<tr>
<th>Organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella</td>
</tr>
<tr>
<td>Escherichia Coli (E. coli.)</td>
</tr>
<tr>
<td>Enterohaemorrhagic E. coli (EHEC)</td>
</tr>
<tr>
<td>Shigella</td>
</tr>
<tr>
<td>Listeria</td>
</tr>
<tr>
<td>Campylobacter</td>
</tr>
<tr>
<td>Norovirus</td>
</tr>
<tr>
<td>Adenovirus</td>
</tr>
<tr>
<td>Enterovirus</td>
</tr>
<tr>
<td>Hepatitis</td>
</tr>
<tr>
<td>Giardia lamblia</td>
</tr>
<tr>
<td>Cryptosporidium perfingens</td>
</tr>
<tr>
<td>Ascaris</td>
</tr>
</tbody>
</table>

06/06/2018

Sewage Sludge Workshop - Warsaw
European Waste Catalogue

- **19 08** wastes from waste water treatment plants not otherwise specified
- 01 screenings
- 02 waste from desanding
- **05 sludges from treatment of urban waste water**
  - 06* saturated or spent ion exchange resins
  - 07* solutions and sludges from regeneration of ion exchangers
  - 08* membrane system waste containing heavy metals
  - 09 grease and oil mixture from oil/water separation containing only edible oil and fats
  - 10* grease and oil mixture from oil/water separation other than those mentioned in ..09
  - 11* … containing dangerous substances from biological treatment of industrial waste water
  - 12 … from biological treatment of industrial waste water other than those mentioned in ..11
  - 13* … containing dangerous substances from other treatment of industrial waste water
  - 14 … from other treatment of industrial waste water other than those mentioned in ..13
- 99 wastes not otherwise specified

* Indicates that the waste is considered as a hazardous waste
Residues from Thermal

- Ash (can be up to 40% of DS)
  - Recovery
    - Potential for use in building products
    - Portland cement, aggregate, mineral filler … brick
    - Phosphorus …
  - Disposal
    - Landfill

- Flue gas cleaning residues

- European Waste Catalogue
  - 19 01 wastes from incineration or pyrolysis of waste
  - 19 01 02 ferrous materials removed from bottom ash
  - 19 01 05* filter cake from gas treatment
  - 19 01 06* aqueous liquid wastes from gas treatment
  - 19 01 07* solid wastes from gas treatment
  - 19 01 10* spent activated carbon from flue-gas treatment
  - 19 01 11* bottom ash and slag containing dangerous substances
  - 19 01 12 bottom ash and slag other than those mentioned in 19 01
Basic

~60 g DS per capita per day
22 kg per capita per annum

<table>
<thead>
<tr>
<th>10,000 p.e.</th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Day Dry Solids</td>
<td>0.6</td>
</tr>
<tr>
<td>Per Annum Dry Solids</td>
<td>220</td>
</tr>
<tr>
<td>Per Annum @ 5%DS</td>
<td>4,500</td>
</tr>
<tr>
<td>Per Annum @ 25%DS</td>
<td>900</td>
</tr>
<tr>
<td>Per Annum @ 70%DS</td>
<td>300</td>
</tr>
<tr>
<td>Per Annum @ 95%DS</td>
<td>230</td>
</tr>
</tbody>
</table>

Characteristics

- Wet Mixture
  - Largely long chain organics
  - Nutrients
  - Metals
  - Pathogens

- Potential
  - Soil conditioning
    - Humus / peat / compost
  - Fertilization
    - N and P
  - Source of Energy

- Management / Disposal
  - Source of Significant costs
Thank-you for your attention

Questions and Discussion
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:

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JASPERS Networking Platform: www.jaspersnetwork.org

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