Sludge & Filamentous Bacteria Reduction with ozone

Jan Parmentier
Expert Wastewater Treatment
AIR LIQUIDE GROUP
Partnership with one of our industrial clients:

- Test AL approach
- Dimension & construction pilot plant full scale
- Start up of pilot plant in 2000
- Evaluation of changes in WWTP and results in sludge reduction
- Dimension & construction modified permanent installation
- Start up of final full scale plant in 2001
The return sludge line combines all parameters needed to implement the process:
- The sludge concentration is high (=good ozone efficiency)
- The line ends in the biology (released nutrients can be metabolised)
ASPAL Sludge: 4. Layout

1. Container
   O₃-production/ controls

2. Pump rack

3. Reactor

The world leader in industrial and medical gases
ASPAL Sludge: 5. Ozone production

O3ONIA Standard products:
Ozone flow 0.1kg/h – 15kg/h

Requirements of Ozonia for maximum production:
- Ozone concentration: 6-10 wt%
- Composition of feed gas:
  98 % O₂ and 2 % N₂
- Power
- Cooling water: 12-15°C

Advantages of ozone:
- High oxidation potential
- Residues are harmless to environment

Applications of ozone:
Disinfection (potable & cooling water)
Colour removal, Hard COD, toxicity, ...
Main Advantage

- Sludge reduction in a cost effective way
- Non selective process that has been proved in different industries
- Amount of sludge reduction:
  - 50% to 90%
  - Depends on the % of organic matter present

Beneficial side effects

- Preventive curing effect against filamentous organisms
- Optimisation of the nutrient balance
- Optimisation of dewatering potential
1. Understanding the ecofysiology of the filamentous bacteria present.

- Link to production
  - Type of industrie
  - Type of raw materials used in production
- Link to WWTP layout
  - Structural
  - Operations
Example in Food & Beverages WWTP
Filamentous organism: *Nocardia*
  - Grows on fats
  - Likes the reduction of superficial tension by tensioactive products (e.g. Soaps)
  - Short term explosive growth
  - Curring: remove foam mechanically & eliminate growth trigger

Example in Pulp & Paper WWTP
Filamentous organism: *Thiothrix-021N*
  - Likes Sulfides and anaerobic conditions
  - Grows well in suboptimal aeration conditions and shortages of nutrients.
  - Curring: Eliminate trigger conditions

Correct determination is of the essence

(*) use of FISH
2. Curring through chlorine dosing

- **Advantages**
  fast, cheap product, easy dosing

- **Needs**
  close follow-up, correct calculation of dosage

- **Disadvantages**
  Chlorine derivatives in effluent,
  Very aggressive
  Non-selective (e.g. increase of turbidity)
  Long remediation time due to:
    - Lysis products
    - Intact morphological structure
  Foaming
3. Filamentous treatment with Ozone

Advantages:
- No by-products
- Works fast (one or two sludge ages)
- Semi selectif
  (more than chlorine-see next slide)
- No negative effects on daily operations
- Allows accurate dosing

Disadvantages:
- Reputation of being an overall killer
- Relative expensive if not combined
  with other application (e.g. excess sludge
  reduction, water recycling, desinfection,
  hard COD treatment)
- Ozone disrupt the integrity of the bacterial cell envelope through oxidation of the phospholipids and lipoproteins. In filamentous bacteria, ozone inhibits cell growth at certain stages.

- A significant increase of the mortality of the filamentous population was observed after ozone treatment.

- The degree of cell lysis depends on the dose and duration of ozone application.
Some references: BASF (BE)
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Some references: DESSO (BE)
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- **Idea:** Decrease of water demand by reusing up to 40m³/h of the WWTP effluent
- **Problem:** Colour residuals as disturbing water components
- **Solution:** Decolourisation by oxidation of pigments with Ozone

Ground water (20m³/h)

- Dyeing
- Washing
- WWTP
- O₃ up to 95%
- Effluent 60m³/h

Carpets

The world leader in industrial and medical gases
Some references: DESSO (BE)

- The ozonation has several effects on the sludge properties:
  - Biomass is converted into biodegradable matter by ozonation and degraded in the bio basin
  - Ozone kills filamentous MO’s
  - Bio flocs are more compactly
  - Enhanced settlement properties

- which leads to a decrease of the SVI and therefore compensates partially the hydraulic overload of the WWTP
Some references: DESSO (BE)
For compensating the effects of the hydraulic overload a simplified method of return sludge ozonation has been applied in Desso

- Injection of $\text{O}_3$ off-gas directly into the bio-basinn
Some references: DESSO (BE)

Before

After
Some references: Municipal Valencia (SP)

**WWTP FACILITIES**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water lines:</td>
<td>2</td>
</tr>
<tr>
<td>Sludge lines:</td>
<td>1</td>
</tr>
<tr>
<td>Trials in:</td>
<td>Line 1</td>
</tr>
</tbody>
</table>

**LINE 1 FACILITIES**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Number of reactors:</td>
<td>1</td>
</tr>
<tr>
<td>Type of reactor:</td>
<td>Plug flow, anoxia selector</td>
</tr>
<tr>
<td>Reactor dimensions:</td>
<td>66 x 22 m, depth = 3,05 m</td>
</tr>
<tr>
<td>Number of clarifiers:</td>
<td>2</td>
</tr>
<tr>
<td>Clarifier dimensions:</td>
<td>Ø = 29 m, surface = 660 m²</td>
</tr>
</tbody>
</table>
Some references: Municipal Valencia (SP)

Parameters of Plug-flow reactor 1

Flow: 985 m³/h → 23,640 m³/day

IN:
- COD: 470 mg/l
- BOD₅: 214 mg/l
- SS: 186 mg/l
- TN: 55 mg/l
- P-PO₄⁻: 10 mg/l

OUT:
- COD: 52 mg/l
- BOD₅: 11 mg/l
- SS: 21
- TN: 38 mg/l
- P-PO₄⁻: 2,7 mg/l
**Some references: Municipal Valencia (SP)**

### Key parameters of the wastewater treatment plant

<table>
<thead>
<tr>
<th>Activated sludge</th>
<th>Filamentous bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MLSS:</strong></td>
<td>3.180 mg/l</td>
</tr>
<tr>
<td><strong>MLVSS:</strong></td>
<td>2.480 mg/l</td>
</tr>
<tr>
<td><strong>Sludge age:</strong></td>
<td>4.73 days</td>
</tr>
<tr>
<td><strong>Dominant species:</strong></td>
<td>Nocardia sp. Present the whole year</td>
</tr>
<tr>
<td><strong>Non dominant species:</strong></td>
<td>Microthrix parvicella</td>
</tr>
<tr>
<td></td>
<td>Type 1851</td>
</tr>
<tr>
<td><strong>Return sludge</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Flow:</strong></td>
<td>1.266 m³/h</td>
</tr>
<tr>
<td><strong>Dry matter:</strong></td>
<td>4.500 mg/l</td>
</tr>
<tr>
<td><strong>Occasional species:</strong></td>
<td>Haliscomenobacter hydrossis</td>
</tr>
<tr>
<td></td>
<td>Type 0021</td>
</tr>
<tr>
<td></td>
<td>Type 0041</td>
</tr>
<tr>
<td><strong>Excess sludge</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total production:</strong></td>
<td>7.044 Ton/year</td>
</tr>
<tr>
<td><strong>Daily production:</strong></td>
<td>19.3 Ton/year</td>
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<tr>
<td><strong>Dry matter:</strong></td>
<td>240 g/l</td>
</tr>
<tr>
<td><strong>Nostocoida sp.</strong></td>
<td></td>
</tr>
</tbody>
</table>
Some references: Municipal Valencia (SP)

LOX Vessel
Type: EV-10.000
Capacity: 9,500 L

Vaporiser
Type: M80
Capacity: 80 Nm³/h

Ozone Generator
Type: OZAT - CF6
O₃ production: 2,300 g/h
O₂ consumption: 28,5 Nm³/h
Electrical consumption: 17,1 kW

TURBOXAL®
Type: T300 - V2
Capacity O₂: 20 - 100 Nm³/h
Electrical consumption: 17 kW
Some references: Municipal Valencia (SP)

Difference in both reactors after a few weeks

Lane 1

Lane 2
Some references: Municipal Valencia (SP)

- Before

Start of the installation in February 2006

- After

The same situation some weeks later
ASPAL SLUDGE: The End

Thank you for your attention.

Any Questions?