E V O L U T I O N  O F  M I C R O B I A L
C O M M U N I T I E S  I N  A E R O B I C  G R A N U L A R
S L U D G E  D U R I N G  C H A N G E S  O F  T H E
W A S T E W A T E R  C O M P O S I T I O N

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Christof Holliger
Microbial processes for wastewater treatment

Activated sludge

- Conventional microbial process in wastewater treatment plants
- Flocular structures, settle slowly

Aerobic granular sludge

- Granular structures, settle fast
- Allows high sludge concentration → Space and time saving
- Suited for biological phosphorus removal
  - > chemicals saving
Phosphate accumulating organisms (PAO)

PAO model organism: **Accumulibacter**

**Anaerobic**
- VFA
- PO$_4^{-3}$
- Energy
- Glycogen
- PHA
- Poly-P

**Aerobic**
- CO$_2$ + H$_2$O
- O$_2$
- Energy
- PO$_4^{-3}$
- Biomass growth
- Glycogen
- PHA
- Poly-P
Phosphate accumulating organisms (PAO)

Fermentative PAO

**Tetrasphaera**

### Anaerobic
- Glucose
- Amino acids
- PO$_4^{-3}$
- Poly-P
- Energy
- Fermentation products
- Storage?

### Aerobic
- CO$_2$ + H$_2$O
- Biomass growth
- Poly-P
- Oxygen (O$_2$)
- PO$_4^{-3}$
- Energy
- Storage?
Aerobic granular sludge (AGS) for wastewater treatment

AGS fed with simple synthetic wastewater ...

... and with raw municipal wastewater

- Are **fermentable** or **polymeric** compounds responsible for this difference?
- How do they impact - the settling characteristics,
  - the nutrient removal,
  - the microbial communities of the AGS?
Progressive changes of the wastewater composition in two lab-scale reactors

1 reactor ← 2 reactors → 1 reactor

Transition to simple monomeric wastewater

AGS fed with complex monomeric wastewater

Transition to complex polymeric wastewater

VFA

VFA, glucose, amino acids

VFA, glucose, amino acids, starch, peptone
Evolution of nutrient removal efficiency

- **to simple monomeric**
- **Transition from complex monomeric**
- **to complex polymeric**

![Graph showing nutrient removal efficiency over time.](image)
Evolution of the settling properties

$SVI_{10}$ [ml/g]

Time [day]

to simple monomeric  |  Transition from complex monomeric  |  to complex polymeric

flocs
Evolution of the structure of the bacterial communities
phosphate accumulating organisms (PAO)

 Accumulibacter

 Tetrasphaera

 Accumulibacter

relative abundance in granules [%]

100
80
60
40
20
0

to simple monomeric
transition from complex monomeric
to complex polymeric

others
other Sphingobacteria (c)
CYCU-2081
Spirochaetes (c)
other Chlorobia (c)
OPB56 (f)
SJA-28 (f)
Deltaproteobacteria (c)
Saccharibacteria (p)
Flavobacteria (c)
other Actinobacteria (c)
Sbr-gs28
Micropruina
Nocardioides
 Tetrasphaera (PAO)
Propioniciava
Propionicimonas
other Alphaproteobacteria (c)
Hyphomonadaceae (f)
DB-14(o)
Rhodobacter
other Gammaproteobacteria (c)
Lysoctera
CPB C22&F32
Competibacter
Thiophrix
other Betaproteobacteriales (o)
Zoogloe
Nitroto
 Dechloromonas (putative PAO)
 Accumulibacter (PAO)

Time [day]
fermenting bacteria
Overall evolution of the microbial communities
Conclusions

• The AGS settleability and the nutrient removal performances were good with the simple and the complex monomeric wastewaters.

• With the introduction of polymeric compounds, a significant proportion of flocs appeared and the N-removal decreased.

• Accumulibacter was the predominant PAO with the simple wastewater. With the fermentable and polymeric compounds, the guild of PAO was more diverse.
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Identification of microorganisms in aerobic granular sludge actively involved in biological phosphorus removal

Poster n°51
Thank you for your attention!
## Synthetic wastewater compositions

<table>
<thead>
<tr>
<th>Medium</th>
<th>COD [mgO₂/L]</th>
<th>VFA</th>
<th>Glucose and amino acids</th>
<th>Starch and peptones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple monomeric</td>
<td>450</td>
<td>100 %</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Complex monomeric</td>
<td>600</td>
<td>33 %</td>
<td>66 %</td>
<td>-</td>
</tr>
<tr>
<td>Complex polymeric</td>
<td>600</td>
<td>33 %</td>
<td>33 %</td>
<td>33 %</td>
</tr>
</tbody>
</table>

*Phosphorus*: 22 [mg/L]  
*Nitrogen*: 56 [mg/L]
Some taxa are found in higher abundance with the simple wastewater
Some taxa are found in higher abundance with the complex wastewater.
Rhodobacter was found in higher abundance with the polymeric wastewater
Sludge volume index (SVI)

$SVI_{10}$ [ml/g]

Transition from complex monomeric to simple monomeric

$ratio \frac{SVI_{10}}{SVI_{30}}$

to simple monomeric

Transition from complex monomeric

to complex polymeric
Evolution of the settling capability of the AGS

Transition to simple monomeric  
Complex monomeric  
Transition to complex polymeric
Correlation between the relative abundance of main taxa with complex monomeric wastewater
Microbial communities evolution in two reactor fed with complex monomeric wastewater

- others
- Chlorobia (c)
- Saccharibacteria (p)
- Sphingobacteriia (c)
- Cytophagia (c)
- other Flavobacteriia
- *Flavobacterium*
- other Actinobacteria
- *Micropruina*
- Sbr-gs28
- *Tetrasphaera*
- *Propioniciclava*
- *Propionicimonas*
- other Alphaproteobacteria
- B142 (f)
- *Rhodobacter*
- other Gammaproteobacteria
- *Thiothrix*
- *Competibacter*
- other Betaproteobacteria
- Rhodocyclaceae (f)
- Zoogloea
- *Dechloromonas*
- *Accumulibacter*