Degrade the Tardigrade: The Immortal Water Bear

MWEA Annual Conference 2018

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Purpose of this Presentation

• Understand your bugs

Prevent permit violations

Source: MDEQ
Project Background

- ~ $12 million
- Design: 2013-2015
- Construction: 2015-2017
- Civil/Mechanical: Moore & Bruggink, Inc.
- Electrical/Architectural: Century A&E
- General Contractor: Grand River Construction
BEFORE (March 2016)

(1) New Bldg. Addition

(2) New Final Clarifiers

(2) New Primary Tanks

(1) New Blower/RAS Building

(2) New Aerobic Digesters

(6) New Aeration Tanks

New Township Force Main

Odor Control Unit
AFTER (Fall 2017)

- (2) New Primary Tanks
- (2) New Aerobic Digesters
- (6) New Aeration Tanks
- (1) New Blower/RAS Building
- (2) New Final Clarifiers

Focusing on the bio-reactors and digesters

(1) New Bldg. Addition

Odor Control Unit

New Township Force Main
Microbiology

Chart by: Jarod Stuyvesant
The Tardigrade

• “Water Bear” / “Space Bear” / “Moss Piglet”
• First Discovered in 1700s
• Fossils – 500 million yrs.
• Water Dwelling
• Eight legs
• ~0.5mm (.02 in) long
• Claw-like hands/feet
• “Use their mouth to pierce their prey before sucking out their insides.”

Image credit: http://dailycaller.com
Pictures from the Zeeland CWP

Video by: Doug Engelsman
Reproduction

Male Water Bears fertilize the eggs after they are shed.

Female’s shed molt

3 eggs (can lay up to 30 at a time)

Image: Doug Engelsman
Apocalyptic Champion

- Up to **85,000** PSI
- Up to 5,000 Gray (J/kg) of radiation (170X Humans)
- Can Survive in a Vacuum
- Can live thirty **YEARS** without water or food

- Red Flat Bark Beetle: -150 to 80°F
- Water Bear: -458 to 300°F
- Gray Wolf: -70 to 120°F
- Humans: 40-95°F

Image: https://themeaningofwater.com

**Hint: (~5.5X Pressure in the Mariana Trench (36,000 ft.))**
**Hint #2: 1 foot water = .433 psi**

-458°F

**Free Beer!**
Wastewater Conditions

Not Quite Apocalyptic

- 60-65°F, 14-21 PSI, no γ-rays, plenty of food/water
- Plenty of dissolved oxygen
- Low toxicity (usually)
WTF, Water Bears, this is so cool!

Image credit: Brian Hannon
Wait a Minute....

- Where are the other Microbes?

https://imgflip.com/memetemplate/86528146/Surprised-Look
Food Chain

Nematodes, Mites, Spiders
0-1% of microbe population

Metazoa (multi-cell)
(e.g. Water Bears, rotifers)
1% of microbe population

Protozoa (single-cell)
(e.g. Ciliates, Flagellates)
4% of microbe population

Bacteria
94-95% of microbe population

• Zeeland CWP
  ▫ Increase in Water Bear Population
  ▫ Throws off food chain balance
    • Eat more Protozoa
    • Increase in bacterial population
    • Turbidity of Effluent can increase if left unattended

Image: https://themeaningofwater.com
Problems Encountered as a Result

- Phosphorus levels jumped from 0.25 mg/L to 1.0 mg/L because PAOs within anoxic zones could not perform due to high D.O. content & low VFA’s.
- Increased TSS in effluent
  - Older sludge causes pin floc
  - Protozoans cannot keep the water as clear.

http://chasebc.ca/chase-living/turbidity/
What Led to the Issues?

• New force main from neighboring Township not on line yet.
• Labor Day Weekend, flows down to 0.7 MGD (20 hr. detention time in Aeration Tanks)
• ~23 day Solids Retention Time (SRT) during this time period
  ▫ No wasting occurred over Labor Day Weekend (3 days)
What Led to the Issues?

• Mixed liquor return pumps (internal recycle pumps within the Bio-P System) set to 2Q design flow (3.5 MGD)
  ▫ Increases D.O. within entire aeration system (including anoxic zones)

Image source: https://edu.glogster.com/glog/oxygen/22dmf60qu1q
What Led to the Issues?

- Water Bears thrived in Digesters
  - Were returned to plant via decant stream & filtrate from sludge thickening
  - Very low ammonia, non-toxic environment, plenty of food.
Steps to Solve

• Turned off mixed liquor return pumps.
• Turned turbo blowers down to minimum mixing flows.
  ▫ Still kept 2.0 mg/L D.O. levels
• Wasted more to allow for a shorter SRT
• Monitored permit levels closely
• Consistently took samples and checked microscope to gauge the health of the system
Resolution

- Phosphorus levels dropped once the MLR pump was shut off
  - PAOs began working again.
- Microbial population balances improved
- Effluent became clearer
- Water Bears slowly removed from plant over time via WAS stream
  - Still seeing some from time to time (WHICH IS COMPLETELY NORMAL).
Challenges Faced

• New leadership at the plant
  ▫ Getting the Operators to adopt and implement new ideas.

• New processes to manage and operate
It’s Right in Front of Your Eyes

• CHECK YOUR SLIDES!
  ▫ Understand the process better by physically seeing what is going on within the plant.
  ▫ Confirms the condition of your plant and whether or not calculations are correct.
    • Example from CWP – leaking mixed liquor to the head of the plant
• Counting the micro-organisms on your slides is one way to determine the health of your plant.

<table>
<thead>
<tr>
<th>ORGANISM</th>
<th>Slide #1</th>
<th>Slide #2</th>
<th>Slide #3</th>
<th>Average</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoebae</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>Flagellate</td>
<td>13</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>10.5%</td>
</tr>
<tr>
<td>Free-swimming Ciliates</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>11</td>
<td>14.5%</td>
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<tr>
<td>Crawling ciliates</td>
<td>22</td>
<td>15</td>
<td>20</td>
<td>19</td>
<td>25%</td>
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<tr>
<td>Stalked ciliates</td>
<td>40</td>
<td>32</td>
<td>23</td>
<td>32</td>
<td>42%</td>
</tr>
<tr>
<td>Metazoa (Rotifers, nematodes etc.)</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4%</td>
</tr>
</tbody>
</table>

Image source: https://www.iowaruralwater.org/tools_tips/toni_glymp/Bacteria-Protozoa.pdf

Ciliates should be the most abundant organism for Conventional Activated Sludge (CAS) systems, as shown in the example above.
Revisiting the Chart

Chart by: Jarod Stuyvesant

"Sweet Spot"
Important Outcomes

• Worked as a team within the plant staff, engineers, & equipment support staff to define a possible approach/solution
• Execute one step at a time, monitor the outcome.
References:

- Doug Engelsman, City of Zeeland Clean Water Plant.
Questions?

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