Brainstorming Nutrient Removal at Four North Carolina wastewater treatment plants

Webinar for North Carolina Wastewater Operators
April 7, 2021
10:00 - 11:45 AM

Grant Weaver, PE & wastewater operator
G.Weaver@CleanWaterOps.com
Energy & Nutrient Optimization of NC Municipal Wastewater Treatment Plants

Biological Nitrogen Removal, Parts 1&2
Activated Sludge, Parts 1&2
Biological Phosphorus Review, Parts 1&2
North Carolina Case Studies, Part 1

Today: Following up on North Carolina site visits:
Asheboro, Eden-Mebane Bridge, Newton-Clark Creek & Reidsville

Apr 15: Energy Management, Part 1
Apr 22: Energy Management, Part 2
Apr 29: North Carolina Case Studies, Part 3 (your plants!)
Eden, North Carolina          Population: 15,000          13.5 MGD design flow
The City of Eden’s Wastewater Facility is responsible for handling and treating up to 13.5 million gallons of wastewater from the local citizens, businesses, and industries in a day’s time. On average, the plant only has to handle approximately 2.5 – 4.5 MGD. All of the wastewater is collected in lines throughout the city and either pumped from the city’s pump stations or gravity fed to the wastewater facility.

Once inside the plant, the wastewater goes through a preliminary treatment system. First, it must pass through one of two mechanical bar screens in order to remove larger inert material, such as rags or sticks. Next, it passes through an aerated grit channel to freshen up the wastewater and remove smaller inert material, such as sand or egg shells. The removal of this material helps to protect the equipment in the plant from extra wear. The collected material is then sent to the nearest landfill after it is dried out.

After preliminary treatment, the wastewater is divided between two, seven million gallon aeration basins. Each basin contains 12 brush aerators that keep the liquid mixed and the dissolved oxygen above a 2.0 mg/l. This mixed liquor contains “bugs” that feed off of the solids in the wastewater, which helps the solids to settle out in later treatment units. This is what makes the whole process a biological treatment system. Extra settled solids are sent back into these basins to make sure that there are enough “bugs” to feed on the solids, and periodically, part of the older settled solids are wasted into a digester for further treatment so that the “bugs” do not get over populated.

From here, the wastewater is divided into four secondary clarifiers. There are two 90 feet diameter clarifiers and two 130 feet diameter clarifiers on this site. In this secondary treatment, the solids in the mixed liquor from the aeration basins are given time to settle out in the bottom of the tanks. The clear water then goes into the final stage of treatment.

Solids wasted from the secondary process are sent to a CleanB system for chemical treatment and then stored on site and dewatered. Once ready, it is dewatered on a belt press into a cake form, stored on a storage pad as needed, and then land applied on farm land. This is a beneficial use for farmers, reducing the amount of chemicals that they might need to produce healthy crops.

This final stage of treatment consists of three chlorine contact basins. All of the water from all four of the clarifiers comes together at one point where chlorine gas in injected. The chlorine contact basins are designed in a serpentine pattern to allow proper contact time for the chlorine to disinfect the water. The contact time for each basin is between 30 and 45 minutes. At the end of the three basins, sodium bisulfite is added to the wastewater to neutralize the chlorine since too much chlorine can be harmful to the aquatic life in the river. At this point, the effluent is released to the Dan River clean and safe.
Questions?
Comments?

Melinda Ward
mward@edenncc.us
Reidsville, North Carolina
Population: 14,000
7.5 MGD design flow
Section 2: Treatment Process Flow Diagram
Questions? Comments?

Scott Bryan
sbryan@ci.Reidsville.nc.us
BREAK TIME
Newton Clark Creek
Newton, North Carolina          Population: 13,000           MGD design flow
Effluent total-Nitrogen
Newton, North Carolina

- Monthly average tN
- Rolling AVG tN
Questions?
Comments?

Eric Jones
ejones@newtonnc.gov
Stacy Rowe
srowe@newtonnc.gov
Asheboro, North Carolina          Population: 26,000          9.0 MGD design flow
Asheboro WWTP

- Rated for 9 MGD
- Extended aeration (Schreiber System)
- BOD limit 5mg/l : 10mg/l
- NH3 limit 2mg/l : 4mg/l
- Monitor only for Total Nitrogen and Total Phosphorus
Changes Affecting Asheboro

From 2005 to Present

- Major industrial users shut down
- Went from 70% industrial to 90% domestic
- Lost 3 MGD in daily average flow
- Press Filtrate disrupting aeration basins
- Permit Renewal in 2016 is still pending
- Detention Time too long through plant
- Diurnal Flow
- Shrinking Budgets!!!
Why Look at BNR?

- Permit requirements?
- Good Stewards of the Environment
- Potential Money SAVINGS!!
What we found out

- Our existing equipment is capable of removing total N and Total P
- It has to have some help
- Current system performs Nitrification only (NH$_3$ $\rightarrow$ NO$_2$ $\rightarrow$ NO$_3$)
- Now we need to perform Denitrification (NO$_3$ $\rightarrow$ N$_2$)
- In order to do this we found that we have to turn the air off and add a carbon source
- If you leave air off an additional 30 minutes, phosphorus will also be consumed (luxury uptake)
What we did

- We obtained a carbon source from a local cereal manufacturer (sugar water)
- Air on for 2 hrs/ air off for 2 hrs
- Before Eff Total N avg was 20mg/l, After it is 12mg/l
- Before Eff Total P avg was 1.0mg/l, After it is 0.3mg/l
- Lowest Eff Total N 1.93mg/l, Total P .07mg/l
Costs Associated with BNR Changes

- Purchased a 12,000 gallon tank, 2 tanker trailers, feed pump, coriolis flow meter, nitrate sensor, and ammonium sensor.
- Added a new card and programming to PLC, updated SCADA to reflect changes
- Total Investment of $100,000
Results

- Successfully proved we can BNR, more work to do to meet expected permit limits
- Air on for only 12 hrs instead of 24 hrs, huge savings
- Saving in pH adjusting chemical costs because denitrification process recovers pH and alkalinity
- We know what is happening in real time and can react accordingly
Historical Trending-NO3 & NH4
Effluent total-Phosphorus
Asheboro, North Carolina

Phosphorus concentration (mg/L)

Jan18  Jul  Jan19  Jul  Jan20  Jul

Rolling 12-mo AVG
Acknowledgements

**US EPA**
Brendan Held & Craig Hesterlee

**NC DEQ**
Terry Albrecht, Corey Basinger & Ron Haynes

**U MEMPHIS**
Larry Moore, PhD

**ASHEBORO**
Mike Wiseman

**EDEN**
Melinda Ward

**NEWTON**
Eric Jones

**REIDSVILLE**
Scott Bryan

... and many more!
Next Webinar:
North Carolina Case Studies: part 2

Thursday, April 8
10:00 - 11:45 AM

Energy Management (4/15 & 4/22)
NC DEQ’s Ron Haynes

NC Case Studies (4/29)
Energy Savings – the icing on the cake?
Facility Characteristics

- Medium-strength influent. No large industry, septage, or leachate.
- Underloaded hydraulically, but operating 50% of available aeration volume
- Aeration controls have VFDs with DO set point (1.5 mg/L)
- Operator had already been shutting off aerators intermittently w/ goal of denitrifying
- Controls do not allow automated shut off & start up of aerators. Shut off only when operator has time.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent Avg</th>
<th>Effluent Avg</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (MGD)</td>
<td>0.96</td>
<td>0.96</td>
<td>1.9 (design)</td>
</tr>
<tr>
<td>CBOD-5 (mg/L)</td>
<td>280</td>
<td>4.3</td>
<td>8</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>290</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>NH3 (mg/L)</td>
<td>-</td>
<td>0.2</td>
<td>3.0-10.5 seasonal, most stringent May-Oct</td>
</tr>
<tr>
<td>TN (mg/L)</td>
<td>-</td>
<td>20.5</td>
<td>Report only</td>
</tr>
<tr>
<td>TP (mg/L)</td>
<td>-</td>
<td>0.7</td>
<td>1.0</td>
</tr>
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Ditch Aerator Electrical Demand
Continuous Aeration

DO Control Variations

12:30:00, 42.6

Diurnal Trend

Demand (kW)

February 8, 2020
DO and ORP during anoxic cycle

Aerators turned off

DO < 0.3 mg/L

ORP = ±100 mV
But what about the savings?

### Continuous Aeration

<table>
<thead>
<tr>
<th>Billing Component</th>
<th>Quantity</th>
<th>Monthly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh consumed</td>
<td>32 kW x 3 aerators x 6 hrs = 17,280 kWh</td>
<td>$0.034 x 30d = $588/mo</td>
</tr>
<tr>
<td>“Surge” demand</td>
<td>N/A</td>
<td>$0/mo</td>
</tr>
<tr>
<td><strong>Total cost to leave aerators running:</strong></td>
<td></td>
<td><strong>$588/mo</strong></td>
</tr>
</tbody>
</table>

### Intermittent Aeration w/ hard restart

<table>
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<tr>
<th>Billing Component</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh consumed</td>
<td>0 kWh, some days</td>
<td>$0/mo</td>
</tr>
<tr>
<td>“Surge” demand</td>
<td>12 kW/aerator x 3 aerators = 36 kW</td>
<td>36 kW x $21/kW = $756/mo</td>
</tr>
<tr>
<td><strong>Total cost of hard restart:</strong></td>
<td></td>
<td><strong>$756/mo</strong></td>
</tr>
</tbody>
</table>

Increased electrical costs over $2000 per year!

...need to ramp up DO setpoint gradually
16% improved TN removal

Hard re-start
avg: 157 lbs/d

Ramp-up
avg: 132 lbs/d
Obviously, this is a special case. But:

• Saving energy does not always mean saving money

• Understanding the electric billing structure is critical

More on energy management is coming over the next couple weeks!