Newly Developed Cloth Media for Low Phosphorus & Water Reuse Applications

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Matt Castillo, P.E.
mcastillo@msa-ps.com
Outline

- Cloth media
- Chemical addition
- Jar testing
- Why conduct a pilot study?
- Pilot testing protocol
- Platteville Water Resource Recovery Facility
- Cloth media comparison
- Water reuse potential
Surface Filtration

• Many technologies are available
• Media is evolving
  • Granular
  • Compressible
  • 10 µm
  • 5 µm
  • 2 µm - NEW
Cloth Media – The Basics

- Pile fibers create filtration area
- Backing and filament construction make a difference
**Cloth Media - Ultrafiber**

- **Ultrafiber**
  - Newly developed cloth – ultrafiber
  - Originally designed for water pretreatment systems
  - Clean feed source (5-10 mg/L TSS)
  - Designed to improve particle retention
  - “Filtration rating” of 2 micron
  - Fiber construction – 1/2 to 1/3 of microfiber
Filtration and Chemical Addition

SECONDARY CLARIFIER EFFLUENT

CHEMICALLY TREATED FILTER INFLUENT

FILTER

FILTRATE

Particulate

Soluble Reactive

Soluble Nonreactive

Chemical Solids
(precipitation of soluble reactive)

Particulate captured by media

Particulate

(weak chemical solid and small particles)
Where to Start – Jar Testing

- Should be tailored to closely match actual conditions
- **Conditions**
  - Sequence of chemical addition
  - Rapid mixing time and intensity
  - Flocculation time and intensity
- **Visual Evaluation**
  - Time of first floc formation
  - Floc size
  - Floc Quality
  - Settling Rate
- **Settled Samples**
  - Turbidity
  - Color
  - Particle count
  - Filtered turbidity
  - Phosphorus
Jar Testing
Jar Testing – Dose Response Curve
Pilot Study – Why?

• **Advantages**
  - New technology uneasiness
  - Hands-on experience
  - Performance assessment at different conditions
    - Influent and effluent constituents
    - High flows and solids loadings
    - Chemical usage – type and volume
    - Chemical contact time
    - Phosphorus speciation
    - Backwashing – frequency and volume
  - Improve startup activities

• **Disadvantages**
  - Costs: $5,000 - $40,000
  - Time
Onsite Pilot Testing – The Protocol

- Agree on protocol
- Get the biggest bang for your buck
- Plan for normal or upset conditions
- Sampling schedule
- Lab testing requirements
- Daily schedule
- Staffing plan
# Protocol – Daily Schedule

<table>
<thead>
<tr>
<th>Day</th>
<th>Test</th>
<th>HLR (gpm/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment arrives on site and setup</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Setup</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Finish setup and start flow</td>
<td>3.25</td>
</tr>
<tr>
<td>4</td>
<td>Metal salt &amp; polymer optimization</td>
<td>3.25</td>
</tr>
<tr>
<td>5</td>
<td>Metal salt &amp; polymer optimization</td>
<td>3.25</td>
</tr>
<tr>
<td>6</td>
<td>Metal salt &amp; polymer optimization</td>
<td>3.25</td>
</tr>
<tr>
<td>7</td>
<td>Steady State</td>
<td>3.25</td>
</tr>
<tr>
<td>8</td>
<td>Steady State</td>
<td>3.25</td>
</tr>
<tr>
<td>9</td>
<td>Steady State</td>
<td>3.25</td>
</tr>
<tr>
<td>10</td>
<td>Maximum Flow</td>
<td>6.5</td>
</tr>
<tr>
<td>11</td>
<td>Metal salt &amp; polymer optimization</td>
<td>2.0</td>
</tr>
<tr>
<td>12</td>
<td>Metal salt &amp; polymer optimization</td>
<td>2.0</td>
</tr>
<tr>
<td>13</td>
<td>Steady State</td>
<td>2.0</td>
</tr>
<tr>
<td>14</td>
<td>Steady State</td>
<td>2.0</td>
</tr>
<tr>
<td>15</td>
<td>Steady State</td>
<td>2.0</td>
</tr>
<tr>
<td>16</td>
<td>Maximum Flow</td>
<td>4.0</td>
</tr>
</tbody>
</table>
# Protocol – Sampling Requirements

## Sampling Schedule

<table>
<thead>
<tr>
<th>Influent</th>
<th>Onsite Lab</th>
<th>3rd Party Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (pre chemical)</td>
<td>-</td>
<td>2 Composite/day</td>
</tr>
<tr>
<td>TSS (post chemical)</td>
<td>-</td>
<td>2 grab/day</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>2 Composite/day</td>
<td>2 Composite/day</td>
</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Soluble Phosphorus</td>
<td>2 Composite/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Soluble Reactive Phosphorus</td>
<td>2 Composite/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Particle Size Analysis</td>
<td>2 Composite/day</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effluent</th>
<th>Onsite Lab</th>
<th>3rd Party Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>-</td>
<td>2 Composite/day</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>2 Composite/day</td>
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</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Soluble Phosphorus</td>
<td>2 Composite/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Soluble Reactive Phosphorus</td>
<td>2 Composite/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Grab/day</td>
<td></td>
</tr>
<tr>
<td>Particle Size Analysis</td>
<td>2 Composite/day</td>
<td></td>
</tr>
</tbody>
</table>
Platteville Water Resource Recovery Facility

- Located in southwestern WI
- Current population of 12,200
- Annual average of design flow = 2.05 MGD
- Current annual average = 1.0 MGD
- Integrated biological treatment system
  - Primary settlers
  - Trickling filters
  - Intermediate clarifiers
  - Aeration basins
  - Secondary clarifiers
  - Sand filters
  - Disinfection
Platteville WRRF – Aerial
# Phosphorus Compliance Schedule

<table>
<thead>
<tr>
<th>Required Action</th>
<th>Year Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 – OER</td>
<td>2015</td>
</tr>
<tr>
<td>Year 2 – Status Report</td>
<td>2016</td>
</tr>
<tr>
<td>Year 3 – Preliminary Alternatives</td>
<td>2017</td>
</tr>
<tr>
<td>Year 4 – Final Alternatives</td>
<td>2018</td>
</tr>
<tr>
<td>Achieve Compliance – 0.075 mg/L</td>
<td>2023</td>
</tr>
</tbody>
</table>
Phosphorus Compliance

- Chemical phosphorus removal study
  - Multipoint chemical addition
    - Intermediate clarifier effluent
    - Sand filter influent
  - Results indicate that effluent phosphorus < 0.3 mg/L is possible

- Watershed
  - 3,000 lb annually

- WWTF upgrades – surface filtration
- MDV
• Two types of cloth media
  • Standard cloth – microfiber
    • “Filtration rating” of 5 micron
  • Ultrafiber
    • “Filtration rating” of 2 micron

• Standard cloth – microfiber
  • Average HLR = 3.25 gpm/ft\(^2\)
  • Peak HLR = 6.5 gpm/ft\(^2\)
  • Design SLR = 2.0 ppd/ft\(^2\)

• Ultrafiber
  • Average HLR = 2.0 gpm/ft\(^2\)
  • Peak HLR = 4.0 gpm/ft\(^2\)
  • Design SLR = 1.0 ppd/ft\(^2\)
Pilot Trailer

- Commercial unit, full-scale, single disk
- 10.8 ft\(^2\) of effective filtration area
- Chemical feed pumps
- Flocculation tanks
- Data monitoring
  - Influent and effluent turbidity
  - Influent and waste flow
  - Tank level
  - Influent and effluent ortho-phosphorus
Results – Particle Removal

The graph illustrates the average percent removal of particles across different size ranges, comparing Microfiber and Ultrafiber treatments. The x-axis represents the particle size in microns, while the y-axis shows the average percent removal. The data suggests a higher removal efficiency for both Microfiber and Ultrafiber as the particle size decreases.
Particle Removal

CHEMICALLY TREATED FILTER INFLUENT

FILTRATE

Chemical

Particulate (weak chemical solid and small particles)

Particulate captured by media

Soluble Nonreactive

Soluble Reactive

Chemical Solids (precipitation of soluble reactive)
Results – Total Suspended Solids

The graph shows the comparison of TSS Concentration (mg/L) for Influent and Effluent across Microfiber and Ultrafiber.

- Influent
  - Microfiber: 12 mg/L
  - Ultrafiber: 6 mg/L

- Effluent
  - Microfiber: 2 mg/L
  - Ultrafiber: 1 mg/L
Phosphorus – Influent Speciation – SNRP

- Insoluble Reactive: 0.41
- Soluble Reactive: 0.15
- Soluble Non-Reactive: 0.05
- Insoluble Non-Reactive: 0.04
Phosphorus – Effluent Speciation – SNRP
Phosphorus – Influent Speciation – Orthophosphate
Phosphorus – Effluent Speciation – Orthophosphate

- Insoluble Reactive: 0.11
- Soluble Non-Reactive: 0.05
- Soluble Reactive: 0.05
- Insoluble Non-Reactive: 0.01
Phosphorus – Effluent Speciation – Orthophosphate
Phosphorus – Influent Speciation – Insoluble Forms

- Insoluble Reactive: 0.41
- Soluble Reactive: 0.15
- Soluble Non-Reactive: 0.05
- Insoluble Non-Reactive: 0.04
Phosphorus – Effluent Speciation – Insoluble Forms

- Insoluble Reactive: 0.02
- Insoluble Non-Reactive: 0.01
- Soluble Reactive: 0.01
- Soluble Non-Reactive: 0.02
Results – Microfiber Adjustment Period
Results – Microfiber Optimization
Results – Ultrafiber Optimization
Overall Summary of Results – Phosphorus

![Bar chart showing phosphorus concentration for Microfiber and Ultrafiber. Microfiber has an influent concentration of 0.086 mg/L and an effluent concentration below 0.01 mg/L. Ultrafiber has an influent concentration of 0.057 mg/L and an effluent concentration of 0.057 mg/L.](image-url)
## Results – Avg. and Peak HLRs

<table>
<thead>
<tr>
<th>Cloth Type</th>
<th>HLR (gpm)</th>
<th>Avg. Molar Ratio (mol Fe:mol P)</th>
<th>Average Total Phosphorus (TP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Influent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(mg/L)</td>
</tr>
<tr>
<td>Microfiber</td>
<td>3.25</td>
<td>1.81</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>6.50</td>
<td>1.92</td>
<td>0.64</td>
</tr>
<tr>
<td>Ultrafiber</td>
<td>2.0</td>
<td>3.77</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>2.33</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Results – Total Waste Flow

- Automatically initiated at 12” differential
- Cleans by drawing filtrate backwards through cloth
- Solids at bottom of tank are wasted using same backwash pump

<table>
<thead>
<tr>
<th>Cloth</th>
<th>No Chemical</th>
<th>Ferric</th>
<th>Ferric + Polymer</th>
<th>High Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microfiber</td>
<td>-</td>
<td>3%</td>
<td>3.5%</td>
<td>-</td>
</tr>
<tr>
<td>Ultrafiber</td>
<td>7%</td>
<td>10%</td>
<td>11%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>
Results from Lab 2 were suspiciously low compared to the other labs.

On average, influent data from onsite and Lab 1 were 27% and 31% greater than Lab 2, respectively.

Effluent results showed greater differences:
- Onsite and Lab 1 were 60% and 44% greater than Lab 2.

All of Lab 2 data was removed from the data analysis.

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Onsite</td>
</tr>
<tr>
<td>Influent</td>
<td>0.59</td>
</tr>
<tr>
<td>Effluent</td>
<td>0.121</td>
</tr>
</tbody>
</table>
• High solids sources: MLSS, recycling backwash
• Backwash recycled at 3% of forward flow
• Could recycling solids reduce effluent concentrations and the need for chemical?

### Results – Upset Conditions & High Solids

<table>
<thead>
<tr>
<th>Cloth</th>
<th>Influent TSS (mg/L)</th>
<th>Effluent TSS (mg/L)</th>
<th>Influent Phosphorus (mg/L)</th>
<th>Effluent Phosphorus (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microfiber</td>
<td>19</td>
<td>2</td>
<td>0.95</td>
<td>0.087</td>
</tr>
<tr>
<td>Ultrafiber</td>
<td>11</td>
<td>1</td>
<td>0.60</td>
<td>0.060</td>
</tr>
</tbody>
</table>
Potential for Water Reuse

- Testing completed in Saint Johns County, FL
- Filter influent was spiked with inactivated cryptosporidium and giardia lamblia
- 2.2 log removal of cryptosporidium
- 3.5 log removal of giardia

<table>
<thead>
<tr>
<th></th>
<th>Cryptosporidium (oocysts/100 L)</th>
<th>Giardia (cysts/100 L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>13,600</td>
<td>6,800</td>
</tr>
<tr>
<td>Effluent #1</td>
<td>103</td>
<td>4</td>
</tr>
<tr>
<td>Effluent #2</td>
<td>98</td>
<td>1</td>
</tr>
<tr>
<td>Effluent #3</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>Average Effluent</td>
<td>89</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Summary

- Onsite piloting can provide valuable hands-on experience for operators
- Critical aspects of onsite testing
  - Protocol agreement
  - Laboratory requirements
- Upstream performance is critical
- Chemical and SNRP play a critical role
- Tighter media construction results in better removal rates
- Ultrafiber appears to have potential for water reuse applications
- Disadvantages of tighter media construction include higher wasting rates and lower design flow and solids loading rates