1. Introduction

Magnetite ballasted activated sludge systems are growing in acceptance as a viable solution for expanding the treatment capacity of wastewater treatment plants (WWTPs). A growing installation base across the US and UK continues to prove and improve process application with many of these plants having been in operation now for over 7 years.

The magnetite ballasted process (commonly known as the BioMag® system) can double or triple the treatment capacity of an existing conventional activated sludge (CAS) process without the need for additional tankage. This process has been found to be a cost-effective alternative for a WWTP to meet future effluent permit limits when compared to CAS processes as well as more advanced technologies such as membrane bioreactors (MBR), moving bed bioreactors (MBBR), and integrated fixed film activated sludge (IFAS).

- Magnetite (Fe₃O₄) with a specific gravity of 5.2 is used to ballast biological floc.
- Ballasted floc settles rapidly and reliably allowing for significantly increased mixed liquor concentrations and increased clarifier SRT and SOR rates.
- Increased settling rates allow for process intensification within existing tankage making available capacity to process greater loads, increased flows, target nutrient removal or a combination of all three.

The process requires a baffle to prevent unwanted settling in tanks, pipes and channels.

2. Process

**Bioreactor**

The first step is addition of magnetite to the bioreactor. This is achieved by adding magnetite from the storage system into a side stream of MLSS fed directly into the bioreactor where it is mixed and fully infused into the biological floc.

**Clarifier**

Commonly the pinch point in a reactor-clarifier process, ballasted mixed liquor settles rapidly allowing increased SORs of 2-3 times and increased SIRs coupled with low and stable sludge blanketing, high TSS removal and ability to manage wide swings in flow and load.

3. Application and Design

**Mixed Liquor Concentration**

Magnetite impregnated biological floc has a specific gravity of approximately 1.7 which dramatically increases the settling rate. Secondary clarifier loading rates can be significantly increased compared to CAS systems allowing for much higher biological MLSS concentrations in the reactor and therefore increased reactor capacity.

Typically the ratio of mixed liquor to biological solids is 2:1 but can vary between 0.5 and 1.1 in normal operating conditions. As with MBR applications, the upper MLSS concentration is typically around 8000 mg/L due to decline in beta above this point.

**Clarifier Capacity with Ballasted Mixed Liquor**

Typical loading rates for CAS compared to ballasted mixed liquor systems are compared in Table 1.

<table>
<thead>
<tr>
<th>Process Description</th>
<th>Average</th>
<th>Peak</th>
<th>Average</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>22</td>
<td>55</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>Magnetite-infused</td>
<td>20</td>
<td>70</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>Improvement with MBF</td>
<td>25%</td>
<td>35%</td>
<td>100%</td>
<td>125%</td>
</tr>
</tbody>
</table>

4. Case Studies

**Starbuck**

- Installation completed 2012
- Selected over MBR
- Plant expanded from 2.8 ML/d to 6.1 ML/d without additional tankage
- Improved secondary effluent quality TN: 5.0 mg/L, TP < 0.2 mg/L

**Upper Gwynedd**

- Challenge: to meet new TP limit of 0.2 mg/L, manage high wet weather peaks and avoid need for tertiary treatment
- BioMag enabled plant to almost double peak flow capacity from 45 ML/D to 85 ML/D

5. Conclusion

While many components of magnetite-ballasted activated sludge systems are similar to conventional activated sludge systems, there are several special considerations which need to be incorporated into new BioMag system installations. These include proper preliminary treatment, biological process and secondary clarification, aeration and mixing requirements, hydraulic profiling chemical addition, solids management, and magnetite feed and recovery design.

The information in this presentation is intended to serve as a guide for those interested in assessment of capacity increase potential and evaluation versus alternatives solutions. As the technology becomes more widely adapted and understood, there will be opportunities to revisit and expand these findings from future pilots, installations and operational experience, and benchmark studies.

References: