Control of bulking of sludge in activated sludge process treating pulp and paper mill effluent

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Aerobic biological treatment specifically activated sludge process is well proven and established process for treatment of wastewater from pulp and paper industry.

Continuous shifting of the boundary conditions and paradigm change of process technology in the pulp and paper mills bring a new challenge in the age–old, too familiar and convenient wastewater treatment process.

The removal of biodegradable organic substances; both soluble and finely dispersed is accomplished by biological oxidation with the help of microbial consortia principally bacteria.

Different types of problems related to separation of activated sludge solids have been experienced throughout the world viz. dispersed growth of microorganisms, non–filamentous bulking, filamentous bulking, pinpoint floc, foaming and scum formation.

Sludge bulking not only creates the settling problem of the microorganisms but also impairs the ultimate quality of the treated effluent.

Bulking problem is global phenomenon and is predominant in paper industry.
<table>
<thead>
<tr>
<th>Operating/ process parameter</th>
<th>Working range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.5–9.0</td>
</tr>
<tr>
<td>Temperature, °C</td>
<td>25–40</td>
</tr>
<tr>
<td>Organochlorine compounds, mg/l</td>
<td>2–20</td>
</tr>
<tr>
<td>HRT, h</td>
<td>5–12</td>
</tr>
<tr>
<td>Nutrients (CODs:N:P)</td>
<td>100:5:1 – 100:1:0.5</td>
</tr>
</tbody>
</table>
Specific/ nonspecific treatments

- Use of selectors
- Application of oxidants
  - Ozone
  - Chlorine
- Application of flocculants
Dissolve Oxygen
<table>
<thead>
<tr>
<th>Reactors</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO to be maintained (mg/l)</td>
<td>1.5±0.15</td>
<td>2.0±0.2</td>
<td>1.0±0.1</td>
<td>0.5±0.05</td>
<td>0.2±0.02</td>
</tr>
</tbody>
</table>

- Phase I: First 10 days
- Phase II: Next 10 days
- Phase III: Next 8 days
- Phase IV: Next 8 days
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.0 ± 0.2</td>
</tr>
<tr>
<td>Nutrient dose (CODs:N:P)</td>
<td>100:5:1</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>36.0 ± 0.5</td>
</tr>
<tr>
<td>HRT (h)</td>
<td>8.5 ± 0.5</td>
</tr>
<tr>
<td>Organic load (kg/m³/d)</td>
<td>0.9 ± 0.2 (as CODs removal)</td>
</tr>
<tr>
<td>F/M ratio, d⁻¹</td>
<td>0.28 ± 0.03</td>
</tr>
</tbody>
</table>
Phase: II

R1 (DO: 1.57 ± 0.20)

R2 (DO: 2.08 ± 0.15)

R3 (DO: 1.07 ± 0.07)

R4 (DO: 0.56 ± 0.08)

R5 (DO: 0.28 ± 0.09)
Phase: III

R2 (DO: 2.31 ± 0.86)
R3 (DO: 1.39 ± 0.57)
R4 (DO: 0.54 ± 0.23)
R5 (DO: 0.28 ± 0.06)
R1 (DO: 1.59 ± 0.92)
Phase: IV

R1 (DO: 1.55 ± 0.60)

R2 (DO: 2.08 ± 0.75)

R3 (DO: 1.20 ± 0.61)

R4 (DO: 0.52 ± 0.31)

R5 (DO: 0.26 ± 0.10)
<table>
<thead>
<tr>
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<th>R3</th>
<th>R4</th>
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<td>0.2±0.02</td>
</tr>
</tbody>
</table>

- **Phase V**: Next 7 days
- **Phase VI**: Next 8 days
- **Phase VII**: Next 7 days
<table>
<thead>
<tr>
<th>Phase</th>
<th>R1</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>DO: 1.60±0.13</td>
<td>DO: 0.65±0.21</td>
</tr>
<tr>
<td>VI</td>
<td>DO: 1.69±0.26</td>
<td>DO: 0.54±0.17</td>
</tr>
<tr>
<td>VII</td>
<td>DO: 1.51±0.17</td>
<td>DO: 0.53±0.06</td>
</tr>
<tr>
<td>Phase</td>
<td>DO: 1.38±0.39</td>
<td>DO: 1.09±0.18</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Phase V</td>
<td>R5</td>
<td>R5</td>
</tr>
</tbody>
</table>
The DO level affects the morphology as well as performance of the process to a great extent.

Very low level of DO (0.2 to 0.3 mg/l), supports excessive growth of filamentous organism and suppress the growth of higher organism.

The performance of process at low DO condition was poor and COD reduction was 25-30% where as no reduction in colour was observed.

At 0.5 mg/l DO level, the performance of process was moderate but sludge remains bulking with excessive proliferation of filamentous organisms.

0.9 to 1.1 mg DO/l level was found to be adequate for running of activated sludge process. The morphology of sludge and performance of reactor was comparable to that of at 2.0 mg DO /l level.