Energy Consumption in Large Wastewater Treatment Plants as a Function of Wastewater Strength

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Introduction

Wastewater treatment (WWT) is an energy-intensive process. Strict standards for discharge often require energy intensive advanced treatment technologies. As a result, the number of plants using advanced treatment has increased (Figure 1).

Rising energy costs and concerns about greenhouse gas generation present a major incentive for tracking energy usage of WWT. Energy usage in plant, for instance, typically represents 18 to 30% of the operational budget.

Water efficient fixtures are also increasing loadings of organic matter to plants while lowering or maintaining overall liquid flow. The increased loadings have a significant impact on energy consumption.

Previous work has focused primarily on aeration consumption for activated sludge rather than a plant as whole. There are very few studies that show energy requirements on a plant-wide scale with the Water Environment Federation (WEF) being one major source.

This research presents a general methodology for tracking energy usage in a plant with regards to wastewater strength. It is anticipated that this research will provide a tool for designers and owners who wish to predict their energy impact before construction of a new plant or before implementing a new process on an existing plant.

Objectives

There are two objectives to this research:
1. Track energy usage in a plant for all major processes.
2. Observe the effect of wastewater strength on energy usage.

Methodology

For this research a large 100 million gallon per day (MGD) plant in the arid southwestern US was chosen (Figure 2).

Each component was designed to have the ability to model the effect of wastewater loading. Three wastewater loading conditions were chosen: low, average, and high loadings (Table 1). From the design and loading conditions, energy usage was predicted in kWh/day. Efficiencies of components such as pumps were assumed using typical values.

Methodology

Methodology

Methodology

Methodology

Methodology

Methodology

Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Low Strength</th>
<th>Average Strength</th>
<th>High Strength</th>
<th>Efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOM</td>
<td>120</td>
<td>230</td>
<td>400</td>
<td>≥30</td>
</tr>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>110</td>
<td>220</td>
<td>400</td>
<td>≥30</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>20</td>
<td>40</td>
<td>70</td>
<td>≥0.5</td>
</tr>
</tbody>
</table>

Figure 3 shows a sample design for the aeration basins from the program BioWin. Table 2 shows design parameters for the aeration basins and Table 3 shows design parameters for the secondary clarifiers.

Results

Figure 4 shows that the largest energy consumer in the plant for all three strengths is the aeration basin. This is due to high energy consumption in the blowers. Other high energy consumers are the secondary clarifiers and dual media filters. This is due to large amounts of pumping. Figure 5 shows the overall energy consumption in kWh/day.

Conclusions/Future Work

The results obtained for the average flow are mostly in line with previous energy estimates published by sources such as the Water Environment Federation. While the numbers are comparable, site-specific parameters affect energy consumption.

Future work will focus on the effect of switching different treatment processes to less energy-intensive processes. There is also room to address how wastewater strength has changed as a result of water efficiency measures.