Anaerobic Digestion Fundamentals

Optimising the anaerobic digestion process through improved understanding of fundamental operational parameters

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INTRODUCTION

Sewage sludge management is a key aspect of wastewater treatment, both because of the potential environmental risk that sludge poses if not properly treated and because of the significant resource recovery potential that it offers. Anaerobic digestion (AD) is a well-established technology, accounting for about 70% of the sewage sludge treated in the UK, with around 150 operating sites of different sizes across UK wastewater treatment plant (WWTP). The process offers socio-environmental benefits reducing odour and associated vector attraction potential of the sludge, and reducing the greenhouse gas emission due to the degradation of the residual organic, as well as economic benefits arising from the recovery of energy under the form of biogas. The process is therefore one of the most successful and economically viable sludge treatment methods and it is likely to continue to have an expanding role as a principal technology for the treatment of sewage sludge. The AD of biodegradable matter is performed by a complex series of interdependent microbiological steps, and the process engineering is controlled by a combination of process conditions and critical physio-chemical parameters, such as reactor temperature, loading rate and mixing energy, sludge dry solids (DS) and volatile solids (VS) content, sludge biodegradability fraction, and many others depending on the type of wastewater collection network and upstream processes. However, the biogas production performance is highly variable within and between sites and there is potentially significant scope to increase the treatment efficiency through a better understanding of the interactive effects of these parameters on the system.

MATERIALS AND METHODS

The aim of the research is to determine the impact of fundamental operational parameters on the anaerobic digestion process at Imperial College London’s Autodigesters. The findings from the experimental research have been used to develop a performance model which is aimed at improving the operational performance of the anaerobic digestion process at WWTPs.

RESULTS

Aim and objectives

1. Autodigesters
2. Thickening rig
3. Chemostats
4. BMP test kit
5. Sludge feed source
6. Experimental design

Performance

Biogas yield

Autodigesters

Chemostats

Sludge feed source

Biogas yield

Alkalinity

Reactor stability

CONCLUSIONS

Anaerobic digestion as core technology to improve overall WWTP sustainability

The results from the optimisation of AD performance can be used to understand the impact of upstream process performance on overall cost and energy consumption of WWTP. In this example four scenarios are modelled (Table 1), to determine what is the cascade impact of having a poorly performing primary sedimentation tank (PST) and an efficient sludge thickening system. Between the effects modelled are: PS/SAS, OLR, activated sludge point oxygen demand, poly consumption, energy generated and value of incentives.

The results (Figure 5) indicate that overall a WWTP with a good performing PST and thickening system can reduce energy and polymer cost by up to 32% and displaces up to 31% more energy compared to the worst case scenario.

Table 2 - Other relevant assumptions used for the modelling

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Temperature</th>
<th>OLR</th>
<th>Poly consumption</th>
<th>Energy generated</th>
<th>Value of incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>PST</td>
<td>28°C</td>
<td>3.1</td>
<td>1.2</td>
<td>7.5</td>
<td>150</td>
</tr>
<tr>
<td>Thickening</td>
<td>38°C</td>
<td>2.0</td>
<td>0.5</td>
<td>10.0</td>
<td>200</td>
</tr>
</tbody>
</table>

Figure 5 - Outcomes of the modelling using results from the experimental research

Outcomes - normalised to worst case scenario & actual values

10.0 - biogas produced

150 - total energy displaced

150 - total cost (emnergy incentives)