OPERATIONAL ISSUES AND REMEDIES IN THE ANAEROBIC SLUDGE DIGESTION PROCESS

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32nd Annual Qld Water Industry Operations Workshop
Walter Pierce Pavilion, Showgrounds Complex - Rockhampton
17 to 19 April, 2007

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ABSTRACT

Anaerobic sludge digestion is an oft fundamental component of municipal sewage treatment, with operational management often proving both complex and labour-intensive for water authority and council-based entities.

Managers of the anaerobic digestion process units, which require significant capital investment to establish within a treatment facility, attempt to maximize the treatment capacity to the limits of design capabilities, often to the detriment of the biological process that drives the organic degradation.

Inadequate/deficient heating, operation outside favourable biologically viable conditions, re-commissioning following asset maintenance activity, poor sludge drying characteristics and poor and/or inconsistent gas production from process units are all design inadequacies or indicators of poor process unit performance.

Operational issues experienced in anaerobic sludge digestion are varied, with specific remedies often a combination of system optimisation and specialist product addition, with each application scenario requiring a concerted investigation prior to solution application.

The optimisation of established anaerobic sludge digestion process units is achievable, through the application of appropriate strategies designed to ensure both operational and managerial considerations are adequately addressed.

KEY WORDS

Anaerobic digestion, optimisation.

1.0   INTRODUCTION

Anaerobic digestion is a treatment process where stabilisation of biodegradable solids removed from the municipal wastewater stream occurs. Anaerobic digestion feed streams generally consist of material known as primary sludge, solids removed from raw wastewater, and secondary sludge, solids removed from biological treatment processes. The anaerobic digestion process is a multistage biological progression where complex organic substances are solubilised and fermented to end-treatment stabilised digested sludge, methane, carbon dioxide and trace gases. Being described as an anaerobic process, the biological processes inherent in digestion, cycle in the absence of oxygen.

In most applications, anaerobic digestion involves retaining both primary and secondary sludges in a well mixed vessel for a hydraulic residence time of between twenty (20) to thirty (30) days, maintaining the sludge within an appropriate temperature range to enable the biological processes to cycle without interruption.

Despite this apparent lack of complexity, anaerobic sludge digestion requires strict operational control to enable process stability and satisfactory sludge stabilisation. Satisfactory operation depends heavily upon temperature control within the process unit which heavily influences start-up speed, stability of fermentation and gas production. In addition to temperature control, hydraulic retention, also known as contact time or sludge age, based on the daily feed of sludge to the process unit, is a heavily dimensioning element in operation. Additional influences include the intensity of mixing and the evenness of sludge feed to the process unit – often a design consideration or shortfall.

Throughout the operation of BioRemedy Pty Ltd as a consulting agent to water authority and council-based entities over the past ten (10) years, the operational managers of anaerobic digestion process units, common themes have arisen, requiring a process remedy or intervention to ensure viability. Case study examples from water authority and council-based entities from all Australian eastern seaboard states provide the basis for a discussion and reference paper.

2.0 DISCUSSION

2.1 Process Unit Design

At the operational level, managers of wastewater treatment facilities containing anaerobic digestion process unit(s) generally inherit a system design based on an appropriate budgetary allocation. Ideal process unit designs allow for adequate temperature control and sludge mixing capability – an example is represented as Figure 1 below.

Figure 1: *Desirable Process Unit Design*

In such process units, gas production as a result of the biological process is captured and used as a fuel for heating and mixing (via sparging) of sludges. Enclosing the unit also removes the sludge from influencing ambient environmental conditions such as cool seasonal variation in inland locations.

In a range of examples, operational staff are not afforded such a luxury, with process unit design limited to mixing of sludges via the gas produced within the unit reaching equalised pressure at the tank surface – an example is represented as Figure 2 below.

Figure 2: *Restrictive Process Unit Design*

In such process units, operational managers much seek to load the process unit appropriately with regard to a design load as biological cycling operates at a slower rate, with the absence of adequate temperature control and mixing. Significantly, in the seasonally cooler months of the year, inland centres (Gilgandra Shire Council –NSW, Gwydir Shire Council - NSW, Leeton Shire Council – NSW & Warwick Shire Council, QLD) sought consultation from representatives of BioRemedy Pty Ltd with regard to optimising their process unit.

The initial response by BioRemedy Pty Ltd was to provide general operational parameters to Council representatives to enable a benchmarking process to be undertaken. Observation of general operational parameters provides operational managers direction with regard to an appropriate intervention or remedy.

2.2   Operational Parameters

Anaerobic digestion is carried out in three (3) distinct stages, Acid Fermentation, Acid Regression and Methane Production and provides for the following operational parameters (Table 1):

Table 1:   *Anaerobic Digestion Operational Parameters*

Parameter	Optimal Range
Alkalinity	2500 – 3000 mg/L
Volatile Fatty Acids (VFA)	200 – 800 mg/L
pH	6.8 – 7.4
Gas Production	0.02 – 0.03 m^3/capita

Domination of Acid Fermentation, the degradation of sludge to organic acids, carbon dioxide, carbonates and hydrogen sulphide, is generally associated with a reduced digester pH (5.0 – 6.8).

Domination of Acid Regression, the degradation of organic acids and nitrogen-based compounds created in the acid fermentation stage, is generally associated with an increase in digester pH, foaming, and limited gas production.

Domination of Methane Fermentation, the degradation of proteins and amino acids to create methane, is generally associated with an increase in volatile acids and alkalinity and a stability of digester pH within the 6.8 – 7.4 range.

2.3 Exceeding Design Capacity

In general terms, acid fermentation and acid regression should be dominant during digester commissioning, either initial or re-commissioning following a maintenance activity. However, if the design capacity of the process unit is exceeded, methane fermentation can be suppressed and acid fermentation may dominate, necessitating an appropriate operational intervention.

In the experience of BioRemedy Pty Ltd, operational managers are most often experiencing a system overload, with respect to the process design capacity.

2.4 Operational Intervention

Operational intervention, from the BioRemedy Pty Ltd perspective, is restricted to an application of chemical agents (Calcium Carbonate or Sodium Carbonate) to maintain an appropriate range of alkalinity within the process unit and the provision of seed bacteria to either the head of the treatment facility or the process unit to enhance the biological degradation of complex, long-chain fats, oils, proteins and sugars present in wastewater sludge.

An increase in alkalinity has the effect of protecting the digester from toxic shock which may be experienced when acid fermentation dominates and increases the range of conditions favourable for sustaining the sensitive methane-forming bacteria which drive the methane fermentation stage of digestion.

Enhancing biological degradation, through the addition of seed bacteria, provides an ability to reduce the organic load upon a process unit – often the most effective method of intervention.

3.0 CONCLUSION

Considering the sociological shift within Australia which has seen the population of regional communities reduce, hence limit the budget available for infrastructure expenditure, it seems likely that optimisation of existing treatment facilities will become a more frequent and required skill for operational managers. While capable, operational managers may have struggled to find the required means to conduct the required activities. In businesses such as BioRemedy Pty Ltd, process optimisation, especially in a municipal wastewater treatment context, is a core skill, with the ability to be engaged by operational managers.

The provision of basic strategies for management should allow operational managers to better characterise the issues being experienced within the poor performance of process units.

While optimisation of existing facilities is essential in the short-term, over the long-term, consideration to design deficiencies currently being experienced should be identified to be addressed in any future augmentation of facilities.

Operational staff can play a valuable role in setting priorities for senior management when individual knowledge and skill sets are commensurate with their vocation.

Figure 3: *Glenorchy City Council STP (TAS)*

4.0   REFERENCES

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