ANAEROBIC DIGESTION – REVIVAL AND SURVIVAL

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ABSTRACT

Anaerobic digestion is a crucial step in the processing and stabilisation of primary sludge at the Bairnsdale Wastewater Treatment Plant (BWWTP). The Anaerobic Digester has been in operation since 2015 after being reconditioned and has the capacity to hold 608 m^3. The health of the digester is monitored by analysing the quality of the supernatant sludge from within the digester during weekly on-site laboratory analysis.

These laboratory processes are vital for monitoring the ongoing health of the digester to determine whether process control intervention is required to maintain operational efficiency.

Multiple changes have been made to the digestion process over a period of 18 months. This has included adjustments to in-house laboratory testing processes, upgrades to feed sludge quality and feed processes including timing and volumes. These adjustments and process controls have proven to be a vital part in the revival and survival of the BWWTP Anaerobic Digester.

1.0 INTRODUCTION

Anaerobic digestion is a process in which microorganisms known as methanogens break down biodegradable material in a controlled environment where there is no oxygen present. This process creates the by-products of carbon dioxide and methane gas. At the Bairnsdale Wastewater Treatment Plant, the methane gas generated is exported from the anaerobic digester to a storage vessel, then passed through a combustion engine known as a Combined Heat and Power unit (CHP). Heat produced by the CHP maintains a constant internal digester temperature and the power generated supplements the treatment facilities' energy needs and exports any excess to the grid.

This process can be easily disrupted by a number of environmental factors or system changes, including but not limited to the addition of an unknown substance, chemical overdosing, high phosphorus loads, rapid changes in temperature and feed sludge quality.

This paper will outline an investigation into the above factors during a period of time where the anaerobic digestion process had shown serious signs of failure with a dramatic turn for the worse in regards to the gas production and quality and the overall health of the anaerobic microbiology.

Continuous testing and monitoring of the situation included testing volatile fatty acids (VFA), alkalinity and pH on a daily basis to monitor for any variations in that would indicate process issues. More regular analysis of total and volatile solids, ammonia and chemical oxygen demand (COD) was conducted along with some in-depth laboratory testing of a broader suite of parameters unable to be tested on-site with assistance from a National Association of Testing Authorities (NATA) accredited laboratory service. This directly aided in the revival of the anaerobic digester.

The results from this testing were used to determine the process control changes required to further reduce the risk of deterioration of the digestion process.

2.0 DISCUSSION

Initial on-site laboratory analysis determined that the digesters' efficiency had reduced significantly due to a dramatic change in chemistry. From this point, a more regular testing regime was initiated to monitor the health of the digester.

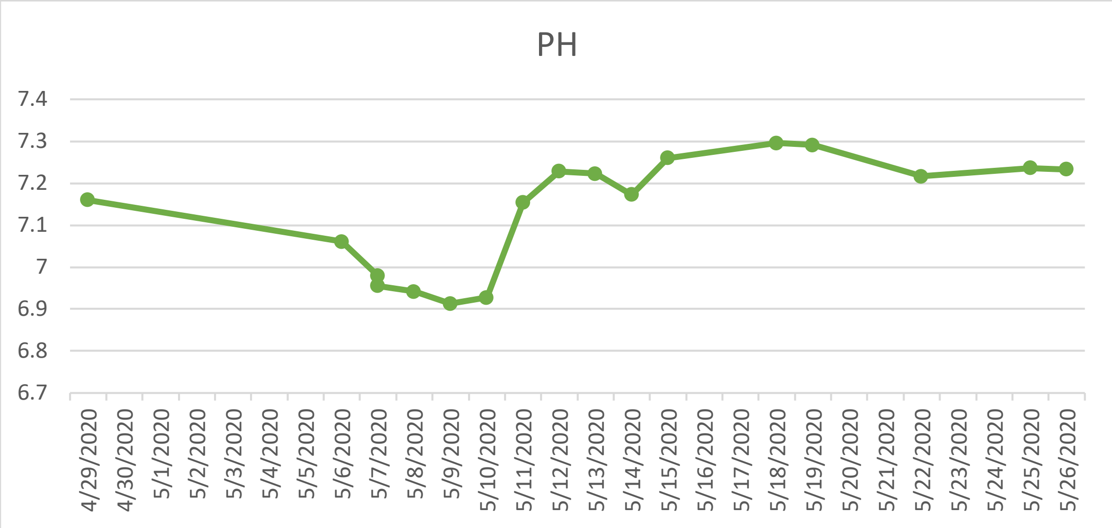
It was believed initially that the digester had suffered from a poisoning event around the 6th of May which resulted in the biology suffering with a form of toxic shock. Within a very short period of time, gas production decreased and the digester sludge VFA/ alkalinity ratio had elevated. This resulted in additional attention being given to the process including after-hours work to minimise the risk of total process failure.

Attempts were made in consultation with some process experts to stabilise the digestion process. Feed sludge flow rates were slowed significantly to reduce the COD loading into the digester and approximately 160kg of lime was added over a 1-week period to boost alkalinity levels and keep the pH levels above 7. Feed rates continued to be reduced significantly for a further period of 3 weeks by diverting a large proportion of primary sludge away from the digester to the sludge holding lagoon. There were a number of risks identified with the diversion this change, in particular the risk of odour emissions from the site due to the high volatile-solids loading that was inevitably sent to the sludge holding lagoon.

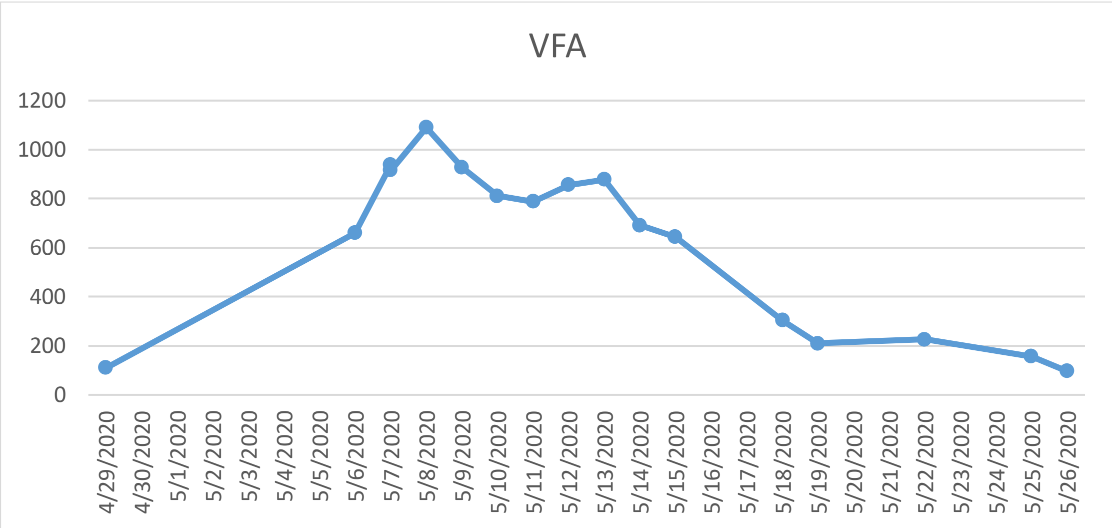
After the 3-week period, the operating parameters of the digester returned to normal levels with gas production and all digester chemistry back within operating limits. Continued testing and monitoring now occur on a weekly basis and any change in activity is investigated. This was a very close call and could have been a very costly event.

Table 1: Results from on-site lab testing over the month of May:

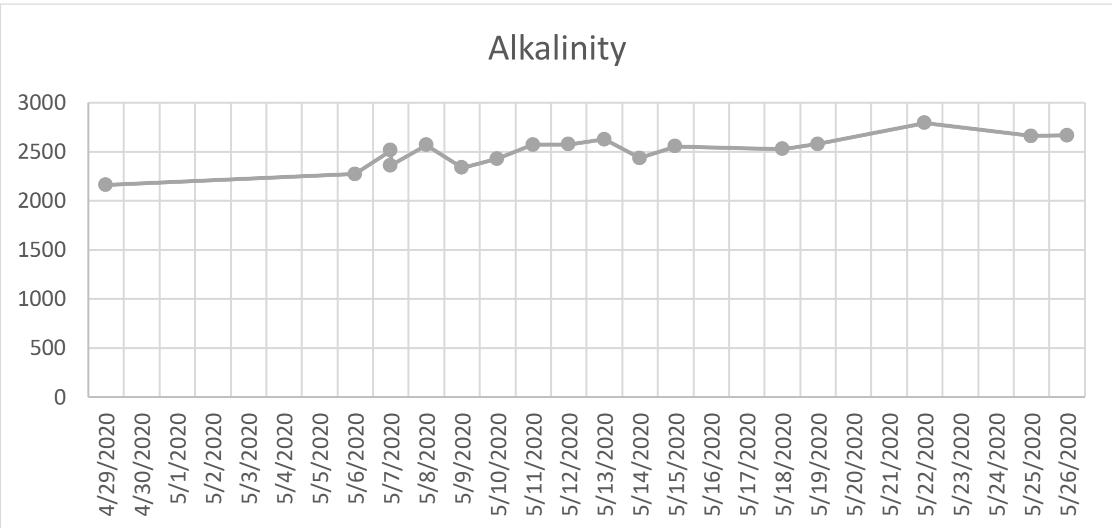
Digester Supernatant Results						
Date	pH	VFA	Alkalinity	COD	Ratio	Comments
29-4-20	7.160	110	2161.2	387	0.05	
6-5-20	7.061	659.7	2271.6	766	0.29	
7-5-20 (am)	6.979	938.8	2512.0		0.37	
7-5-20 (pm)	6.955	915.9	2360.7	1552	0.38	
8-5-20	6.942	1090.1	2566.5	1209	0.42	Drained thickener; added 2 20kg bags of lime
9-5-20	6.913	926.9	2336.8	1281	0.39	Added 3 20kg bags of lime
10-5-20	6.927	810.7	2427.8		0.33	Adjusted feed time
11-5-20	7.154	788.1	2571.2	11136	0.30	
12-5-20	7.228	856.4	2576.4	1290	0.33	Added 3 20kg bags of lime
13-5-20	7.223	878.0	2625.7		0.33	
14-5-20	7.173	691.7	2433.6		0.28	
15-5-20	7.260	644.1	2554.0		0.25	
18-5-20	7.296	303.6	2527.8		0.12	
19-5-20	7.291	210.0	2578.7	666	0.08	
22-5-20	7.216	226.7	2792.1		0.08	
25-5-20	7.236	156.9	2661.3		0.05	
26-5-20	7.233	96.2	2667.0	586	0.03	



<u>Figure 1:</u> *pH results*



<u>Figure 2:</u> *VFA results*



<u>Figure 3:</u> *Alkalinity results*

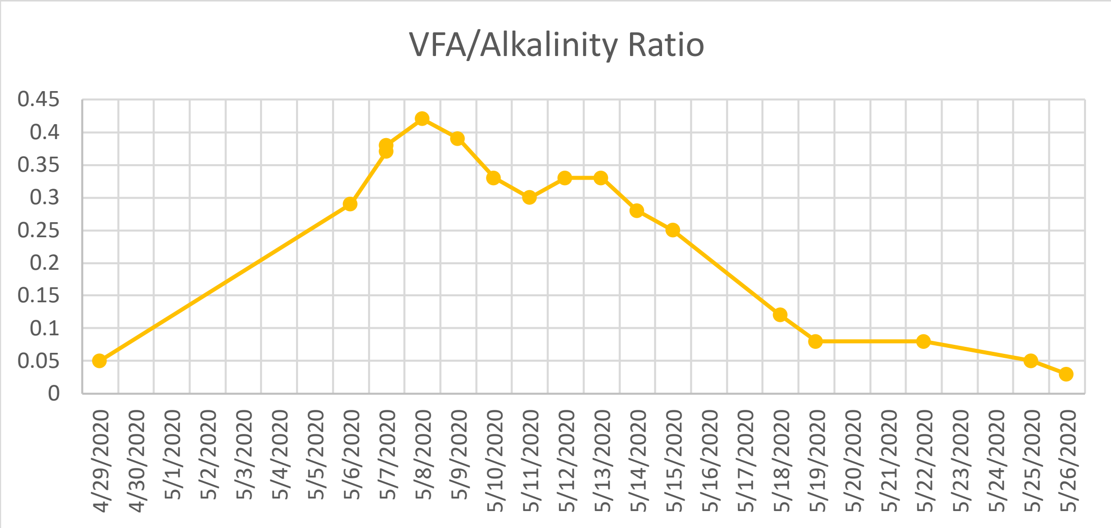


Figure 4: *VFA/Alkalinity ratio results*

2.1 Consultation

Advice from a consultant was sought and discussion was held with a number of experienced process specialists. This advice was sought to increase confidence levels in the process decision making. Advice from consultants also assisted in the further development of the digester troubleshooting guide, utilising past parameter indicators and new information discovered during this event to ensure operators are able to identify when to proceed with specific process interventions.

2.2 Adjustments to Laboratory Testing Processes

Further diagnostic work was completed to validate the on-site auto-titration method to ensure that the programming and calculations were set correctly (in regards to our specific digester operating parameters). It was determined that the current VFA/alkalinity testing programme had the incorrect sulphuric acid solution listed within the auto-titrator. This resulted in the calculation method being incorrect and giving a higher VFA/alkalinity ratio result. Once the programme was adjusted, the ratio results reduced significantly and more in line with process norms. However, the technical 'ranges' stayed the same. Previously stable results may have been a ratio of 0.40-0.50, whereas stable results were now 0.02-0.12 with the ranges remaining the same.

Another adjustment made to the laboratory process was the introduction of a centrifuge. Samples tested during routine laboratory sessions include digester feed and supernatant sludge along with raw sewage from the treatment plant inlet. As these samples have a high solids concentration, testing for VFA/alkalinity was found to be imperfect as over time the pores in the pH probe were prone to become blocked and reduce the efficacy of the testing. The centrifuge is used to reduce the solid concentration of the samples significantly prior to analysis, reducing the likelihood of negative effects on the pH probe.

The combination of these two actions has resulted in significantly increased reliability and confidence in the VFA/alkalinity testing process and long-term improved performance of the digester.

2.2 Trial and Methodology

Various actions were taken in a bid to resolve the digester health issue. In addition to those already discussed, humus sludge was diverted away from the digester for a period of time to aid in reducing the load and overall sludge feed volume into the digester. Humus sludge is relatively low in COD and total solids concentration, making it difficult to thicken and it offers little to the gas production potential of the digester. Sludge retention time within the digester is an important factor in maintaining strong biological health and the additional water volume that the humus sludge delivers to the digester reduces retention time.

Ferric Sulphate dosing is used at the treatment plant for phosphorous removal and this was also analysed for possible impacts on the digester. It was determined that the levels of ferric sulphate dosing were significant enough to contribute to the poor performance of the digestion process. By diverting the sludge from the humus tanks away from the digester almost 50% of the ferric sulphate dosed within the treatment plant was also diverted.

2.3 Results

A NATA accredited laboratory was approached to complete a series of tests from a sample of supernatant sludge from within the digester. These results are in Table 2 below:

Sample No	Site Code	Site Description	Sample Type	Sampled Date/Time
6561497		Bairnsdale WWTP - Anaerobic Digester Sludge	W-SLUDGE	12/05/20

Analysis - Analyte	*Sample No. Site Code Units*	6561497
NH3 as N (DA) - Ammonia, as N	mg N / L	560
MS Total Metals - Aluminium	mg/L	7.4
MS Total Metals - Antimony	mg/L	<0.01
MS Total Metals - Arsenic	mg/L	0.03
MS Total Metals - Barium	mg/L	0.49
MS Total Metals - Beryllium	mg/L	<0.01
MS Total Metals - Boron	mg/L	<0.2
MS Total Metals - Cadmium	mg/L	0.003
MS Total Metals - Chromium	mg/L	0.28
MS Total Metals - Cobalt	mg/L	0.02
MS Total Metals - Copper	mg/L	1.2
MS Total Metals - Iron	mg/L	410
MS Total Metals - Lead	mg/L	0.05
MS Total Metals - Manganese	mg/L	0.72
MS Total Metals - Mercury	mg/L	<0.001
MS Total Metals - Molybdenum	mg/L	0.07
MS Total Metals - Nickel	mg/L	0.12
MS Total Metals - Selenium	mg/L	0.02
MS Total Metals - Silver	mg/L	<0.01
MS Total Metals - Strontium	mg/L	0.80
MS Total Metals - Thallium	mg/L	<0.01
MS Total Metals - Tin	mg/L	0.03
MS Total Metals - Titanium	mg/L	0.15
MS Total Metals - Vanadium	mg/L	0.19
MS Total Metals - Zinc	mg/L	2.4
SOLVENTS - Acetone	mg/L	0.70
SOLVENTS - Acrylonitrile	mg/L	<0.1 LORR
SOLVENTS - Ethylhexyl Acrylate	mg/L	<0.1 LORR
SOLVENTS - Isopropanol (Isopropyl Alcohol)	mg/L	<0.1 LORR
SOLVENTS - Methylethyl Ketone	mg/L	0.11
SOLVENTS - Methyl Isobutyl Ketone	mg/L	<0.1 LORR
GCMS-SV - GCMS SemiVolatile Screen		NR IND
GCMS-V - GCMS Volatiles Screen		NR IND

Table 2: Results from NATA testing of supernatant sludge

These tests were conducted to identify if an outside influence (e.g. a trade waste discharge) had caused the event. The results showed that none of the parameters were significant enough to cause the issues on their own, leading to the belief that the event was caused by processes within the treatment plant.

2.4 Sludge Well Configuration Changes

As a result of identifying the issue relating to humus sludge, permanent changes were made to the configuration of the sludge wells to divert the humus sludge away from the digester. On average sludge feed flows to the digester have been reduced by approximately 15% and the average sludge feed solids concentration has increased proportionally, resulting in a much more stable digestion process. Sludge retention time within the digester increased from 12 to 15 days.

3.0 CONCLUSION

The question still remains, how did the digester come to this point? What was the root cause of the issues experienced? Was it poisoned by a specific product in the influent that wasn't identified during the NATA testing, was a major failure in the treatment process, or a combination of all of the factors discussed?

In the end, the event taught us how to deal with a digester issues more effectively and more quickly and informed us of the actions required to ensure survival of the digester biology.

Gas production and digestate quality since this event have been much more consistent, and although it took some time to improve the VFA/alkalinity ratio and implement on-site laboratory methods it has paid off by reducing reactive manhours and increasing process reliability. We now have a number of updated procedures in place to deal with any issues that arise and the ability to intervene early to minimise the impact on the digester.

4.0 ACKNOWLEDGEMENTS

The successful outcome reached would not have been possible without the combined efforts of many individuals. I would like to thank all involved for their efforts and achievement.

5.0 REFERENCES

Michelle E. Jarvie - Britannica – Anaerobic Digestion
https://www.britannica.com/science/anaerobic-digestion

East Gippsland Water
Internal documentation (ALS lab results, emails, laboratory results)