THE USE OF BLEND LIME FOR BIOSOLIDS STABILISATION TO DEFER OPERATIONAL SPENDING

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ABSTRACT

Alkaline stabilisation of biosolids is a well-known process to reduce pathogenic organisms, control odours and increase cake solids. The Mangere WWTP produces an average of 300 wet tonnes of biosolids a day, which requires approximately 25 tonnes of burnt lime to be added on a daily basis. Lime addition increases the pH biosolids to 12 to comply with the resource consent requirements. It also improves the on-site operation with regards to biosolids processing, handling and disposal, by reducing the machinery blockages and increasing the shear strength. Different blends of burnt lime and additives were tested in a laboratory scale to increase shear strength through the additives without impacting the pH. The results of this study were used to carry out a full scale blended lime trial at Mangere WWTP. The blend is a composition of 70% burnt lime and 30% lime kiln dust. Lime kiln dust is a co-product of the burnt lime process. The main objective of the trial was to assess the performance of the blended lime on the full scale process and over a minimum period of 6 months. The operational savings generated by the use of blended lime to replace burnt lime was estimated to be 15% of the budgeted lime consumption. This paper presents the challenges of this full scale trial and operational results obtained through the trial period, and economic benefits.

KEYWORDS

Biosolids disposal, additives, stabilisation, lime kiln dust, operation variables, costs.

NOMENCLATURE

ASU: Alkaline Stabilisation Units
$CaCO_3$: Calcium Carbonate
CaO: Calcium Oxide
CO_2: Carbon Dioxide
$Ca(OH)_2$: Calcium Hydroxide
CF: Centrifuge
Ltd: Limited
LKD: Lime Kiln Dust
MWWTP: Mangere Wastewater Treatment Plant
MLD: Mega Litres per Day
MAD: Mesophilic Anaerobic Digesters
MSDS: Material Safety Data Sheet
TPS: Thickened Primary Sludge
TS: Total Solids
TWAS: Thickened Wasted Activated Sludge

VS: Volatile Solids

1. INTRODUCTION

The Mangere Wastewater Treatment Plant (MWWTP) is the largest advanced nutrient removal plant in New Zealand, serving the greater Auckland region with a population equivalent of 1,100,000. The plant treats on average 330 MLD of wastewater combining waste (industrial and domestic) and stormwater, in a series of mechanical, biological and physical-chemical processes. The solids generated by the process are digested through Mesophilic Anaerobic Digesters (MAD) and further stabilised through the addition of burnt lime in a 30% solids content in addition to the final dry product. With 300 wet tonnes of biosolids produced per day, MWWTP uses approximately 25 tonnes of lime on a daily basis, which contributes to 25% of the total chemical budget of the plant. In 2013, McDonald's Lime Limited, now owned by Graymont, approached Watercare to trial using a blend of burnt lime and Lime Kiln Dust (LKD), as an alternative to burnt lime, which if successful would result in significant operational savings. A pilot scale study had been previously carried out using blended lime and other additives in 2009. This paper investigates the challenges of a full scale trial and presents the operational results.

2. BACKGROUND INFORMATION

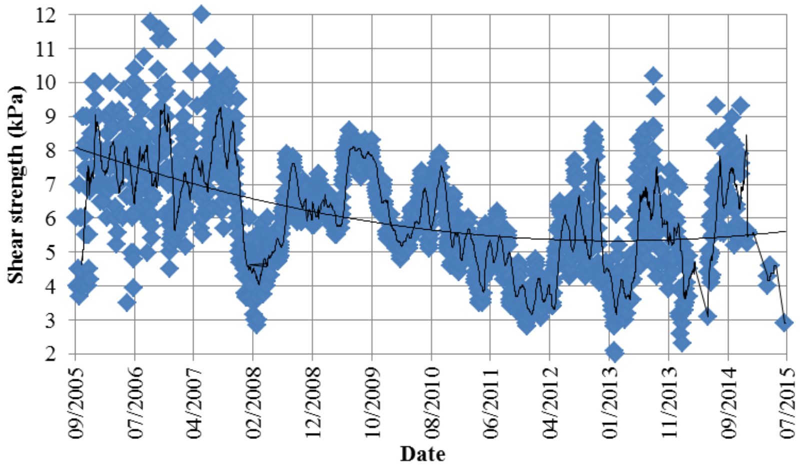
MWWTP produces Class B Biosolids that are land disposed in a rehabilitation site, located near the WWTP, and owned by Watercare. The biosolids were disposed in an area called "Pond 2", adjacent to the MWWTP until late November 2014. In December 2014, Pond 2 reached its final capacity, with biosolids now being disposed to the new rehabilitation site on Puketutu Island.

2.1 BIOSOLIDS SHEAR STRENGTH

The shear strength of the MWWTP biosolids has gradually deteriorated since 2008 (Figure 1). Biosolids shear strength describes the magnitude of the shear stress that the biosolids can sustain, or their ability to resist forces that attempt to cause the internal structure to slide against itself. The European legislation specify the requirement for sludge monofilling to possess a shear strength of 10kPa prior to monofill (CPG, 2011). In the Puketutu rehabilitation plan design, it is intended to maximise the disposal height to up to 26 m, which means that the shear strength should be in the range of 20kPa to ensure the stability of the area.

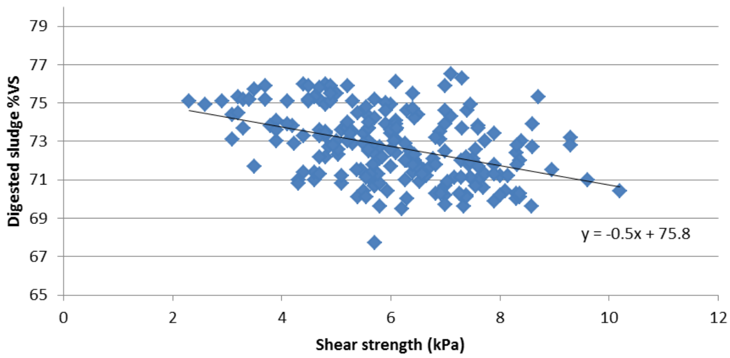
Shear strength is measured on a daily basis once the biosolids have been placed in a cell of the disposal site. With time, as leachate is drained and biosolids are more compact, shear strength increases. The data presented in Figure 1 shows an overall decreasing average trend (based on 30 days average), with seasonal variations of the shear strength. From 2005 to 2008, the biosolids shear strength varied between 6 to 9kPa. From 2008 to 2012, it gradually decreased to a minimum of 3kPa. In the last three years however, the shear strength varied from an absolute minimum of 2kPa to a maximum of 10kPa, and averaged 5.3kPa over the period.

Figure 1: Shear strength over a 10 year period.



The reason for seasonal shear strength variation has not been clearly identified, although intensively studied and monitored over the years (CPG, 2011, AECOM, 2014). One of the potential causes could be the high Volatile Solids (VS) content of the digested sludge. The data analysis shows that there is no strong correlation between the VS and shear strength, however it suggests that the shear strength improves as the VS decreases (Figure 2).

Figure 2: Digested sludge %VS against shear strength, based on 2013 to 2015 database.



2.2 USE OF ADDITIVES

One method of biosolids stabilisation is to add alkaline materials to raise the pH level and make conditions unfavourable for the growth of organisms such as pathogens (EPA, 2000).
The MWWTP biosolids are treated with burnt lime in order to:

- Enhance the shear strength by decreasing the water content and increase the density of the final product to facilitate land disposal and improve land stability,

- raise the pH above 12 to stop biological activity and reduce vector attraction,

- ease the operation of sludge handling from the dewatering plant to the biosolids storage building at the plant,

- increase the Total Solids (TS) content and optimise the land disposal volume.

The dose rate of burnt lime was set up during commissioning of the Alkaline Stabilisation Units (ASU) as part of the last major upgrade of the MWWTP in 2003. Burnt lime was found to meet the performance requirements cited above at a dose rate of 30% weight per dry biosolids weight ratio. This currently corresponds on a daily basis to approximately 25 tonnes of burnt lime for 300 wet tonnes of biosolids. Lime consumption represents 20-25% of the yearly chemical budget. Once the biosolids are mixed with lime, they are conveyed to the biosolids building which can store up to two to four days production, depending on the bulk density of the biosolids.

In 2009, ten different additives were mixed with biosolids to investigate the improvement of biosolids shear strength and land disposal at MWWTP. From the evaluation of different ratios, LKD showed improvement in shear strength even with no burnt lime added (Kayser, 2012). However, the volume of additive was in high to very high ratio (from 40 to 50%). Increasing the amount of additive would increase the stability of the biosolids, but also increase the final volume to be disposed of, and the costs associated with biosolids stabilisation and disposal.

Ideally, the lime to biosolids ratio would not vary from current operation so the life expectancy of the new rehabilitation site would not be reduced. Increasing the amount of additive to achieve a better shear strength would be, in the long term, neither economical nor sustainable.

2.3 FROM PILOT SCALE TO CASE STUDY

In 2013, McDonald's Lime Ltd and Watercare agreed to conduct a trial on a lime mix. The objective of the trial was to use some of the results from the previous studies and adapt it to a full scale trial.

McDonald's Lime Ltd produces and supplies burnt lime from the Otorohanga site to MWWTP on a daily basis. LKD is a co-product of burnt lime, collected in cyclones as part of kiln exit gas pre-cleaning. There were initial concerns from Watercare regarding trialling a new product, especially at the large scale of MWWTP biosolids production. McDonald's Lime Ltd informed Watercare in 2013 that LKD was widely used in New Zealand as a road stabiliser, and was also known as a potential alkaline product for biosolids stabilisation (EPA, 2000).

The main difference between burnt lime and LKD is the Carbon Oxide (CaO) content. According to McDonald's Lime Ltd MSDS, burnt lime is composed of 95% of CaO, and LKD is composed of 48% of Calcium Carbonate ($CaCO_3$), 23% of Calcium Hydroxide ($Ca(OH)_2$) and 15% of Calcium Oxide (CaO). The ratio of CaO in LKD also varies depending on batches. McDonald's Lime Ltd provided the composition of twenty-six LKD control samples for reference. The results showed that the CaO concentration varied from a minimum of 47.6% to a maximum of 71.5%, with an average of 60.5%.

CaO reacts with water to form $Ca(OH)_2$, then $CaCO_3$ through a reaction with Carbon Dioxide (CO_2). $CaCO_3$ and other inert materials contribute in shear strength of the final product, when well mixed through. $Ca(OH)_2$ contribute in increasing the pH of the final product.

The advantages of using LKD as an alkaline stabilisation product include its production costs and availability, as well as its ability to raise the pH level and shear strength of the final product.

McDonalds' Lime Ltd proposed to blend burnt lime and LKD in the Otorohanga site and deliver the blend to MWWTP, in order to use it in an industrial scale.

As discussed, there was little optimisation to be done by increasing the additives to biosolids ratio. In order to optimise the cost of biosolids production and disposal, without negatively impacting on the biosolids properties, it was proposed to reduce the content of burnt lime, and replace it with LKD, keeping the ratio of additives to biosolids at 30%. Initial discussion with McDonald's Lime Ltd and Watercare concluded that a trial could be under-taken initially using a solids content ratio of 20:10 burnt lime to LKD.

2.3.1 RISK ASSESSMENT

Prior to conducting any tests, it was crucial to establish the risks associated with the trial, and reduce them to an acceptable score. A risk assessment was carried out and mitigation steps taken in order to conduct the trial. Out of the risks identified, two high level risks are detailed below:

- Health and Safety risk,

- Compliance requirement risk.

There was a Health and Safety risk with regards to the LKD being a finer product than burnt lime. The condition and capacity of the lime silo filter was assessed in order to ensure that no dust would spill through the filter. The particle size distribution carried out by the Waikato University confirmed that the filter would contain the lime dust.
The new MSDS was communicated to Watercare and recorded into the site hazardous substance register.

The second highest risk was to not meet compliance due to the different product used, or affect the performance of the plant by returning toxic leachate to MWWTP headwork. As there were no reference sites, the success of the trial was based on the pilot scale work and results carried out in 2009. The analysis of the leachate during the study showed that all metals were within the limits for Class A landfill leachate.

2.3.2 TEST TARGETS

The test targets were identified according to the consent for biosolids placement on Pond 2 and later Puketutu rehabilitation site. The main requirement was to meet a minimum pH as specified in the consent. The second requirement was to not affect the shear strength. The test targets are:

- pH above 12 after 2 hours of lime blend addition and above 11.5 after 24 hours,

- shear strength not worse than previous and following days (depending on seasonal variation).

To mitigate risks of not meeting the test targets, a laboratory scale test was performed using biosolids mixed with 30% of blend lime at a 20:10 burnt lime to LKD ratio. pH was measured at t0 and t+24hr for each samples, and results are displayed in Table 2. Provided that the pH was met, the full scale trial went ahead.

Table 2: Laboratory scale test results.

	#1	#2	#3
Additive ratio (%)	30	31	30
burnt lime:LKD ratio	20:10	20:10	20:10
pH t0	8.0	8.1	8.1
pH t+24hr	12.4	12.4	12.5

Once the laboratory scale tests established that pH could be met with the blend at the specific ratio of 20:10 burnt lime to LKD, it was intended to trial the blend lime at full scale for various periods in order to test shear strength.

3. RESULTS AND DISCUSSION

The full scale trial was sectioned into three periods: a short term period (two days), a medium term period (three weeks), and a long term period (six months). At the end of each period, a data review was carried out to ensure that the test targets being met prior to start the next trial. During these trials, additional information was collected as new risks were identified.

3.1 SHORT TERM PERIOD TRIAL

The short period trial lasted for two days, and data was collected over six days for control. The blend lime was delivered at MWWTP to the main lime silo, through two 25 tonnes pneumatic deliveries. McDonald's lime Ltd was responsible to provide Watercare with a record of the weighbridge docket as proof of quality analysis of the blend, as identified in the risk assessment.

Biosolids from each ASUs were diverted into specific bins in the biosolids building, and tested for pH and shear strength in the individual bins. The information collected is presented in Table 3, and results from the trial are in Table 4.

Table 3: Data recorded during the short term period trial.

Digested Sludge Parameters	%TS[1], %VS[2], digester parameters, TPS/TWAS ratio[3]
Centrifuge Parameters	%TS feed and cake, capture, CF parameters, CF running, associated ASUs
ASU	ASU trains running, associated bins
Biosolids (from bins)	pH, %TS, shear strength

1. %TS = Total Solids content (%)
2. %VS = Volatile Solids content (%)
3. TPS/TWAS ratio = Thickened Primary Sludge/Thickened Wasted Activated Sludge mass ratio

Table 4: Results of the short period trial.

		pH	Limed biosolids %TS	Shear strength kPa	TPS/TWAS ratio	CF cake %TS	CF feed %TS	CF capture %TS	Digester %VS
Control	Average	11.8	30.4	6.7	0.65	20.4	2.6	89.5	74.8
	Standard deviation	0.34	2.73	1.17	0.11	0.88	0.19	4.26	1.70
	Standard error	0.10	0.79	0.34	0.07	0.51	0.11	2.46	0.98
Blend lime	Average	12.2	30.1	5.9	0.74	20.2	2.5	88.6	71.6
	Standard deviation	0.17	2.16	0.66	0.15	0.99	0.00	5.19	0.28
	Standard error	0.07	0.88	0.27	0.15	0.99	0.00	5.19	0.28

- The CF cake and biosolids %TS varied within a small range which indicates that there was little impact of the type of lime used.

- On average, pH was higher when blend lime was dosed while shear strength decreased.

- The unexpected higher pH could be explained by poor mixing of lime and biosolids. Overall, the test targets were met following the short term period trial.

A log that recorded the centrifuges and ASU operation highlighted the difficulty to isolate one component out of all the variables. During the two day trial, there were multiple machinery stops due to various operation issues including discharge conveyor faults, interlocks etc.

The operators also noted during the trial that the temperature suddenly increased when standing near the ASU. Although lime reacting with water in high ratio is highly reactive and exothermic, it was not expected to experience a higher temperature with the blend lime in comparison with burnt lime. It was decided to measure both temperature and ammonia gas for the next trial period.

A fundamental observation then was that the shear strength depended highly of how long the biosolids stayed in the bin until the test was done. Some bins were still being filled, some had started to compact and drained leachate. This could explain the lower shear strength using blend lime. Also, the product in the bins would eventually be all mixed and disposed in the same cell at the disposal site, so it was decided to measure shear strength at the disposal site rather than in individual bins for the next trial period.
The medium term period was also initiated in an attempt to reduce the impact of operational variables.

3.2 MEDIUM TERM PERIOD TRIAL

The medium term period trial lasted for three weeks, and data was collected over a five week period for control (one week before and one week after the blend). The goal of extended the trial to three weeks from two days was to reduce the impact of the day to day variations, including the human error and operational issues such as unplanned shutdowns. It was also intended to control the new risks identified in the previous trial by measuring temperature and ammonia gas concentration in the biosolids building. Similar data as per the short term period trial was collected and the results are displayed in Table 5.

Table 5: Results of the medium term period trial.

		pH	Limed biosolids %TS	Shear strength kPa	TPS/TWAS ratio	CF cake %TS	CF feed %TS	CF capture %TS	Digester %VS
Control	Average	12.1	29.3	4.2	0.45	19.2	3.1	84	74.7
	Standard deviation	0.2	3.3	0.8	0.06	0.7	0.2	4.5	1.1
	Standard error	0.03	0.49	0.35	0.02	0.21	0.06	1.29	0.32
Blend lime	Average	12	29.1	4.1	0.47	19.4	3.0	88	74.8
	Standard deviation	0.3	3.6	0.6	0.06	0.9	0.2	4.5	1.1
	Standard error	0.04	0.55	0.17	0.01	0.25	0.04	1.25	0.27

- On average, shear strength and pH were consistent throughout the trial period and the control period.

- The limed biosolids %TS was also consistent, with similar averages between the control and the blend.

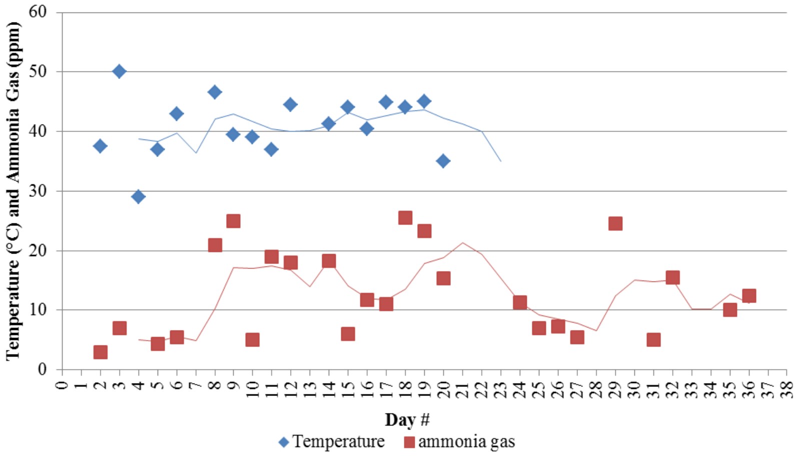
- The CF cake %TS slightly increased during the trial period, while the actual biosolids lime cake was of a lower %TS.

- The digester %VS was high during the trial and the control period, which coincides with previous discussion regarding high %VS and poor biosolids shear strength.

The data shows that the standard deviation is higher in the %TS analysis compared to pH or shear strength. This could mean that small variations on the biosolids quality that would not be detected in the shear strength or pH results could be detected through the %TS variations. The limed biosolids %TS standard deviation was also higher than the CF cake %TS. It tends to show that the difference in average noted above is not significant to conclude on the dewatering capacity of the blend lime versus the burnt lime.

The temperature and ammonia gas concentration were measured on individual biosolids bins as part of the medium term trial, and averaged across each day (Figure 3). The temperature probe broke before the end of the trial and was not replaced in time which is why the temperature database is quite limited. Over the period, the temperature averaged 41 °C, with a standard deviation of approximately 5 °C. The ammonia gas concentration averaged 13.4 ppm with a standard deviation of 7.5 ppm.

Figure 3: Temperature and ammonia gas concentration.



As the data collected did not show any abnormal temperature or ammonia gas released during the trial compared to the control period, it was concluded that the initial high temperature noted by the operator at the time of the first trial was due to poor mixing of lime and biosolids, resulting in a concentrated lime pocket and a highly exothermic reaction. It should be noted that no similar event was reported during the next trials and was considered as an abnormal operation.

The medium term trial results showed that neither shear strength nor pH were affected during the trial with blend lime. A final test period was initiated, this time for six months, to collect and analyse a more comprehensive set of data, as well as assess the wear of the equipment. In addition, daily Faecal Coliforms (FC) count was carried out to ensure that the blend lime was performing similarly to burnt lime regarding the pathogens log reduction, to add confidence with the pH results.

3.3 LONG TERM PERIOD TRIAL

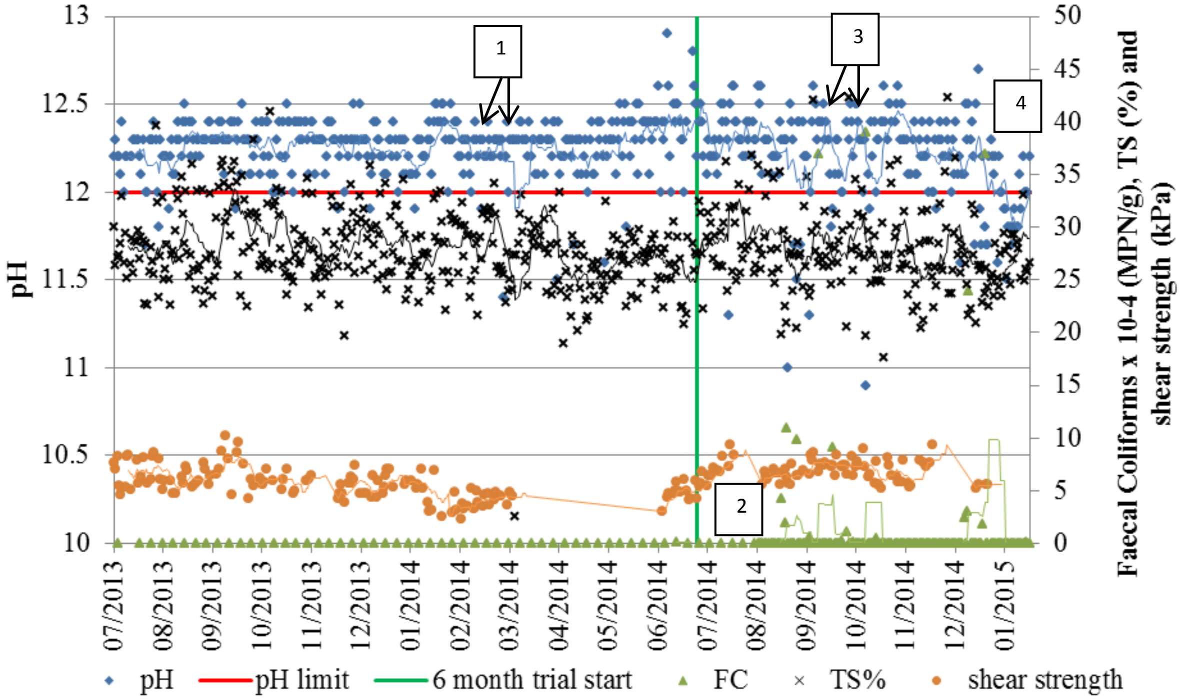
LKD is a finer product than burnt lime, so there was a risk of enhanced abrasiveness on the equipment and instruments at the ASU. This could in time increase the maintenance costs of the assets. The ASU is, regardless of using burnt lime or blend lime, a high maintenance area due to the abrasiveness of the product used. Regular inspections of the lime supply pipe were carried out, and included measurements and photos. A cost analysis was performed to assess the savings of the trial.

The Faecal Coliforms count was also measured as additional performance criteria, and frequency increased from a weekly to daily basis. Background data analysis shows that FC count is less than 10MPN/g.

3.3.1 DATA ANALYSIS

The pH, TS, FC and shear strength were plotted over a year period to compare the background data and the data across the trial period. The trends are presented in Figure 4 and data in Table 6.

Figure 4: Yearly data and long term trial limed biosolids pH, %TS, shear strength and FC count.



1. Start and stop of 3 weeks trial.
2. Increase frequency of FC test.
3. Start and stop period of reduced lime dose rate due to limited supply.
4. Low pH

One of the important events that occurred in September 2014 was an unplanned shutdown of one of the Kilns of the McDonald's Lime Ltd Otorohanga site. The consequence was a limited supply of lime for a month (approximately 15 tonnes per day). However, the pH and FC count held values to their normal range during this period, with only two FC high counts, and one pH result below 11.5. Even the final product %TS and shear strength were unaffected by the lower lime dose rate, which highlights the impact of the digested sludge quality compared to the additives for good stabilisation.

Table 6: Results of the long term period trial.

		pH	Limed biosolids %TS	Shear strength kPa	TPS/TWAS ratio	CF cake %TS	CF feed %TS	CF capture %TS	Digester %VS
Control	Average	12.3	27.9	5.8	0.5	20.2	2.7	92	73.6
	Standard deviation	0.2	3.3	1.5	0.1	3.4	0.3	6.3	1.7
	Standard error	0.01	0.49	0.14	0.005	0.19	0.02	0.4	0.09
	95th percentile	12.5	34	8.3	0.6	22.5	3.3	99.2	75.8
	5th percentile	12	22.6	3.3	0.4	17.8	2.3	80.5	70.4
Blend lime	Average	12.2	27.9	6.8	0.6	21.1	2.5	90.2	72.1
	Standard deviation	0.3	3.6	1.0	0.1	1.4	0.4	20.2	2.3
	Standard error	0.02	0.55	0.12	0.004	0.10	0.03	1.4	0.16
	95th percentile	12.5	35.6	8.4	0.7	23.3	3	98.9	74.3
	5th percentile	11.7	22	5.5	0.5	19.3	1.7	77.2	70.1

- pH is stable until the end of December. The limed biosolids %TS average is stable with similar statistics during the control and trial period.
- Shear strength improved slightly during the trial period, most likely due to the digested sludge characteristics (TPS/TWAS ratio and digested %VS).
- The CF cake average increased during the blend lime trial but the limed biosolids %TS stayed similar
- The CF capture varied significantly during the trial and in the period preceding the trial. The standard deviation during the trial is however higher which highlights the operation issues to maintain stable conditions.
- Figure 4 shows that pH started decreasing below 12 at the end of December, and FC counts varied from a normal range to a few high counts towards the same period. Although still within consent, there were no obvious reasons for a pH decrease.

3.3.2 MAINTENANCE INSPECTIONS

Inspections were carried out by Watercare on the lime supply pipework from the main lime silo to the lime day tanks 1 and 2 (Photograph 1).

Photograph 1: Inspection points location.

Three inspections were organised every two months throughout the trial period. During the second inspection, the camlock fitting on the inspection point 1 had to be replaced due to wear (Photograph 2). The new fitting was inspected two months later and did not show new wear. It was concluded that the wear is due to the long-time usage rather than the change of product in the ASU.
The fitting on the inspection point 2 on Photograph 3 showed similar wear with one edge being very sharp and close to failure (about 3 mm difference between inside and outside diameter). However, as there was no data from previous inspection, and since the inside diameter did not change dramatically throughout the trial period, the wear was not attributed to the change of lime but rather long-time usage.

Photograph 2: Camlock fitting on inspection point 1 worn.

Photograph 3: Inspection point 2 during the first (left) and third (right) inspection.

3.3.3 COST ANALYSIS

The cost analysis was based on current annual biosolids production, burnt lime and lime kiln dust tonnage price and annual maintenance cost over the ASU. It was initially believed that unplanned maintenance costs will increase using blend lime as the product is finer, hence more abrasive, than burnt lime.

Overall, the cost analysis showed that:

- The annual benefit using blend lime instead of burnt lime is $336,000.

- The maintenance cost of the ASU in 2014 is $176,000 and corresponds not only to the lime storage and supply equipment, but also the equipment downstream (biosolids conveying system).

- The variance between 2011 and 2013 or 2014 is within 10%, and there is very little variance between 2013 and 2014.

- The unplanned maintenance costs are decreasing in 2014 compared to 2013 which indicates that there were less unexpected break-downs during the trial period.

- There is a high variance in 2012 and elevated maintenance costs compared to previous and following years.

The ASU was upgraded in 2010 and went through an extensive period of completion tests between 2010 to 2012. The defect period would have lasted until 2011 and may explain the sudden increase in maintenance costs in 2012.
It is expected that, as the asset is ageing, and due to the abrasive nature of the additive (burnt lime or blend lime), the annual maintenance costs will keep on increasing in the next few years.
There is no direct evidence that blend lime increased the maintenance costs as the variance between 2013 and 2014 maintenance costs is within an expected ageing asset cost increase.
Even by taking the variance of maintenance costs out of the direct benefit using blend lime versus burnt lime, the overall benefit is $321,000.

4. CHALLENGES

The solids stream at MWWTP is complex and solids composition varies in time depending on a lot of parameters. One of the biggest challenges was to understand how all the variables would affect the final results, and how to decrease the error from the variables on the final result to a minimum. The variables are all the sludge characteristics, the performance of the dewatering process, the human impact with differences in operating the process, the wear and tear of the equipment resulting in unplanned shutdowns.

The scale of biosolids production, while making this trial economically sound, also increased the risk of not meeting compliance. The contingency of this trial was that previous intensive tests and work had been carried out on LKD. Also, the dose rate could have been easily adjusted to increase the lime to biosolids ratio, in case the test targets were not being met. Nonetheless, the cost to dispose non-compliant biosolids to an alternative site would have outweighed the cost benefit of using LKD.

It was also noticed that during the trial, the number of lime deliveries increased. It was then attributed to the different lime bulk density. The lime screw was commissioned initially on burnt lime, based on time to achieve a target weight or volume (at a specific bulk density). Changing the bulk density of the additive without changing the timing on the lime screw resulted in more lime being added to the biosolids. During the six-month trial period, the lime dose rate was adjusted on the control system and the calculated dose rate, based on deliveries and biosolids production corresponded to 28-30%. The dose rate has now been adjusted to achieve a 30% dose rate during normal operation.

The pH, Faecal Coliforms count as well as %TS remained consistent through the trial, apart from January 2015 where pH started to decrease. The blend lime dose rate setpoint was not changed throughout the 6-month period and it is suspected that the either the actual lime dose rate was lower than 30%, or the LKD varied in composition with potentially a lower CaO, although the pH was sustained when the lime supply was limited for a month in September. Further investigation is required to confirm the hypotheses.

5. CONCLUSION

It is suggested to keep monitoring the lime consumption compared to the biosolids production to ensure that the ratio is within normal range. Various factors also affect the quality of the biosolids such as the primary to secondary sludge ratio, the Volatile Solids Destruction, and the number of digesters in operation.
The trial results support the hypothesis that blended lime at 20:10 burnt lime:LKD ratio does not impact on pH or shear strength of the biosolids. The regular inspections also support that the assets do not wear more frequently than previously when using blend lime. A cost analysis has identified an annual benefit of approximately $300,000 using blend lime instead of burnt lime.

The period of time when lower ratio of lime was dosed to the biosolids also suggests that pH, FC count, %TS and shear strength are holding to their normal range. An optimisation of the costs and biosolids stability would be to adjust the lime dose rate according to the shear strength value.

The following works are recommended:

a) Keep using blend lime for normal operation. Monitor daily pH and weekly lime dose rate in order to maintain the minimum pH required for biosolids disposal.

b) Test regularly the composition of lime to identify the CaO concentration variation over time.

c) Investigate other additives economically sound and sustainable to increase shear strength and optimise the process.

d) Re-assess the ASU maintenance cost on a yearly basis.

e) Monitor shear strength over a year period to analyse the variation using blend lime, and optimise the lime dose rate accordingly.

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