PROCESS MODELLING AND AMMONIA ONLINE MONITORING AT HEALESVILLE STP

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ABSTRACT

In recent years, operation of the Healesville Sewage Treatment Plant had become increasingly difficult, in particular, achieving the EPA licence limits of both Ammonia and Total Nitrogen. Further development was proposed in the catchment area, including a micro-brewery so plant upgrades appeared imminent. Yarra Valley Water engaged a third party to provide a calibrated modelling package to simulate the existing treatment process and the effect of the proposed additional loading. The information gathered provided a firm basis for plant optimisation options and enabled informed investment decisions. In conjunction with the modelling simulation, an online Ammonia/Nitrate analyser was installed to gather real time information on treatment process performance. This paper discusses the model calibration process, review of the outcomes and benefits from having the process modelled and summarises the operational benefits from gathering online Ammonia and Nitrate measurements.

KEY WORDS

Aerobic, Anoxic, Oxidation Ditch, Nitrate, Ammonia

1.0 INTRODUCTION

The Healesville Sewage Treatment Plant is an activated sludge treatment process consisting of an oxidation ditch in combination with two side-stream extended aeration reactors. The plant also incorporates preliminary screening, secondary clarification, upward flow filtration and UV disinfection. With the side stream reactors operational, the plant has an ADWF capacity of 2200kL/day and an organic capacity of 720kg/d BOD. It currently treats approximately 1200kL/day at a peak load of 700kg/d BOD. The Nitrogen related EPA discharge licence requirements at this site are an NH_3 median limit of 2mg/l and a Total Nitrogen median limit of 10mg/l.

While still maintaining compliance, the plant had become increasingly difficult to operate in a stable manner with respect to achieving the Ammonia and Total Nitrogen median licence limits. Operating in a manner to ensure NH_3 levels were under 2mg/l caused reductions in Total Nitrogen removal with levels nearing 10mg/l. This operational difficulty was amplified by the typically large variation in incoming loads to the plant. This variation in loads is a result of a population influx to the catchment area over weekends, festival and holiday periods. The pending acceptance of waste from a proposed micro-brewery being developed was going to compound these issues.

A short-term capacity upgrade was underway with installation of two side-stream extended aeration reactors from another treatment plant that were relocated upon becoming redundant. To confirm performance of the process with introduction of the brewery waste and the additional reactors, AWT Australia were engaged to provide a simulation using BioWin software. In addition to verifying the future performance, it was desired to use the model to provide existing and ongoing plant optimisation options and in doing so, prolong the need for a major capital upgrade.

Considering the varied loads coming into the plant, and the onset of the introduction of the brewery waste, it was desired to gather more real time data on how the plant was operating. This resulted in an online Ammonia/Nitrate analyser being installed into the oxidation ditch as part of the upgrade. In doing so, this also allowed collection of real time Nitrogen data that could be input into the model, providing greater accuracy around the model calibration and outputs.

2.0 DISCUSSION

2.1 Data Collection

The first step in developing a process model is to review the available plant monitoring results. While there was significant data available, it was limited in the sense that it related solely to the grab samples required as part of licence compliance requirements. Even in combination with the daily operator sampling, these only provide a snapshot of the treatment process. Regardless, twelve months of compliance sampling data was reviewed along with the daily flow readings and this formed the basis of the original model build.

Table 1: ***Historical influent and effluent data used for the model build.***

Parameter	Influent		Effluent		Units
BOD_5	355	522	2.0	3.9	mg/L
TSS	400	628	1.5	5.0	mg/L
NH_3	43.5	62.3	0.6	3.3	mg/L
TN	68.5	98.5	5.6	8.9	mg/L
TP	12.0	15.8	0.3	0.6	mg/L
pH	7.6	7.8	6.6	6.8	

While the effluent data presented in Table 1 shows compliance with the EPA licence requirements, it does highlight that at times the plant struggles to meet the median NH3 limit of 2mg/l and pushes the upper end of Total Nitrogen median limit of 10mg/l. Further evaluation of individual monitoring results confirmed the operators observations that when NH3 levels are maintained below 2mg/l the NO3 levels rise causing the Total Nitrogen level limit to come under pressure. The influent data, in particular at the higher concentrations, show relatively strong concentrations in comparison to typical domestic wastewater (Metcalf & Eddy 4th Edition). This would largely be a result of the weekend, festival or holiday population influx.

In conducting a gap analysis on available data, a more intensive and targeted monitoring regime was required for both the influent and effluent streams. This involved a two week composite sampling program which enabled suitable characterisation of the influent and effluent quality for modelling purposes. Plant operation data such as; Mixed Liquor Suspended Solids concentration, Activated Sludge return rates, DO set points, aerator capacities and chemical addition. Brewery waste loads were estimated based on typical concentrations and the trade waste agreement volume limits.

2.2 Model Configuration and Calibration

The oxidation ditch was configured and represented as per Figure 1 below. In order for it to be modelled it was represented by a series of distinct aerobic and anoxic zones with sizes being estimated based upon the physical plant configuration. In addition, the side-stream reactors, the alum dosing, and the brewery waste were added separately to allow easy comparison of alternative scenarios. All available data was then input into the model to achieve satisfactory process calibration.

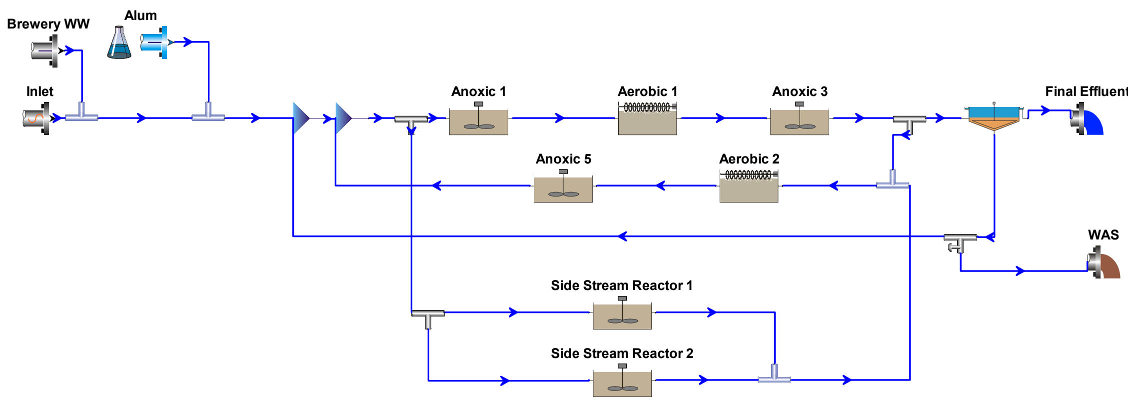

Figure 2: ***Model representation of the Healesville treatment process***

2.3 Modelling Outcomes

Upon adequate configuration and calibration of the model, AWT provided a number of different scenarios for optimising the plant operation. These scenarios were focussed on maximising feed to the anoxic zones and in doing so minimising aeration requirements. They included; Operating side stream reactors in constant aeration with a reduction in the oxidation ditch surface aerator times, Operating side stream reactors as anoxic zones with increased oxidation ditch surface aerator times and augmentation of the inlet feed point to the plant. The effluent quality outputs of all these scenarios could then easily be evaluated against one another. In addition, these scenarios were run with and without the brewery waste to examine the effect of this on the process.

It was determined, as presented in Table 2 below, that with the current configuration and the introduction of the brewery waste, it is most beneficial to operate the side stream tanks in an anoxic manner. It should be noted that the current configuration limits delivery of mixed liquor to the side stream reactors to the capacity of the delivery pump. Implementing this scenario, as opposed to running the side stream tanks aerobically is likely to result in a 50% reduction in the energy requirements for these tanks. In addition, it will result in less sludge production and therefore a direct saving in sludge wasting costs can also be realised.

While the model construction was all done within the BioWin software package, AWT also developed a web client interface. While having less functionality than the full model, it provides a valuable resource in the future for treatment plant operators to run different scenarios and assess the effects prior to making any plant changes.

Table 2: ***Quality outputs from process scenarios.***

Parameter	Side Stream Aerated	Side Stream Aerated with Brewery	Side Stream Anoxic	Side Stream Anoxic with Brewery
MLSS	5021	5381	6180	6607
MLVSS	3624	3539	3998	4295
SRT	25	25	30	30
BOD_5	1.91	2.39	1.57	2.06
TSS	3.10	3.2	3.60	3.80
NH_3-N	0.78	0.87	0.52	0.55
TN	4.19	4.11	4.89	3.85

2.4 Online Ammonia and Nitrate Analyser Data

Installation of the Ammonia/Nitrate analyser was undertaken to get a better understanding of how the plant was performing in respect to the varied incoming flows as well as the brewery discharges when they started discharging. It also provided an online source of Nitrogen data that was input into the process model to give greater certainty around the model calibration.

An initial investigation was done on the options for measuring Ammonia/Nitrate, including UV/VIS and this resulted in the selection of a WTW IQ Sensornet system with an Ammonia/Nitrate ion selective electrode (ISE). This device was selected largely due to the ability to relocate the device to numerous locations or plants if desired. In addition, the ability to do both Ammonia and Nitrate from the one sensor and its suitability to be immersed directly into mixed liquor were other factors.

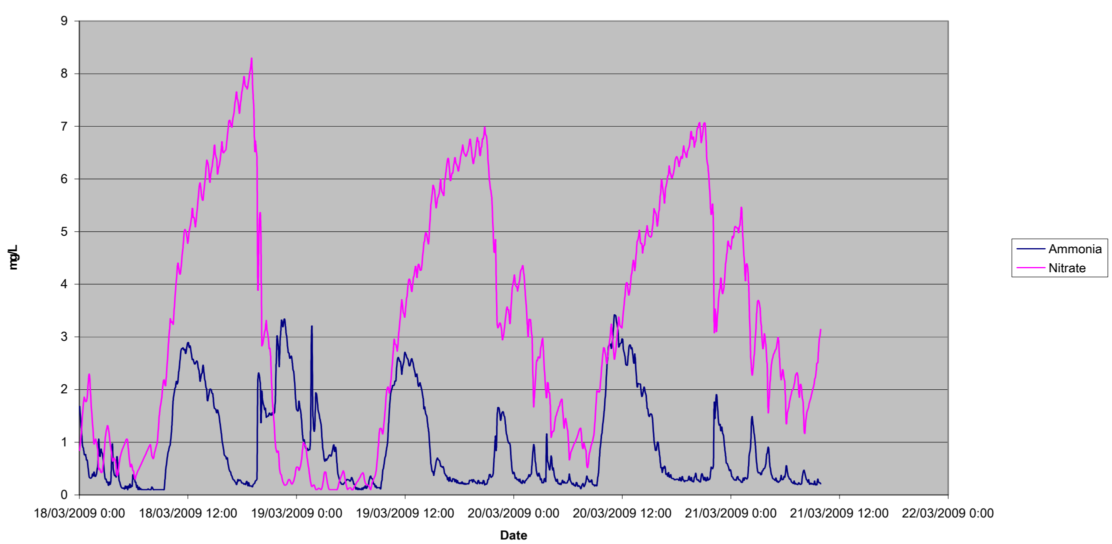

Figure 2: ***Ammonia and nitrate data from the online analyser.***

The data captured from the analyser shows the times of plant loading and the difficulties experienced in operating within the median discharge licence limits during these periods. Please note that this data was taken while operating the side stream reactors aerobically.

Clearly the nitrate levels continued to rise while aerating but they sharply decreased when the aeration stopped. However, what is also clear is that there is a lag period between ammonia levels bottoming out and the aerators stopping. It does highlight that by controlling the aeration in this plant off Ammonia levels as opposed to dissolved oxygen control may provide better treatment and aeration efficiency outcomes. This data also reinforces that there would be real benefits in increasing anoxic reactor zone volume and operating the side stream tanks in an anoxic manner.

3.0 CONCLUSIONS

The Healesville STP process simulation has proved to be extremely beneficial for Yarra Valley Water. The model itself provides many benefits including the ability;

- To predict the effect and evaluate process or plant modifications prior to carrying them out ranging from minor to major changes
- To estimate a maximum plant capacity
- To assess the effect of new waste streams on the process such as a trade waste prior to acceptance.

These benefits all result in being able to make informed investment decisions and as a result the investment in the model can be reclaimed very quickly.

However, an important learning is that the model is only as good as the data that is put into it. It is advantageous to have a sufficient amount of data that is inclusive of weekend and high flow periods. Particular sampling should be conducted at an ongoing frequency to ensure significant changes or growth in the catchment area can continually be accounted for. This will ensure that the output of the model remains representative of the actual process.

It was extremely advantageous to have online Ammonia and Nitrate analyser data that could be downloaded and input to the model to improve the accuracy of its calibration. Consideration should also be given to providing online monitoring in the feed to further characterise high flow and load periods.

The Ammonia and Nitrate analyser data has provided additional process knowledge and data to base operational changes upon particularly in relation to the aeration cycle. In addition, it has provided an insight to the Ammonia and Nitrate profile and presented a potential to control the process based upon these readings.

4.0 ACKNOWLEDGEMENTS

Richard Brice and all other AWT Australia colleagues involved in configuring and calibrating the process model are very deserved of acknowledgement. Their input, as well as ongoing process advice and input has been extremely valuable. Shane Jordan-Hill from Merck provided technical expertise and calibration maintenance on the ammonia analyser throughout the trial period I would also like to thank Healesville lead operator Steve Pritchard for his operational input to the modelling study and the operation, maintenance and interpretation of the data from the ammonia analyser.

5.0 REFERENCES

Metcalf & Eddy, (4th Edition), Wastewater Engineering Treatment and Reuse