INNOVATION TO OPERATIONS – BIOLOGICAL CONTROL OF BLUE GREEN ALGAE

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ABSTRACT

Implementing innovation is often difficult, particularly when moving from trial phase to operationalisation with complex changes involve**d**.

In 2015, a very successful trial demonstrated the effectiveness of dosing the novel commercial product, Diatomix©, to control blue green algae within a treated effluent storage dam at a 2,000 Equivalent Persons treatment plant in Dayboro. The trial demonstrated the ability to reduce blue green algae, decrease pH, and increase % ultraviolet radiation (UV) transmittance.

Operationalisation of dosing was complicated with the mechanism of change not being well understood and seemingly contrary to accepted conventions for waterway and environmental health. The process began in 2016 with a stepped approach to implementation, monitoring, and preparation of the Sequence Batch Reactor (SBR) process. At each step, a "leap of faith" change was required to progress to the next stage.

The STP Operators, Farm Supervisor and Process Engineers have been challenged to adapt but now they are drivers for change. There is one last stage in implementation: changing operating conditions imposed by the regulator and adoption by management into standard reporting. This case study will detail the challenges to overcome and the challenges that remain to effect long-term change such as reporting on sustainability; key performance indicator (KPI) reporting; capital expenditure (CAPEX) vs operational expenditure (OPEX); and biological vs process monitoring.

1.0 INTRODUCTION

Dayboro STP is a small 2,000 Equivalent Persons Sewage Treatment Plant that services the Dayboro community (Figure 1). The treatment plant receives an ADWF of 400 KL/day and undertakes solids and nutrient removal via a SBR process before releasing to a 52 ML Wet Weather Storage Dam (the dam), to undergo ultraviolet (UV) disinfection. Treated effluent is irrigated into 4 Contaminant Release Areas containing improved pasture in accordance with its Integrated Environmental Authority.

The dam offered ideal conditions for algae blooms. By 2015, Blue Green Algae (BGA) became dominant in the dam and altered the conditions by controlling inorganic nitrogen, increasing the pH (Figure 2) and shading out the competition (Figure 3). Driven by BGA, pH values in 2014 were high with all pH values bar one reading above 8.

1.1 Innovations Trials - 2015

In 2014, when concerns about BGA blooms were highest, Unitywater was approached by AlgaEnviro with a new product proposing to control Blue Green Algae. A proposal was submitted to Unitywater's Innovation Steering Group and was approved. The innovation trial was split into two stages to test the product over Autumn/Winter and Spring/Summer. Diatomix was dosed at 125mL per day and inorganic nitrogen was added for the 1st four weeks by dosing 100kg of urea per week.

The key results from the Innovation Trials were: a) when inorganic nitrogen, particularly ammonia, was highest the BGA was lowest (Figure 4) and b) there was notable decreases in pH when BGA was lowest (Figure 5).

1.2 Early Operational Dosing - 2016 - 2019

In July 2016, operational dosing of Diatomix began. The initial phase aimed to increase the population of Diatoms, establish daily dosing of Diatomix and use existing monitoring to inform next steps.

This phase focused on getting the Operators used to the maintenance of the dosing unit; to get the dosing unit incorporated as an asset and into routine asset maintenance; and build on the monitoring data collected during the innovation trial.

1.3 Refined Operational Dosing - 2020 - present

Three key events happened during the second phase of operational dosing.

1. Changed from SWIFT SCADA system to CLEAR SCADA system. Improving aeration control and ability to better control nitrogen speciation released in treated effluent.
2. Upgraded the AlgaEnviro dosing unit after key components reached the end of their design life.
3. Implemented weekly monitoring of the Dam to better develop and correlate changes to the treatment process with responses within the Dam.

In 2020, sufficient monitoring data had been collected to demonstrate that the dosing of Diatomix had benefits to the whole treatment systems. Key results were:

- Soil monitoring results demonstrated a reduction in phosphorus levels (Lowe and Magalhaes 2021).
- Increasing soil structure had reduced runoff and exposed expected build-up of salt from 25 years of treated effluent application (Stantec 2020).
- No sludge was found at the base of the Dam suggesting bacteria consumption as a result Diatom population (Xylem 2021).

The outcome of the Innovation Trial and solution to control Blue Green Algae at the Dayboro STP is to dose 125 mL of Diatomix and to release approximately 6mg/L of ammonia from the SBR process to maintain enough Diatoms in the Storage Dam to minimise Blue Green Algae numbers.

2.0 DISCUSSION

The level of success achieved by the innovation trial and early operational implementation has demonstrated the potential of this solution (Figure 7) to improve sustainability outcomes, reduce capital expenditure for future upgrades and improve operational compliance of the land application of treated effluent. The results achieved have been well received with acceptance and high praise from presentations to Community Groups, State Government Agencies, Qld Water Directorate, QWater and OzWater conferences. There has been strong support internally at Unitywater from Operators, Engineers, Scientists and Managers; commitment of time for staff to coordinate and accommodate necessary operational changes; and work through the challenges of this new approach.

A key to the success has been the commitment of the Operators in driving change. They have had to adapt and respond to a range of challenges including clearing ants from the dosing device, undertaking extra monitoring and working as agents for change; diagnosing and updating treatment plant controls to restrict nitrate/nitrite concentrations and increase ammonia concentrations. All this work has been undertaken in amongst standard Operator duties to prepare for the day when the changes (prompted by the innovation trial) can be implemented on a permanent basis.

Implementation of these changes require different considerations and risks traditionally not considered in conventional sewage treatment solutions. Conventional solutions typically aim to control as many variables as possible. The proposed solution has no history of operational success and will require an adaptive monitoring regime to ensure Diatoms are favoured. The factors limiting the adoption of this Innovation Trial are:

2.1 Risk

Release from the Dayboro STP are fully compliant with release limits despite the presence of BGA blooms in the Storage Dam. Implementation of the proposed solution requires a change to the current condition limiting ammonia releases to a long-term median of below 2 mg/L. Current ammonia levels are too low to sustain Diatom populations and higher levels are required in the long term to break the dominance of BGA.

Change to remove the ammonia limit is necessary but creates a risk. Unitywater is currently fully compliant but if the changes do not work as envisaged, there is a risk of potential non-compliance. There is no alternative to conduct this research at an ecosystem level to test if the solution can be implemented without the risk of non-compliance.

2.2 Counter-intuitive solution to improving sustainability

The proposed solution includes the release of moderate levels of ammonia to maintain a population of Diatoms to counter BGA dominance. The release of more ammonia goes against the prevailing scientific evidence surrounding ammonia toxicity of native flora and fauna. In 1997, when the permit to operate was issued, the Environmental Protection Agency (now known as DES) was sufficiently concerned about the release of ammonia concentrations to place limits on treated effluent releases. To challenge this perception is a significant step for Unitywater.

2.3 Capex vs Opex solution

The preferred pathway in Unitywater to make improvements to solve sewage treatment problems is via Capital Expenditure (CAPEX). This allows a clear pathway to review, assess, justify, and then incorporate CAPEX into the Assets owned by Unitywater. Listing Diatomix dosing units as an asset has been difficult. The dosing units are inexpensive compared to traditional dosing units, so the units were purchased and maintained through Operational Expenditure (OPEX). Unitywater has had the original dosing unit refurbished in 2020 with many of the original parts still in use. The cost of Diatomix dosing is estimated to be between $30 and $40 per day, including installation, maintenance, and dosing.

2.4 Process vs Biological monitoring

The SBR process used at Dayboro STP is well developed and well understood with known operating parameters, set points of control and ability to control the biological treatment process to achieve treated effluent quality; not to mention the collective knowledge gained through the Water Industry use of this type of treatment

The reverse is true for using Diatoms to control BGA. Two 12-week innovation trials have demonstrated the ability, as well as 7 years implementing the partial solution have helped fine tune the full solution that needs to be implemented but this full solution has never been implemented. There will be a trial-and-error phase necessary to determine and define the key parameters, triggers and adaptive methodology required to achieve the final outcomes when the only operational control available is the nitrogen speciation within the treated effluent release to the Dam. This will mean that both the treatment process and dam need to be well monitored to ensure the sustainability outcomes are achieved.

2.5 Incorporation into KPI Reporting

Key Performance Indicators or KPIs are a key part of any Water Utility reporting. KPIs for a traditional sewage treatment plant revolve around the conditions set in the permit to operate or key indicators from individual processes selected (by design) to measure compliance. Since the proposed changes do not use the traditional release limits as a template, finding succinct KPIs that require minimal explanation to the viewer has been difficult. There are a few potential indicators, for example pH, BGA, Diatoms and %UV transmittance, that could be used but each has their challenges; are influenced by factors other than BGA; and require more effort to either measure or explain their relevance.

3.0 CONCLUSION

The water industry has been a key adopter of new technologies to meet customer expectations. In striving for sustainability, the adaption of conventional technology and biological methodologies for treatment is required to improve sustainability of sewage treatment. Many challenges need to be overcome before this can be achieved. The project is achievable but as this case study demonstrates, adoption requires all levels (operational, technical, management and regulators), to be drivers for adoption of biological methodologies, even when they challenge current perceptions and hold back efforts to improve sustainability.

4.0 ACKNOWLEDGEMENTS

There too many people involved in this project to individually name but we would like to single out the Operators at Brendale and Murrumba Downs Sewage Treatment Plants, all levels of management that support the ongoing experimentation and implementation and the Lab staff at the Unitywater Laboratory that support monitoring of our ideas.

5.0 REFERENCES

Lowe S and Magalhaes L *New Solutions for Old Problems at Regional and Remote Treatment Plants,* Proceedings of OzWater'21, May 2021, Adelaide (2021).

Stantec *Dayboro STP Annual Sustainability Load Assessment 2020* (2020).

Xylem. *Dayboro STP Bathymetric Survey 2021* (2021)

<u>Figure 1:</u> ***Location of the Dayboro Sewage Treatment Plant.***

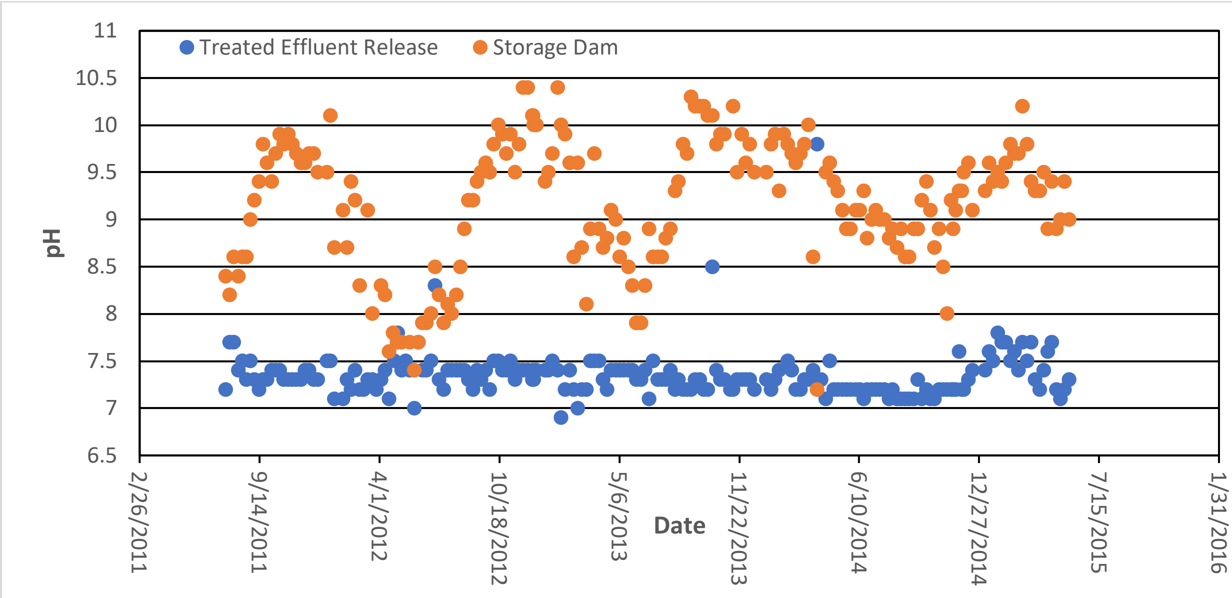

Figure 2: *pH measured in effluent releases and dam prior Diatomix dosing.*

Figure 3: **Dam prior to Diatomix dosing**

Figure 4: **Dam during Diatomix dosing**

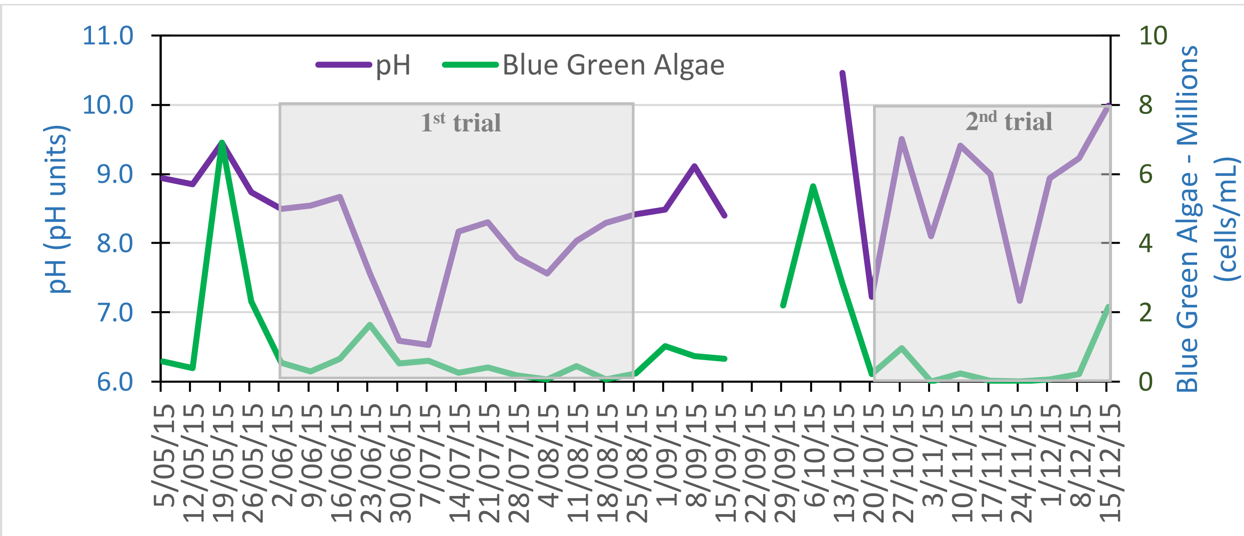

Figure 5: *Response of Blue Green Algae to Diatomix dosing and associated changes in pH.*

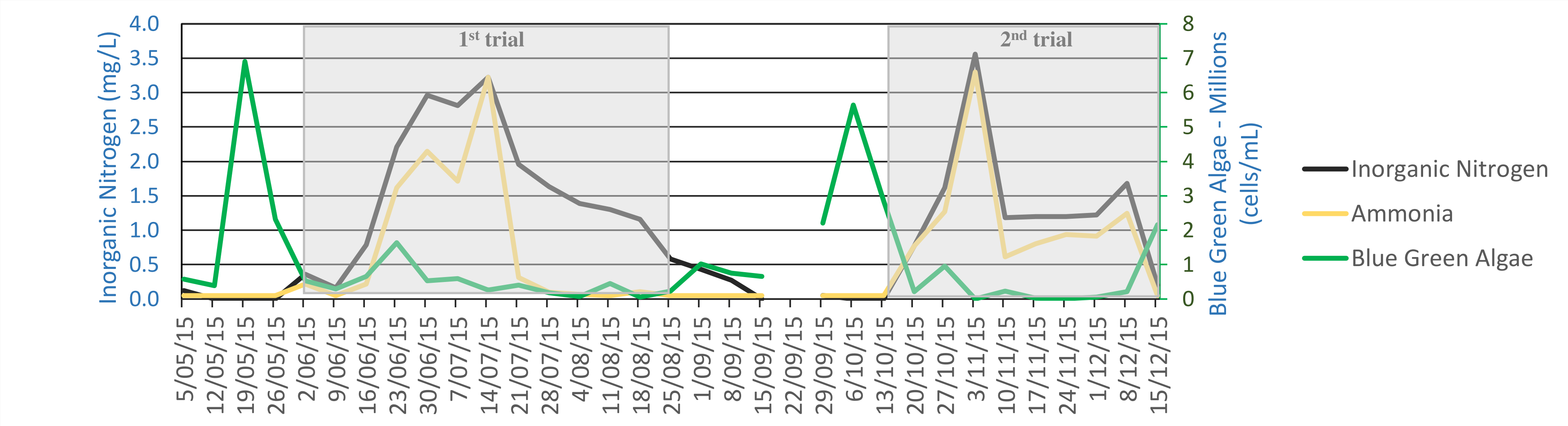

Figure 6: ***Response of Blue Green Algae to Diatomix dosing and associated changes in ammonia and inorganic nitrogen.***

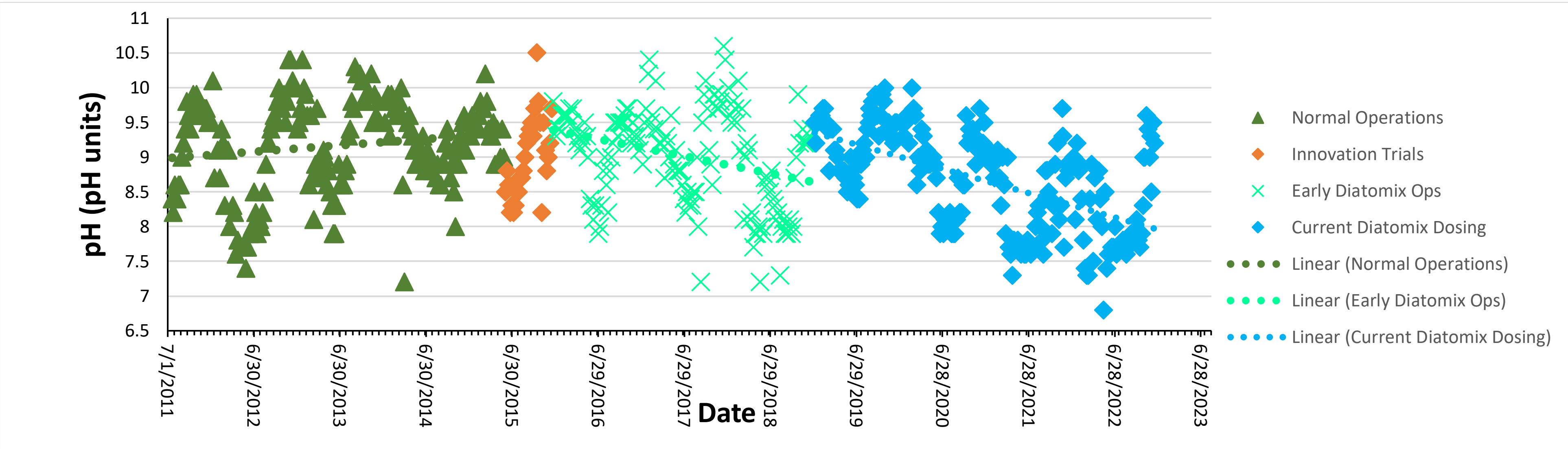

Figure 7: ***Changes in Dam pH over the various phases of Diatomix dosing operationalisation, with linear trend lines.***