Improving oxygen delivery in aerobic treatment and promoting the growth of nitrifiers using nanobubbles

Presenters:
Roshi Selvakumar
Samuel Leong

Bacchus Marsh Recycled Water Plant

- Lagoon process system with an aeration lagoon
- Treats influent to Class C recycled water
- Designed to treat 3.2 MLD (ADWF)
- No nearby waterbody to discharge
- Recycled Water customers
  - Onsite Irrigation
  - Parwan-Balliang Irrigation District

Greater Western Water

What was the problem

- **High inflow** to the treatment plant

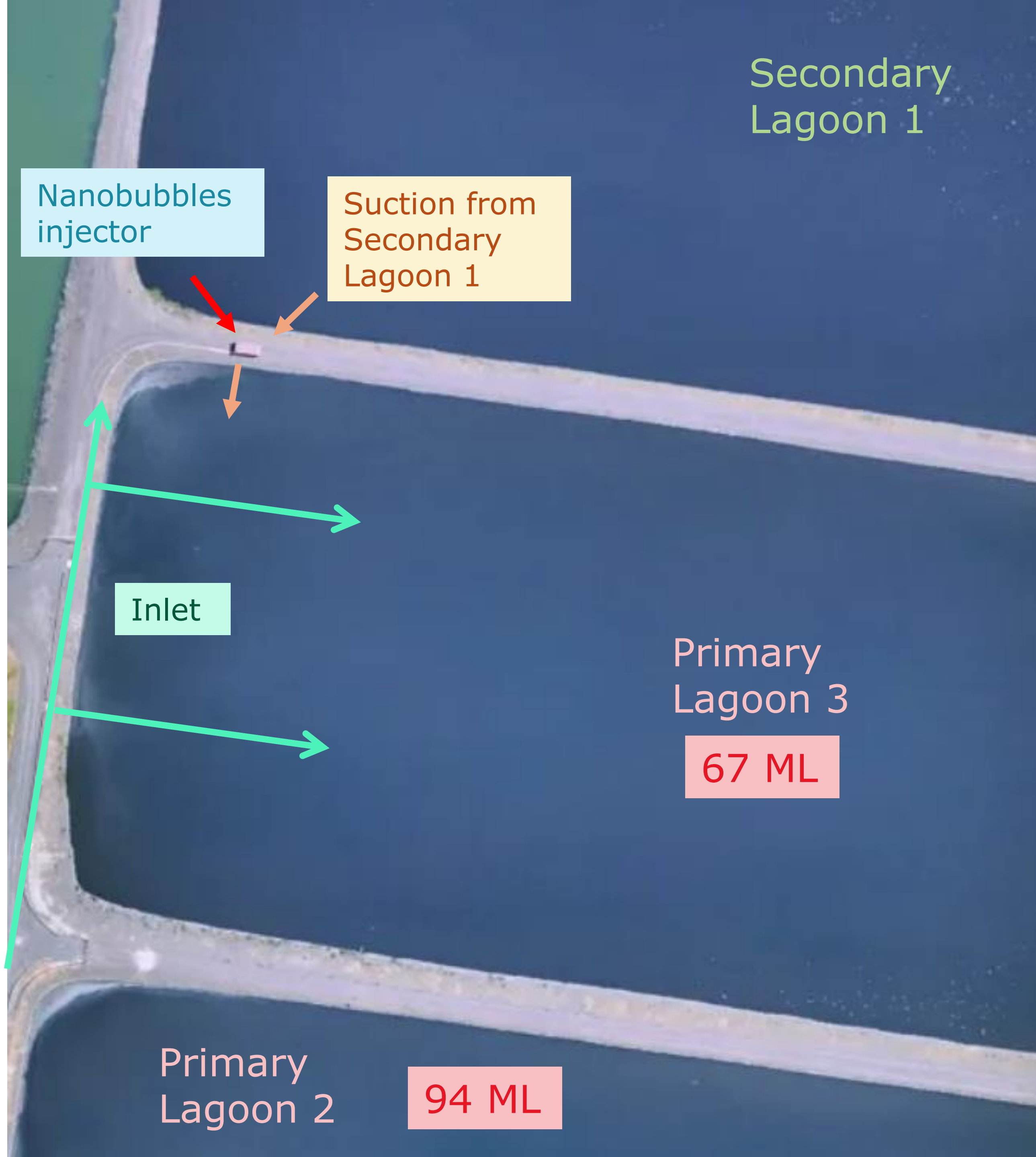
- **Insufficient treatment capacity** in the aerated lagoon
  - Aerated Lagoon hasn't been performing optimally
  - DO readings = 0.2 mg/L during normal operation
  - Aeration Setpoints = 1.7 to 2.2 mg/L

- To remove nutrients (Ammonia NH4):
  - Required sludge retention time = ~ 4 days
  - Before the trial, hydraulic retention time = 1 day

Objectives of the trial

<u>6-months trial</u>

- Increase DO in our primary lagoon system
- Improve the growth of nitrifiers
- Encourage the nitrogen cycle takes place to remove nutrients from sewer inflow

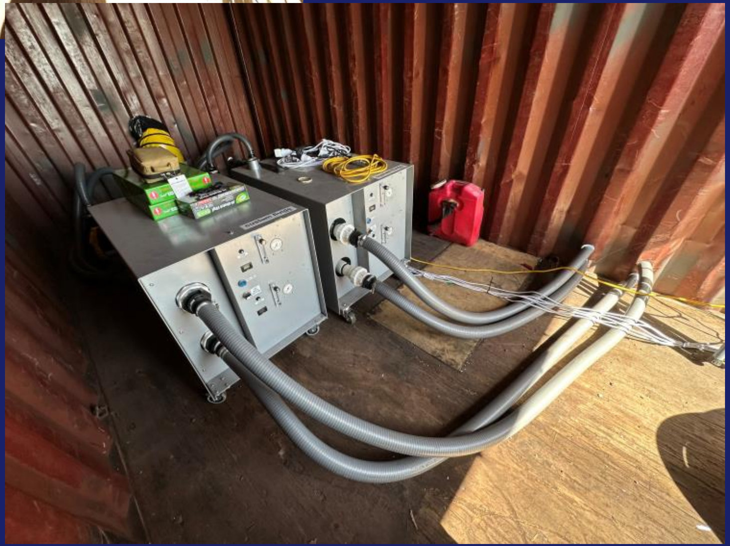


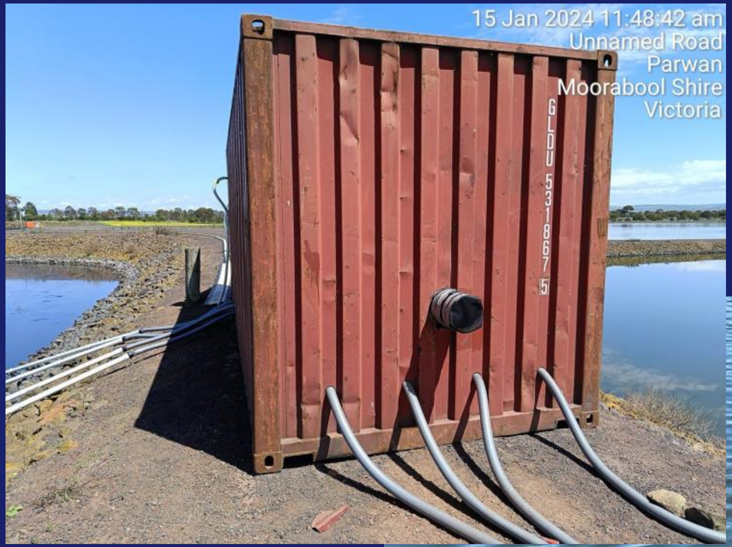
Benefits

- Nanobubbles are an efficient delivery of pure oxygen into the lagoon system
- High surface tension in nanobubbles mean they can stay in the water longer than the traditional aeration bubbles
  - Potential accumulation of DO to undertake nitrification for the high inflow
  - Potential buffer/reserve for dissolved oxygen
- Potential to break down sludge and algae in the lagoon
- Less energy-intensive as opposed to the traditional aeration system
  - Rapid increase in DO in less time than traditional aerators means efficient oxygen supply for the biological matter to consume. (Yaparatne et al. 2022)
- Traditional aeration bubbles are more buoyant and will produce more off-gas when they come up to the surface; Nanobubbles reduces that risk.

Greater Western Water

Setting up the trial

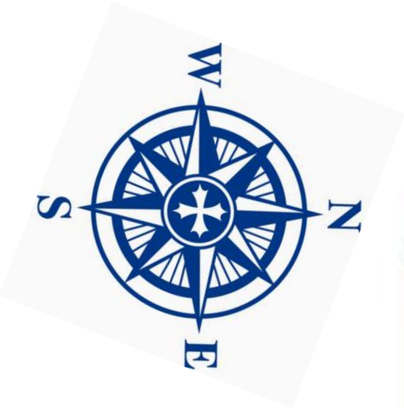


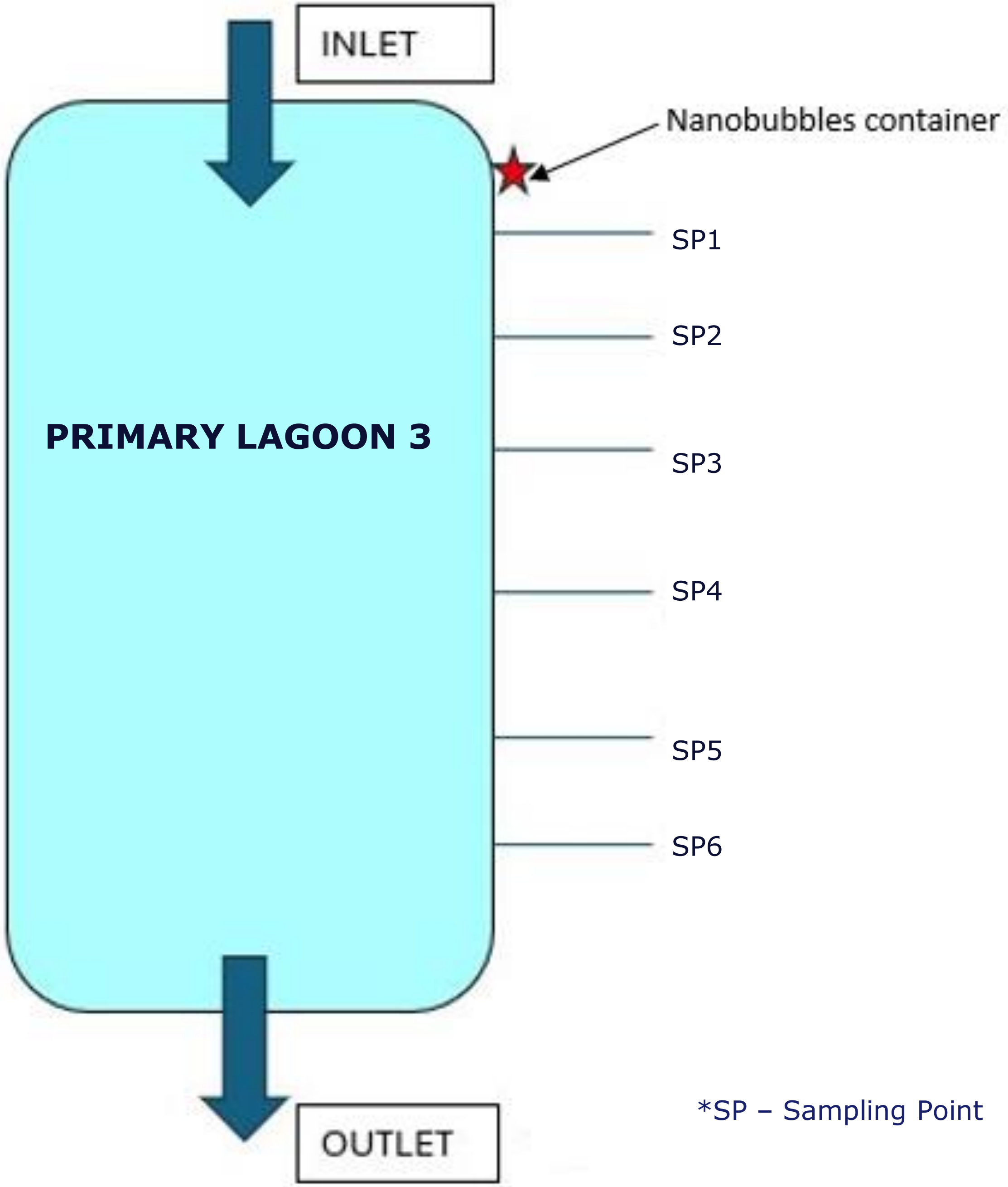


Preliminary Results

Testing for:

- DO in the 6 Sample points
- DO in the Outlet





*SP – Sampling Point

Greater Western Water

Final Data

Primary Lagoon 3 Outcomes	Surface Level	0.26 mg/L	Average DO level across lagoon (pre-trial)
		3.94 mg/L	Average DO level across lagoon (up to recent readings)
		3.33 mg/L	Median DO level across lagoon (up to recent readings)
		1,434 %	Average DO level increase across lagoon w.r.t pre-trial baseline (up to recent readings)
		12.23 %	Average DO level increase per day
		11.09 %	Decrease in Ammonia trends
		78.95 %	System Uptime. Note: use of swimming pool pumps with no filtration resulting in regular blockages by algae/animals upstream of Nanobubble system.
		16.82 %	Decrease in COD trends
	Deeper Level (approx. 50cm-1m)	1.34 mg/L	Average DO level across lagoon. Note: Surface baseline 0.26 mg/L, near 0 mg/L at depth
Secondary Lagoon 1 Benefits	Surface Level	8.11 mg/L	Average DO level. Note: PL3 gravity feeds into SL1. System feed water taken from SL1.
		74 %	Average DO level increase w.r.t measurement taken in week 4.

Key observations

- The technology works - we have seen a sustained increase in DO average.
- The technology is straightforward to use but relies on application specific knowledge and implementation.
- Minor mechanical issues with ancillary equipment such as pumps or filtration – use of swimming pool pumps manifesting in blockages and leaks.

Greater Western Water

Limitations

- Budget constraints
  - Sizing of the equipment is at a smaller scale
  - Materials required to enable the trial run are not industrial grade (e.g. pumps)
  - No budget to install filtration
  - No budget to install permanent DO monitoring

- Limited access to monitor DO

- Weather conditions influence DO readings on surface level

- Other factors that weren’t taken into consideration for ammonia reduction:
  - High organic carbon / Low autotrophic bacteria
  - Short sludge age

Greater Western Water

Further Investigations

- How can we better improve the monitoring of DO
- How can we utilize the high surplus of DO in our lagoon to improve nitrification?
- How would a different setup help raise DO data?
- How could ozone influence our ammonia numbers?

Greater Western Water

Concluding Takeaways

Even with a significant water volume, high COD/BOD and daily inflows,

Oxygen entrained Nanobubbles have shown to:

- Rapidly increase Dissolved Oxygen levels.
- Maintain Dissolved Oxygen levels.
- Increase Dissolved Oxygen levels in gravity fed downstream lagoons.

Reference

- Yaparatne S, Doherty ZE, Magdaleno AL, Matula EE, MacRae JD, Garcia-Segura S and Apul OG (2022) *Effect of air nanobubbles on oxygen transfer, oxygen uptake, and diversity of aerobic microbial consortium in activated sludge reactors*, ScienceDirect website, accessed 10 April 2024. https://www.sciencedirect.com/science/article/abs/pii/S0960852422004199?via%3Dihub

Greater Western Water

Thank you!

Question & Answers time

Emails:

- niroshitha.selvakumar@gww.com.au
- samuel.leong@gww.com.au