Robust, cost-effective sensor for dissolved inorganic nitrogen

The underlying principle used for detecting Dissolved Inorganic Nitrogen (DIN) is the very common and well-established technique of measuring the absorbance of light through a test water sample to determine the concentration of various chemicals. The absorbance spectrum of DIN is in the deep UV-C spectrum (typically in the 200-280nm wavelength range), making measurement difficult without very high cost or highly specialized equipment.

This Project was initiated with an innovation grant through the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation with co-funding from IntelliDesign, to see if a lower cost Nitrate Sensor system could be developed for research, scientific and commercial purposes and specifically utilising the world-class, UV LED technologies available here in Queensland.

Implementation

Phase 1 covered the initial project planning.

Phase 2 saw the development of an original Test Bench Prototype to determine if lower-cost technology could be used to achieve this DIN sensing technique. During the initial reporting period a test bench prototype was delivered where unrefined, adjustable mounts were used to align and focus the light source into the detector.

Phase 3 led to the design of first-generation Prototypes that successfully detected changes in absorbance through test samples in a cuvette. In subsequent reporting periods, testing and verification of a second-generation Optical Pathway Cell was undertaken to also verify the custom data acquisition circuit.

Phase 4 created a Working Submersible Prototype Sensor along with the cabling and proprietary telemetry systems required to allow a limited-scope, in-field trial to be undertaken. In this phase, the main objectives were to:

1. Refine the optical, mechanical, and electronics design into an optical cell that fits into the final form factor of the sensor (capable of fitting inside a 50mm bore hole)
2. Procure components for a small batch of Nitrate Sensors, BlueSpot Head Units and associated Cables
3. Assemble and verify Working Submersible Prototype Sensors.
4. Complete wet-lab tests and leakage pressure tests on the fabricated sensors.
5. Prepare Nitrate sensors, cables, BlueSpot head units and installation equipment prior to conducting a 1-month field trial.

All these objectives were achieved in December 2022. However, leading up to this, significant delays were experienced due to the flow-on effects of Covid-19 supply-chain issues, worldwide.

IntelliDesign's BlueSpot data-logging & telemetry platform

Implementation of nitrate sensor for 1-month Limited-Field Trial

Phase 5 covered a 1-month Limited-Field Trial that was conducted at Coochin Creek (Sunshine Coast) and the Hydrographic Support Unit at Rocklea (Brisbane). Three Sensor-BlueSpot systems were prepared and successfully deployed into these locations and monitored closely for more than four weeks.

While the installations of the systems and the in-field trial activities were deemed successful, the results obtained from these locations highlighted some significant challenges for this version of the prototype system. Specifically:

1. Fouling of the Sensor's Measurement Lenses
2. Sensor Measurement Accuracy
3. Telemetry Systems for Gathering of Field Data
4. Post-Processing of Field Data

These are all positive learnings. But it is now much clearer that significantly more engineering, lab testing, and field work will be required before these system components are ready for a wider-scale 6-month field trial in North Queensland.

During Phase 5, a commercial assessment of market viability was undertaken. Through extensive end-user engagement, both in Australia and New Zealand, it was determined that while interest is high, demand is low. There are insufficient regulatory drivers in place to necessitate the roll out of anything more than units in very low hundreds. Thus, leaving the return on investment in an unjustifiable position.

Key Learnings

The development of innovative technologies is critical to achieving the catalysing changes required to achieve ambitious water quality targets. The Low-Cost Nitrate Sensor development project provided multiple learnings that can be utilised in future developments of this work, including:

- It is possible to detect some levels of Dissolved Inorganic Nitrates using low-cost UV-C LED technology. However, further improvements to this technology (specifically for ultra-violet light wavelengths below 220nm) will be required in order to increase the sensitivity of this type of Sensor for accurately detecting Nitrates.
- The optical path must be cleared of any surface debris (e.g.: silt, algae, bubbles) prior to every measurement in order to provide consistent raw-data measurement results.
- The Sensors need to generate calibrated output data of the measured parameters (e.g.: TSS, N-NO3, DOC) prior to data being uploaded via telemetry. A deeper scientific understanding of hydrography and the key factors affecting these water quality measurements would be very helpful in developing this work further.
- The interconnection cabling between the submerged Sensor and the Telemetry device needs to be very robust, flexible and made in a range of lengths to suit local conditions.
- The Sensor/Telemetry system needs to be very easy to install, while also being robust enough to withstand a wide range of weather conditions, local flooding events and likely damage from animals & insects.
- The Telemetry system needs to be reliable, self-powered, standalone, data buffering and auto rebooting in order to minimise the need for local site or remote log-in maintenance.
- Post-processing of uploaded data will be required to ensure the low-cost Sensor data aligns with results collected from co-located & more sophisticated measurement instruments. Mass Data Processing experts will be required to develop this arena.
- In addition, the costs of producing & installing such Systems (across the chosen locations) would need to be low enough to justify sustainable rollout & maintenance costs for System proponents & end-users.

Instillation of nitrate sensor at the Rocklea Hydrographic Support Unit

Nitrate sensor checks completed at the Rocklea Hydrographic Support Unit

Business case

There is work underway, within the water quality monitoring community in Australia & New Zealand, to advance regulatory control of Nitrate pollution with a strong preference for a “polluter pays” model. It is believed that change is coming but it is difficult to predict an accurate timeline.

To be commercially successful, key market segments would need to create a demand for the development, manufacture and wide distribution of these low-cost Nitrate Sensor / Telemetry Systems. This demand is likely to significantly increase if regulatory authorities require that nitrate levels be monitored & reported.

Funding

The Robust, cost-effective sensor for dissolved inorganic nitrogen innovation project was funded by the partnership between the Australian Government’s Reef Trust and the Great Barrier Reef Foundation with cofunding from Intellidesign.

For further information, contact IntelliDesign Pty Ltd - Smart Solutions™ at intellidesign.com.au.