NEXT GENERATION AUTONOMOUS CHEMICAL SENSORS FOR ENVIRONMENTAL MONITORING

Deirdre Cogan, John Cleary, Damien Maher, Dermot Diamond

Dublin City University

Microfluidic technology has great potential as a solution to the increasing demand for environmental monitoring through minimization of reagents, standard solutions, and power consumption, leading to the development of compact autonomous instruments which can perform in situ monitoring of remote locations over long deployable lifetimes.

The objective of this research is to produce next generation autonomous chemical sensing platforms with a price performance index that creates a significant impact on the existing market.

The focus will be on developing a detection platform for ammonium, nitrate and nitrite for water and wastewater using colorimetric techniques. The goal is to integrate polymer actuator valves into the microfluidic chip, which will significantly drive down the overall cost of the platform.

Miniaturisation

- Latest analyser platform currently €200 (approximate component cost).
- Drive this to €20 by the introduction of **biomimetic materials** replacing conventional pumps and valves.
- New platform technology that can be applied to many environmental targets.

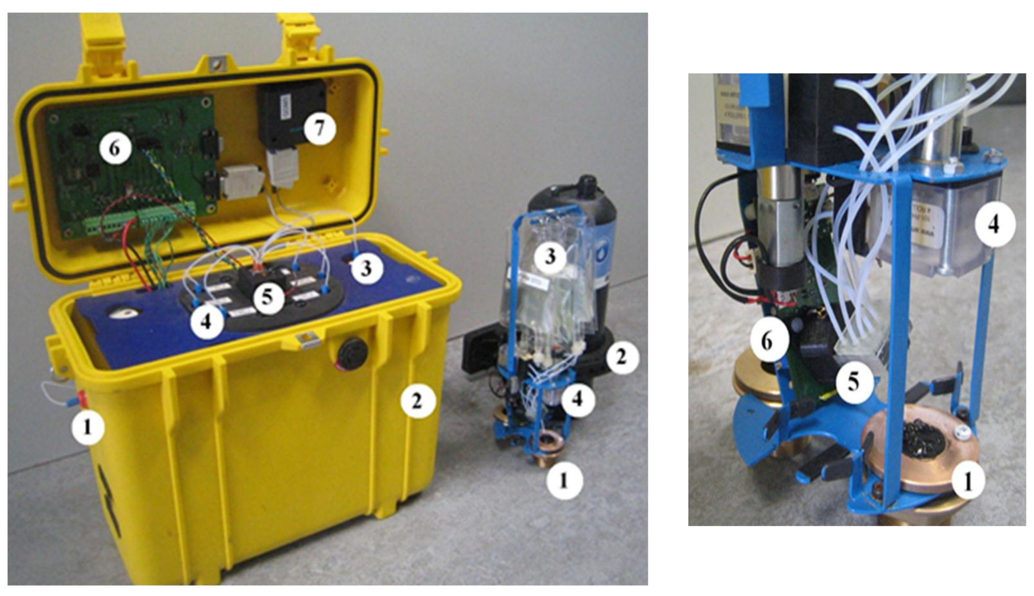

Fig 1: First and second generation phosphate systems. (1) Sample inlet; (2) IP68 Enclosure; (3) Reagent storage; (4) Pumps; (5) Microfluidic detection system; (6) Control board; (7) Communications.

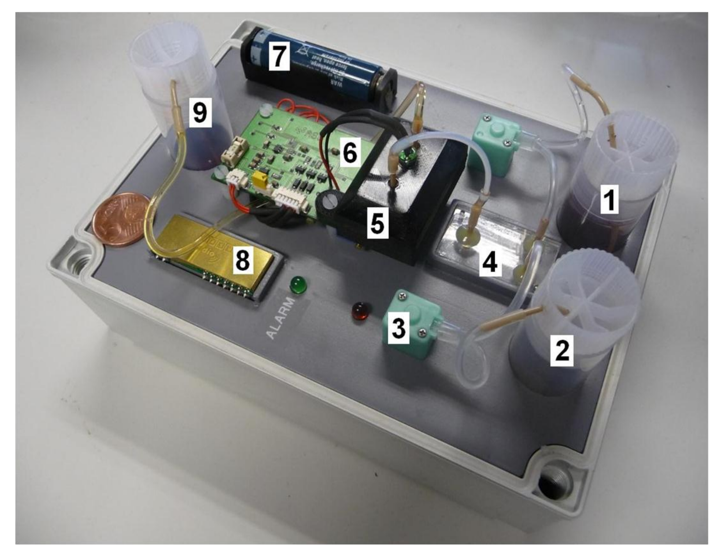

Fig 2: Benchtop nitrite detection system.
(1) Reagent storage (2) Sample storage (3) Micro-pump (4) Mixing chip (5) Detector (6) Control board (7) Battery (8) Easy-Radio (9) Waste storage.

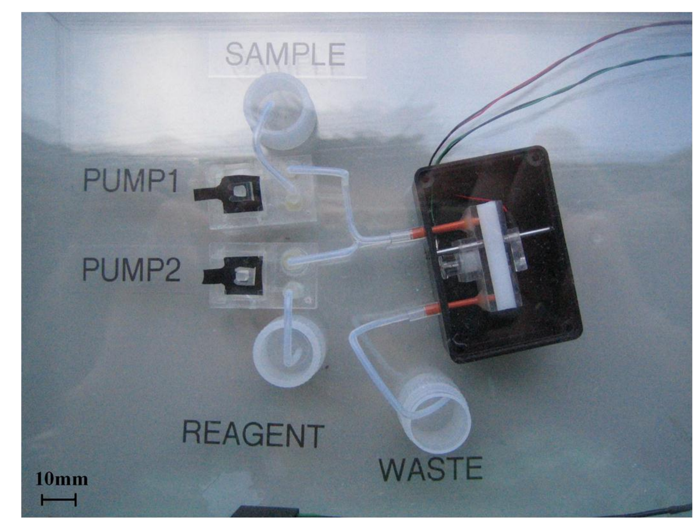

Fig 3: Prototype for next generation micro analyser platform.
Micropumps based on electro-responsive polymer actuators are used to deliver sample and reagent to the LED and photodiode based optical detector.

Phosphate Sensor Deployment

Fig 4: Image of sensor in situ.

- The system was placed in situ at Broadmeadow Water Estuary, Co. Dublin for the period 22Feb2012-2March2012 (fig 4).
- This site is known to have high nutrient levels present due mostly to inputs from industry, agriculture and a wastewater treatment plant situated close by .
- A sample reading was taken in 20 minute intervals. The sensor performed 350 autonomous measurements (fig 5) and 14 manual samples were collected for lab analysis and validation.

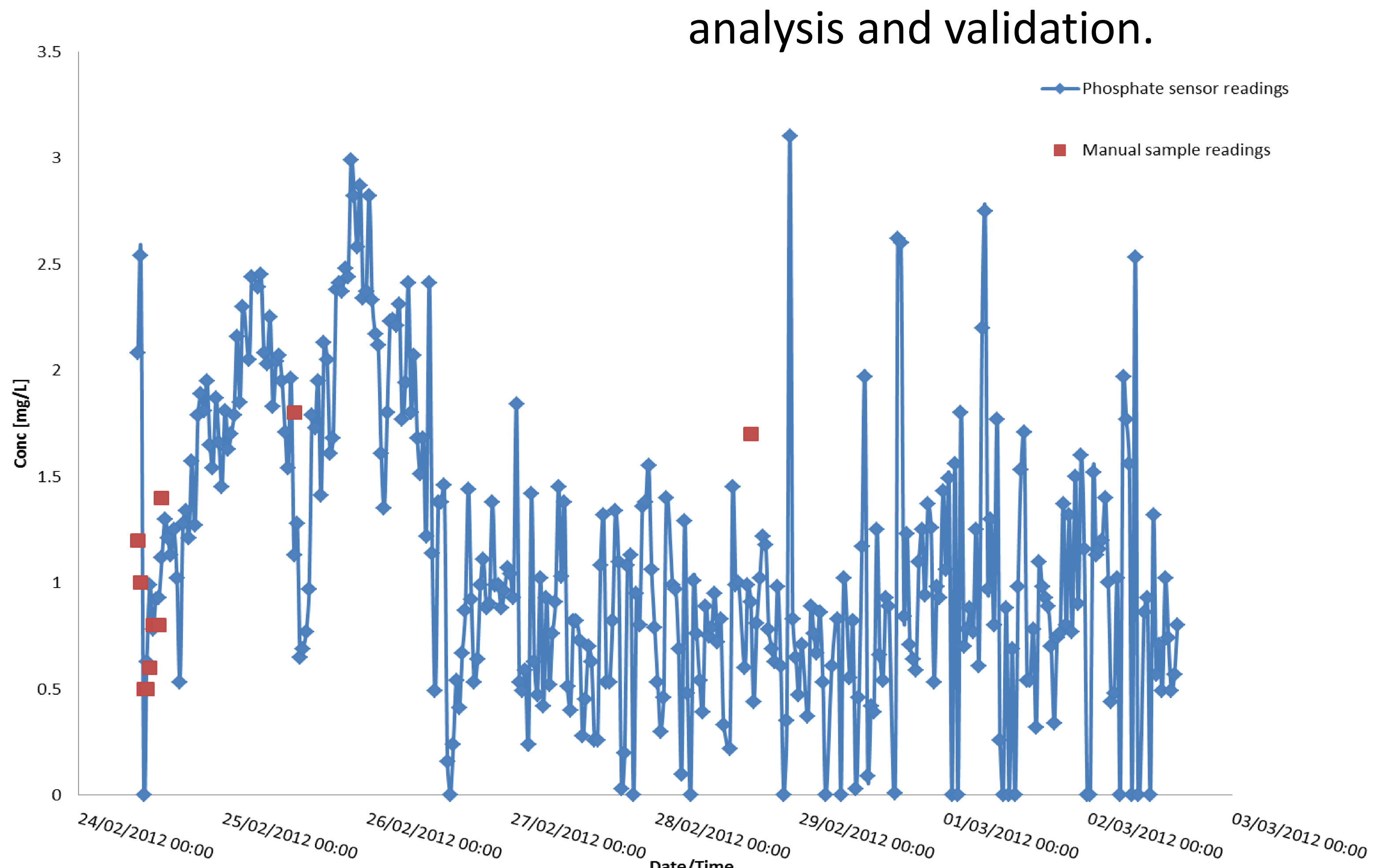

Fig 5: Data from the phosphate analyser and manual calibration samples (red) during the trial.

Nitrite (NO_2^-) Analyser Based on Griess Reagent

Testing of the nitrite reagent chemistry set with the platform (fig 2). Two micro pumps deliver the nitrite sample and Griess reagent through a mixing chip and through to a detector chip where the LED and photodiode measure absorbance at 540nm. Absorbance is proportional to nitrite concentration (fig 6). NO_2^- levels in the samples can be established from a calibration curve (fig 7).

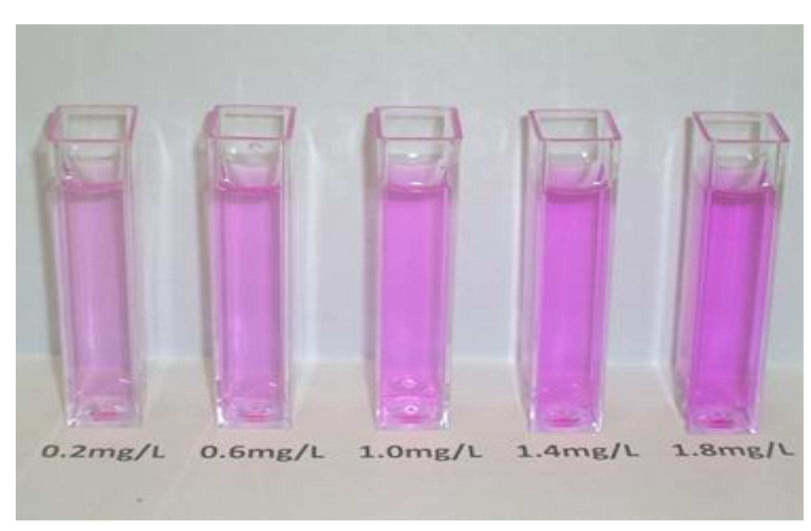

Fig 6: Cuvettes showing the change in colour intensity of 0.2 - 1.8 mg/L nitrite samples with Griess reagent.

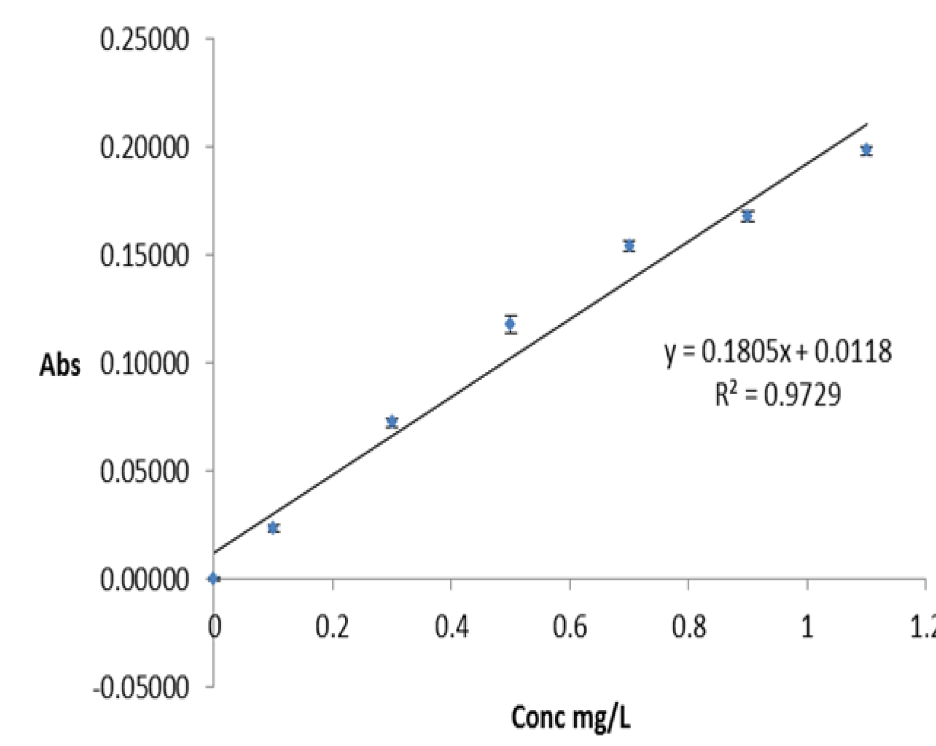

Fig 7: Prototype Calibration of Nitrite Standards 0-1.2mg/L.

Nitrate (NO_3^-) Colorimetric Analysis Based on Chromotropic Acid

A yellow colour is developed when nitrate is treated with chromotropic acid in the presence of concentrated sulphuric acid (fig 8). The absorbance, measured at a wavelength of 430nm, is proportional to NO_3^- (fig 9).

Fig 8: Cuvettes showing the change in colour intensity of 0.5 – 3.5 mg/L nitrate samples with chromotropic acid reagent.

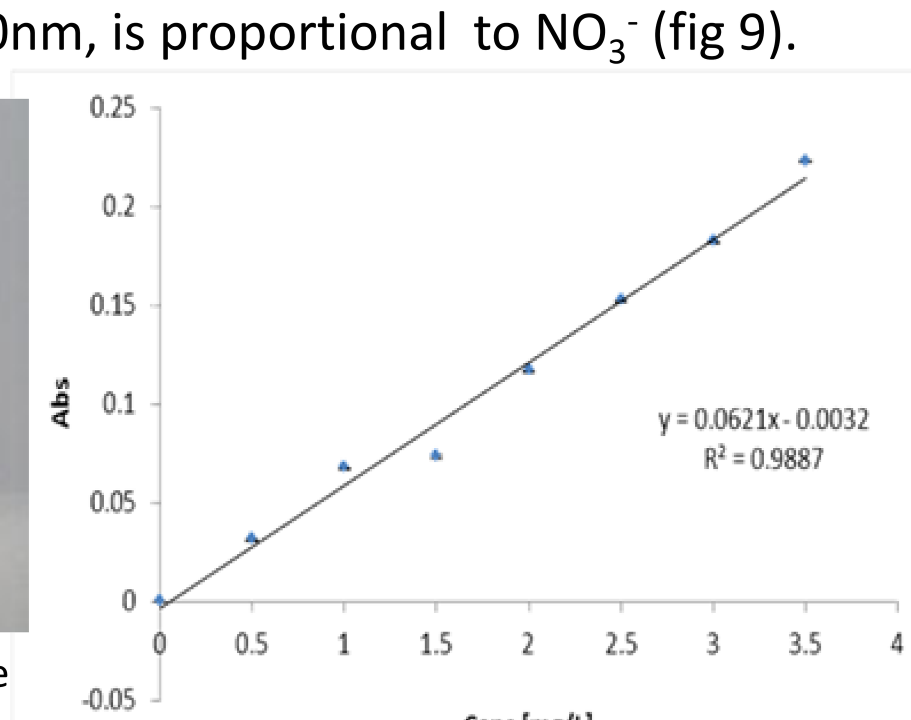

Fig 9: Calibration Curve of Nitrate standards 0-3.5mg/L.

References

- Diamond, D., Cleary, J., Maher, D., Kin, J. and Lau, K.T. 2011. Autonomous Analyser Platforms for Remote Monitoring of Water Quality.
- O' Toole, M., Shepherd, R., Lau, K.T. and Diamond, D. 2007. Detection of Nitrite by flow injection analysis using a novel Paired Emitter-Detector Diode (PEDD) as a photometric Detector.

We acknowledge support for this research from The Questor Centre (grant code DCU9/11/14) and Enterprise Ireland (grant code CFTD/08/111).