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.

Phosphate Sensor Deployment

- 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.

Nitrate (NO$_3^-$) Analyser Based on Griess Reagent

Testing of the nitrate reagent chemistry set with the platform (fig 2). Two micro pumps deliver the nitrate 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 nitrate concentration (fig 6). NO$_3^-$ levels in the samples can be established from a calibration curve (fig 7).

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).

References


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


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.

Fig 4: Image of sensor in situ.

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

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.

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.

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