## Low Cost Autonomous Chemical Sensors for the Direct Determination of Ammonia and Nitrate in Water

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# Insight: Adaptive Sensors Group Dublin City University Dublin Ireland



#### Water sensing



#### Gas sensing

ISES





#### **Materials Chemistry**

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#### **Project Summary**

- To produce environmental autonomous chemical sensing platforms with a price capability that creates a significant impact on existing market
- 2. Focusing on a detection platform for nutrients i.e. phosphate, nitrite, nitrate and ammonia
- 3. Reducing price by integrating material chemistry into system

Futuristic biomimetic platform; tipping point in terms of scale of deployments for water quality monitoring

Significant market demand for low cost nutrient monitoring solutions for water and wastewater applications



## Microfluidics and Colorimetric Chemistry

#### **Combination of Technologies**

- Colorimetric chemical
  assays
- Microfluidic systems: Advantages
- Low cost LED/photodiodebased optical detection systems
- Wireless communications
- Developing low cost systems providing high-frequency data on key water quality parameters









## **Phosphate Analyser**



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## **Phosphate Deployments**

#### Broadmeadow 22Feb 2012- 2March 2012

- The analyser was employed to take a sample reading at 20 minute intervals.
- The sensor performed 350 autonomous measurements.
- 14 manual samples were collected for lab analysis and validation.

#### Glaslough 22May-22June2012

- Sample reading at hourly intervals.
- Manual samples to be validated by DKIT.



# **Determination of Nitrate**

- Current market for nitrate sensors use direct UV spectrophotometric screening, electrodes or cadmium reduction method which in turn can be quite costly.
- Major market for direct, inexpensive and robust sensor.
- Determination of nitrate was investigated by a spectrophotometric method based on **CHROMOTROPIC ACID**.





## Simplifying The Chemistry



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## Nitrate: Optimising the Chromotropic Method



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#### Integration of method into flow analysis platform



**Nitrate analyser and PEDD detection system.** (1) Reagent storage (2) Sample storage (3) Peristaltic micro pumps containing Santropene<sup>®</sup> tubing (4) Waste storage (5) Tygon<sup>®</sup> tubing (6) PEDD flow cell (7) Mixing junction (8) Wixel microcontroller with breakout board containing wireless serial link and data logger (9) Glass flow cell (10) Detector LED at 630 nm (11) Emitter LED at 430 nm (12) Waste line (Tygon tubing).

## Validation and Further Developments



**Blind Test:** Correlation plot of sample concentration obtained by nitrate analyser and ion chromatography.

**Reducing acid** reduces risk factor while maximising lifetime of system

\* Results published in Analytical Methods, July 2013, DOI: 10.1039/C3AY41098F "Integrated flow analysis platform for the direct detection of nitrate in water using a simplified chromotropic acid method"



## Validation and Further Developments One Year Chemical Compatibility Study

Polyurethane	e Santoprene Norprene	PVC	Tygon	Tygon (Fuel)	Silicon	Viton
	Material			Compatibility		
-	PolypropylenePolyurethanePTFE (Teflon)PVC (Polyvinyl chloride)SiliconeSiliconeTygon®Tygon® Fuel(Lubricant) TubingNeopreneSantoprene®Viton®			Severe effect		
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_				Severe effect		
				Excellent		



# **Determination of Ammonia**

Analysis for ammonia includes a variation on:

- the Berthelot method which employs
- Fewer reagents
- Salicylic acid instead of phenol which eliminates a toxic and relatively unstable reagent component.
- Intense colour generated is detected at a wavelength of 660nm



## Ammonia: Simplifying/Validation



# Integration of method into autonomous sensing platform -Schematic



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# Integration of method into autonomous sensing platform -Detection System





- c = concentration
- L = pathlength

#### Effective optical pathlength is doubled

Increased absorbance signal without increasing the sample volume

## Integration of method into autonomous sensing platform



#### **Microfluidic chip**

# Integration of method into autonomous sensing platform -Syringe pumps



#### Integration of method into autonomous sensing platform



\*"Autonomous chemical sensing platform for the monitoring of ammonia in water using the Berthelot method", Analytical Methods RSC (submitted).

## Next Generation Sensing Platforms



- Drive down the overall cost of the platform through material chemistry
- Fully integrated 'matchbox' analyser ready for field deployment

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(1)Benito-Lopez, F., Byrne, R., Raduta, A.M., Vrana, N.E., McGuinness, G., Diamond, D., 2010, Lab Chip, *"lonogel-based light-actuated valves for controlling liquid flow in micro-fluidic manifolds"* 

## Next Generation Sensing Platforms

- Successful phosphate deployments
- Colorimetric method for nitrite and nitrate investigated and optimised
- Nitrate chemistry prototyping developed
- Ammonia analyser ready for field deployments
- Integrated next generation valve structures
- Publications and Outputs

The major focus is on real deployments with these modified approaches for in situ environmental monitoring. The emphasis will be on the real issues related to the analytical approach and sampling within environmental waters and in particular, keeping the sensor platform operating autonomously over time.

#### Thank you for your attention

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