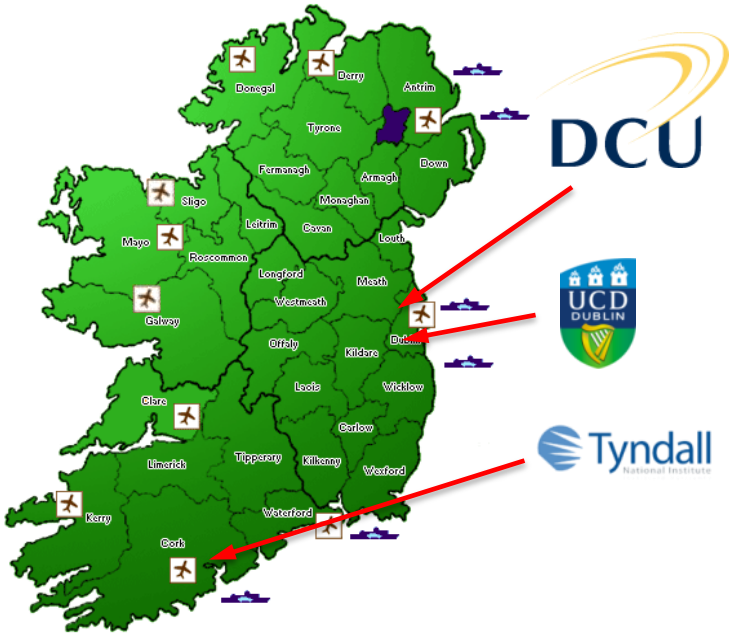
Next Generation Autonomous Chemical Sensors for Environmental Monitoring

Deirdre Cogan, John Cleary, Thomas Phelan and Dermot Diamond

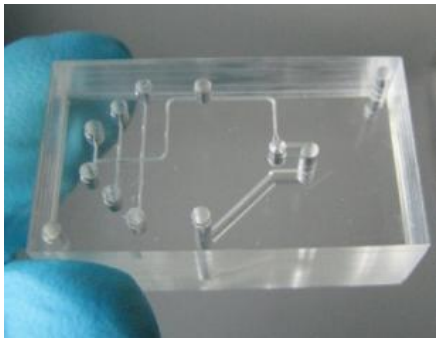
ENVIRON 2013

www.clarity-centre.org www.dcu.ie/chemistry/asg/



Gas sensing


Water sensing




Adaptive Sensors Group, DCU


“The Grand Challenge”

Project Summary

1. 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. nitrite, nitrate and ammonia
3. Reducing price by integrating material chemistry into system

→ *Enable multiple targets to be detected using a single unit.*

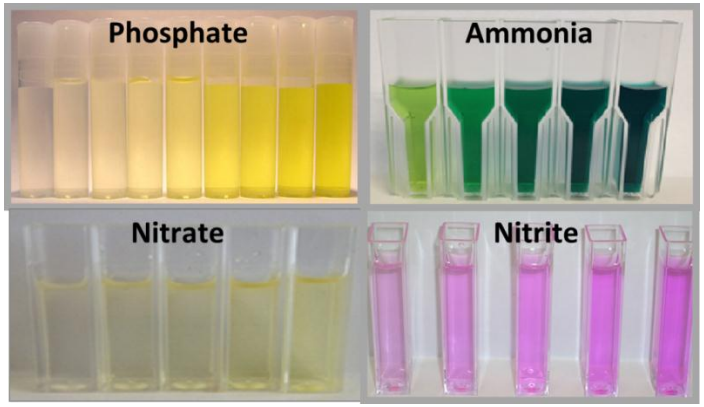
→ *Financial Benefit;*
Futuristic biomimetic platform; tipping point in terms of scale of deployments for water quality monitoring

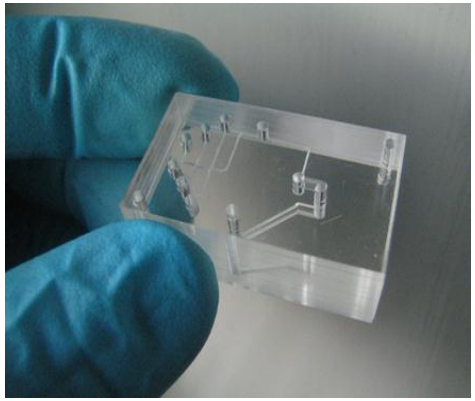
→ *Significant market demand for low cost nutrient monitoring solutions for water and wastewater applications.*

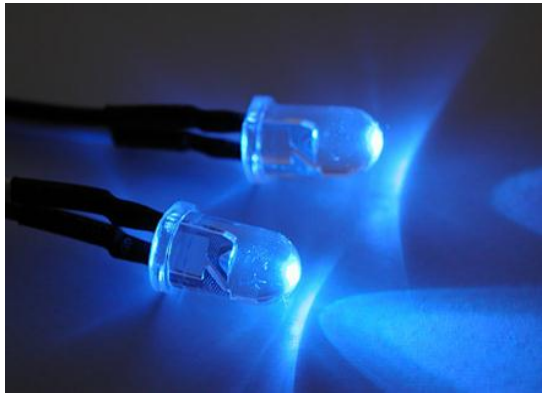
Microfluidics and Colorimetric Chemistry

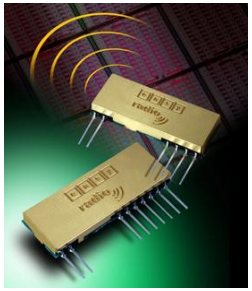
Combination of Technologies

- Colorimetric chemical assays
- Microfluidic systems
- Low cost LED/photodiode-based optical detection systems
- Wireless communications.





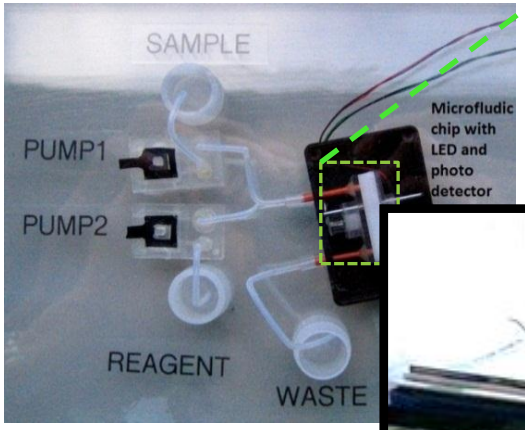


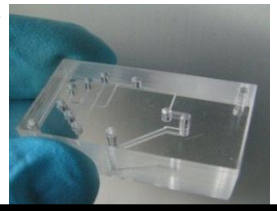


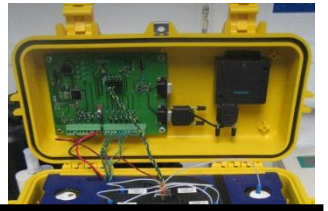
- Developing low cost systems which can be deployed for extended periods providing high-frequency data on key water quality parameters.

COST

€200 ↓ €2000 ↓ €25000 ↓







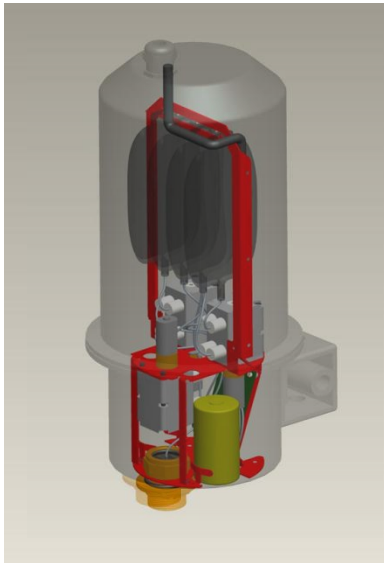
Generation 3:
Incorporating m
material chemit

Commercially Available units

Phosphate Deployments

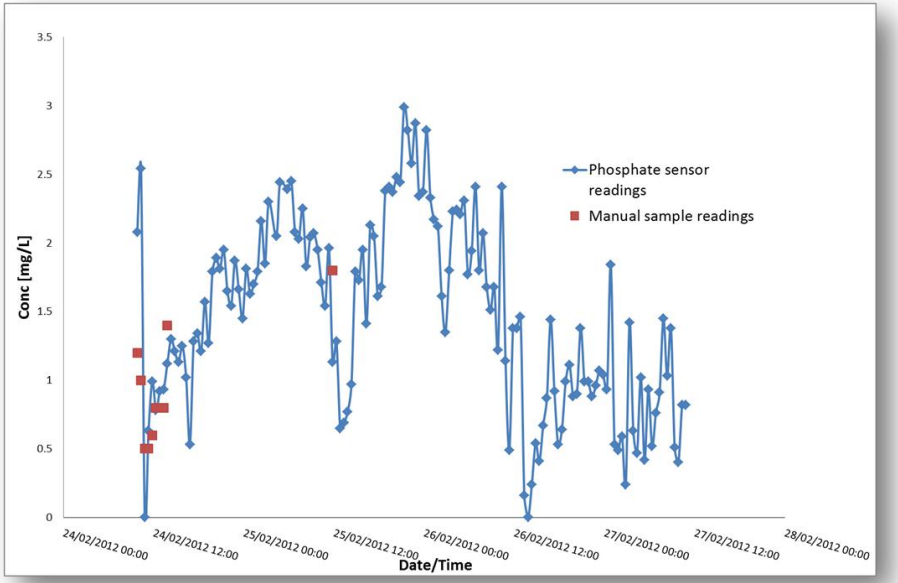
- Following an initial laboratory based calibration; the system was placed *in situ* at Broadmeadow Water Estuary, Co. Dublin for the period 22 Feb 2012 – 2 Mar 2012.

- Deployment of two systems in the Integrated Constructed Wetlands in Glaslough, Co. Monaghan from May – June 2012.

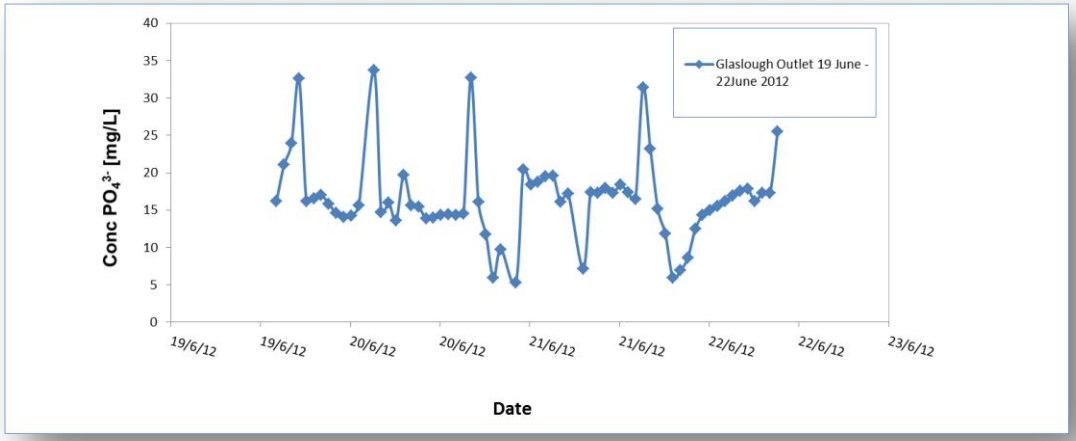


Phosphate Deployment

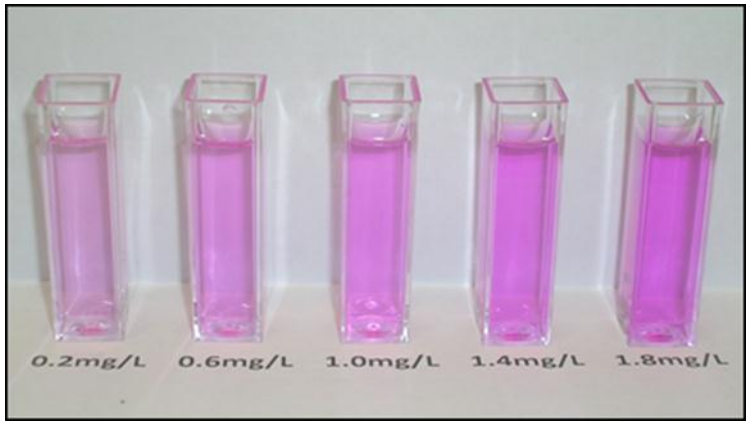
Broadmeadow 22Feb 2012- 2March 2012

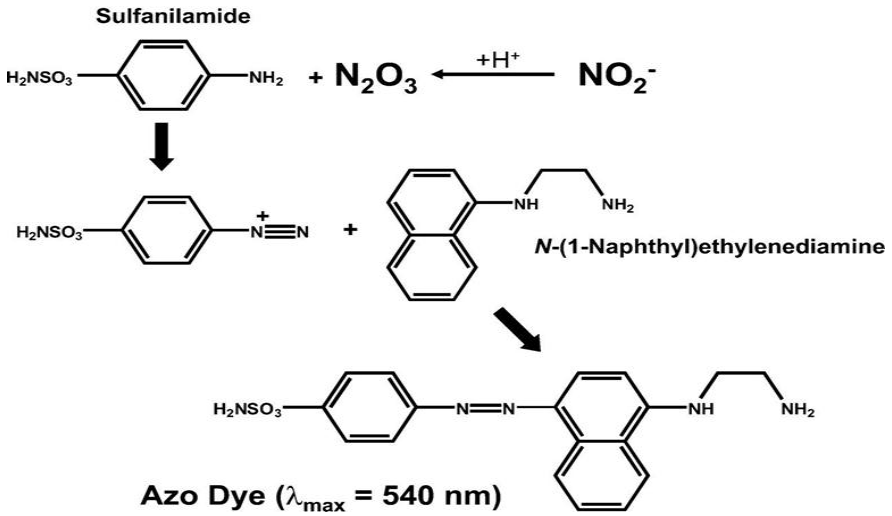


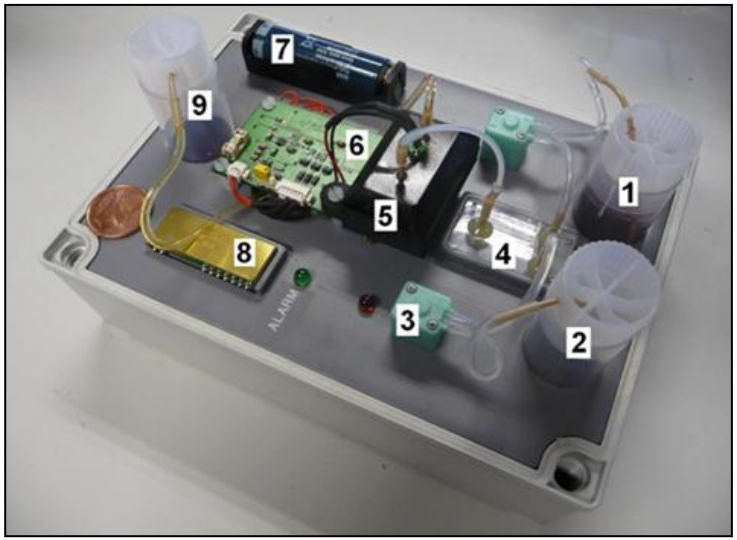
Glaslough 22May-22June2012



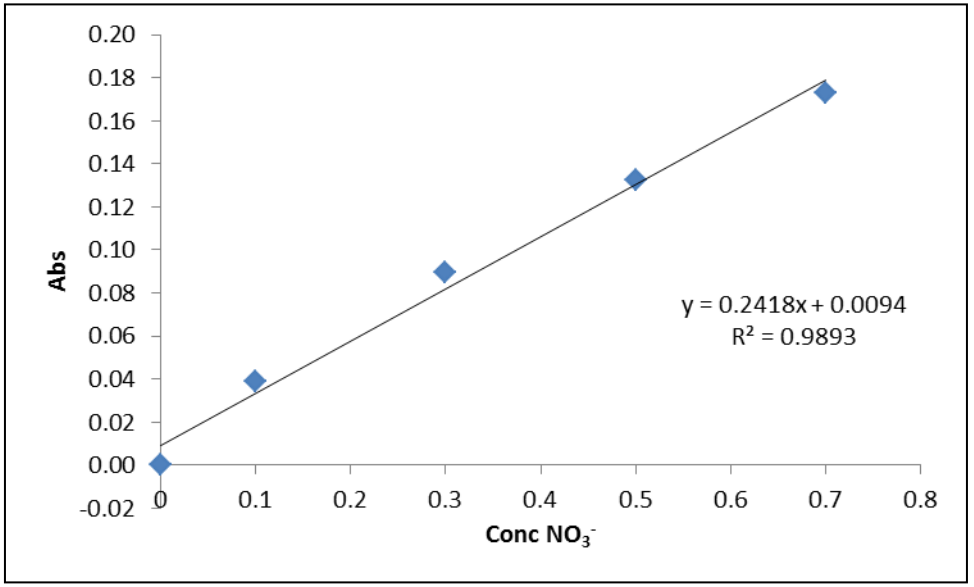
Determination of Nitrite - Griess Reagent







Benchtop nitrite detection system.

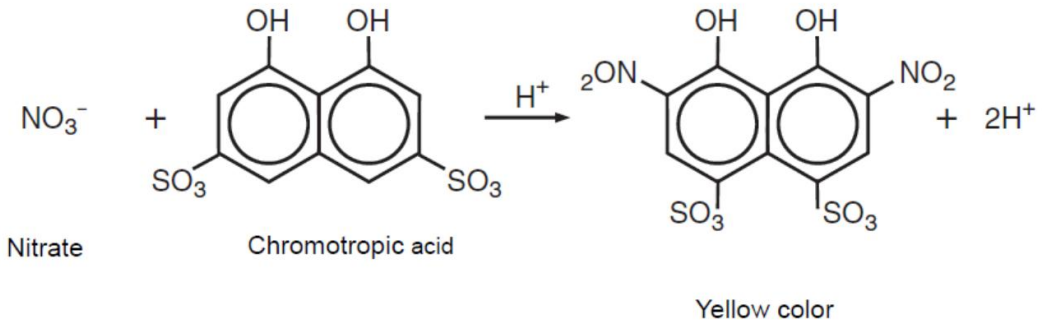


Determination of Nitrate

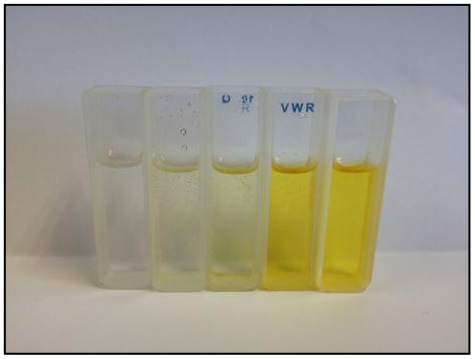
- Current market for nitrate sensors use direct UV spectrophotometric screening, electrodes or cadmium reduction method which in turn can be quite costly.

- Major market for direct, inexpensive and robust sensor.

Determination of nitrate was investigated by a spectrophotometric method based on chromotropic acid. A yellow colour is developed when nitrate is treated with chromotropic acid in the presence of concentrated sulphuric acid and the absorbance measured at a wavelength of 430nm.



(1)

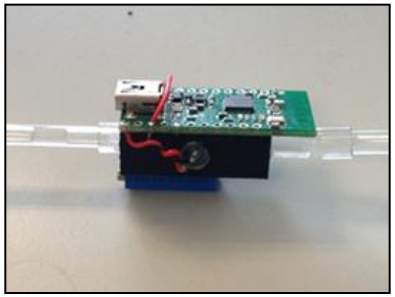


The work represented here on the study for the determination of nitrate has demonstrated that is possible to detect nitrate by a direct colorimetric technique.

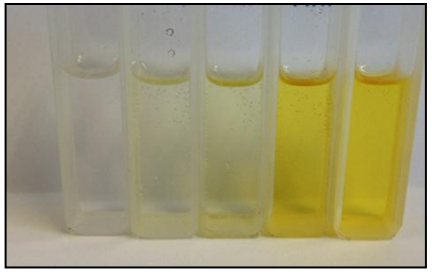
(1) Ryan, J., Estefan, G. and Rashid, A. 2001. *Soil and Plant Analysis Laboratory Manual*. Second Edition. Syria. ICARDA and NARC 2001.

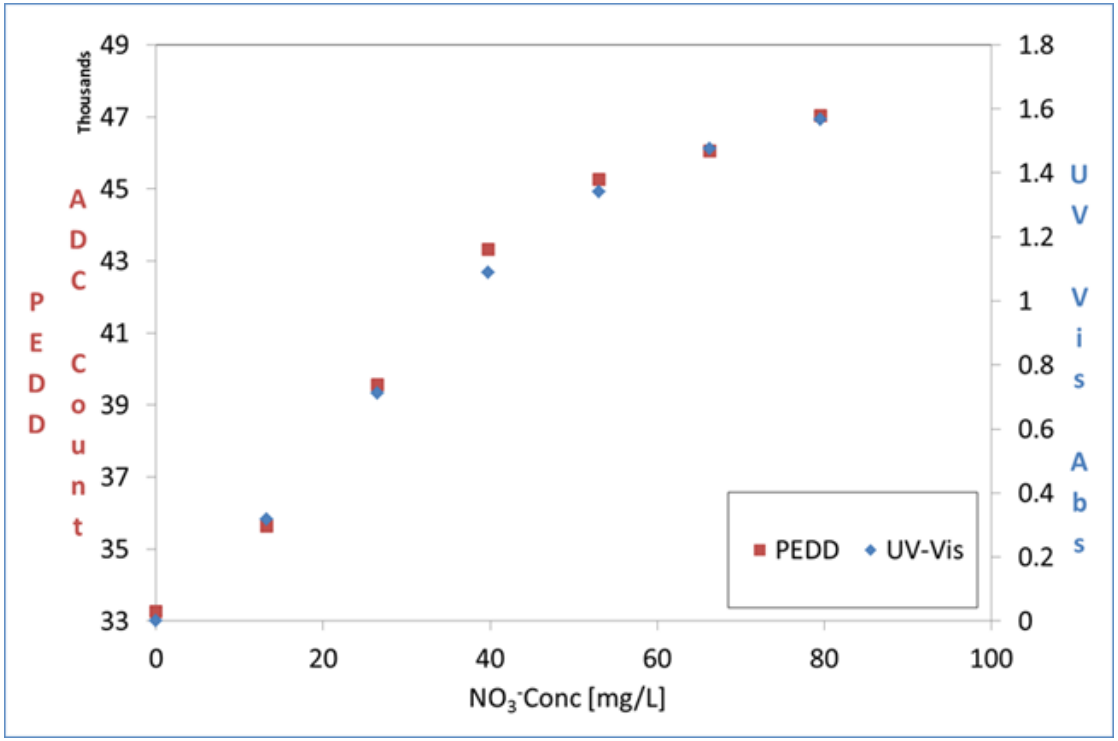
Determination of Nitrate- Chromotropic Method

- Kinetics
- Reproducibility
- Stability
- Linear Range

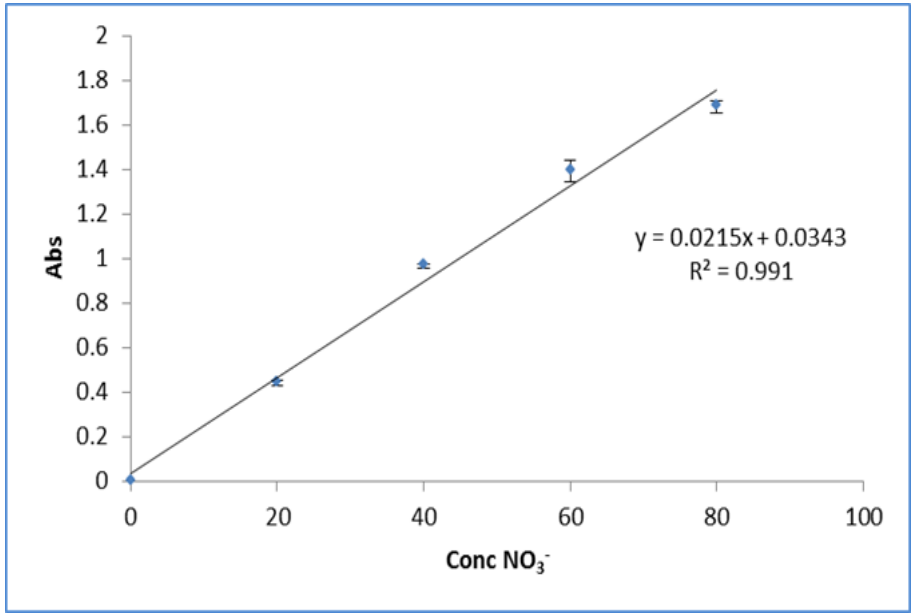


PEDD set up at 430nm

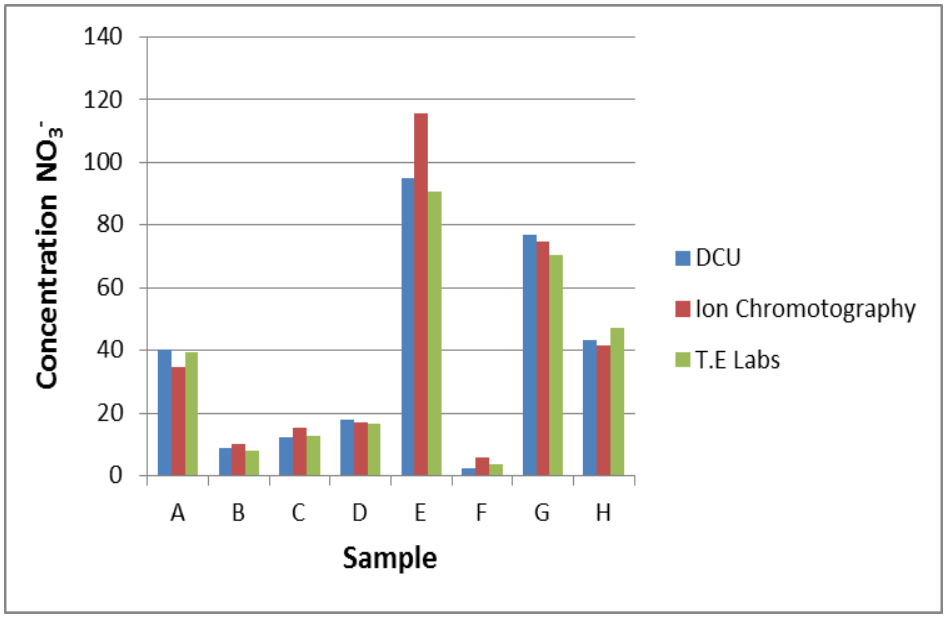




Chromotropic Method vs. Ion Chromatography



Calibration Curve 0-80mg/L Nitrate

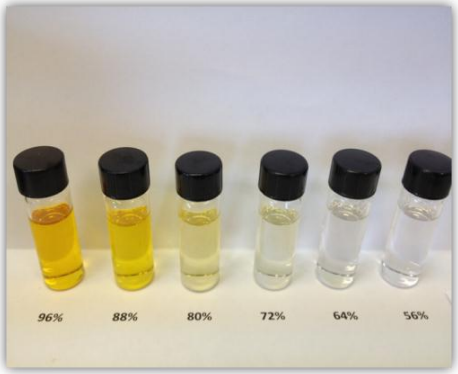


Real Sample Blind Test

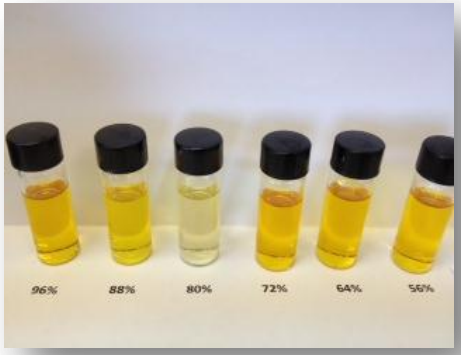
Further Improvements

Improvements on Method: Decrease Concentration of Sulphuric Acid

✓ Proved possible to achieve satisfactory analytical results



↓HEAT↓



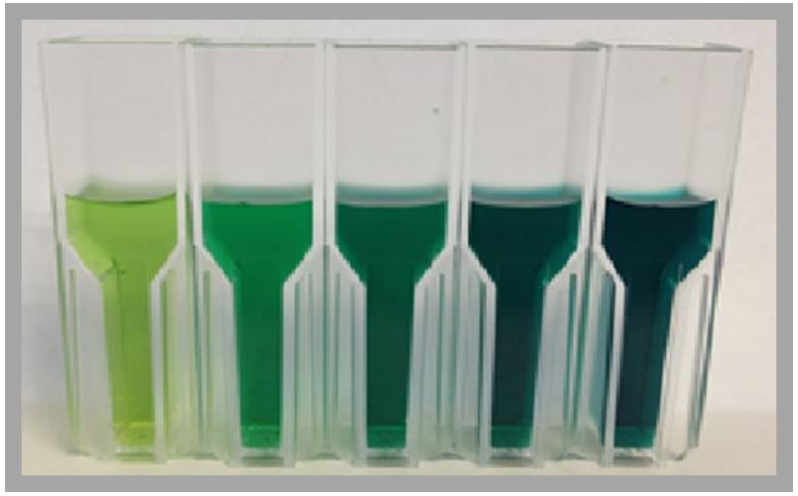
H_2SO_4 Concentration	Result
96% 88% 80%	Immediate colour change when sample added to reagent.
72%	Resulted in a slight colour change when sample was added to reagent.
64% 56%	No colour change when sample was added to reagent however after heating at a 130°C for 50mins, colour developed.

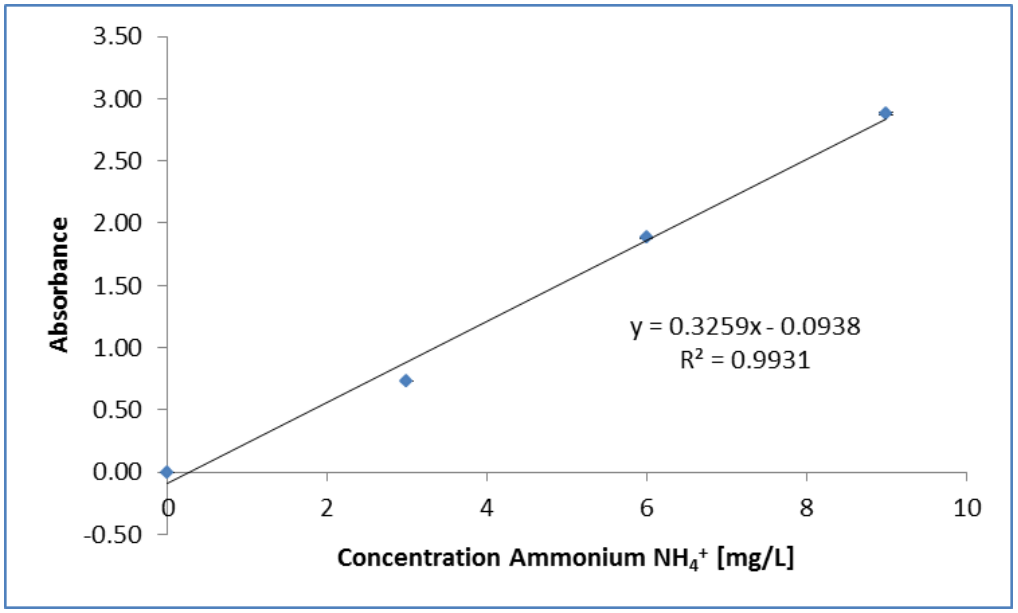
RESULT: Reducing risk factor while maximising lifetime of system

Determination of Ammonia

The reagent cocktail includes a variation on:

- **the Berthelot method** which employs
- Salicylic acid instead of phenol which eliminates a toxic and relatively unstable reagent component.
- Intense colour generated is detected at a wavelength of 630nm.





Further Improvements

- Previous method employs a three step reagent process
- Currently employing a mixed 2 step reagent process

→ Osberstown Waste Water Treatment Plant Sample = 0.6 mg/L NH_4^+

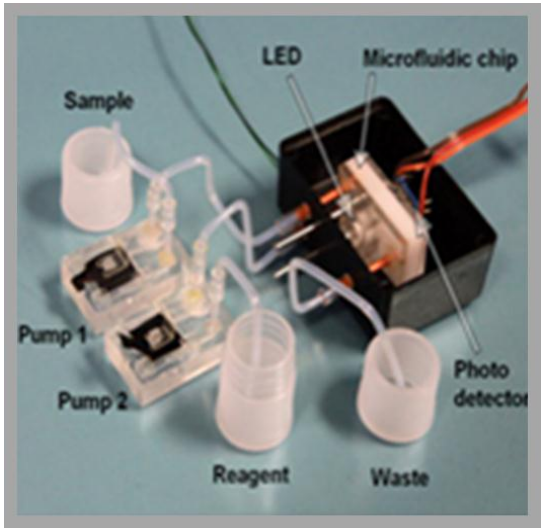
→ ***Using adjusted Berthelot Method:***

Sample Type	Conc NH_4^+ [mg/L]
Sample	0.6335
Sample + spiked with 1ppm	1.7416
Sample + spiked with 3ppm	3.6562
Sample + spiked with 5ppm	5.5696
HACH- Sample	0.75

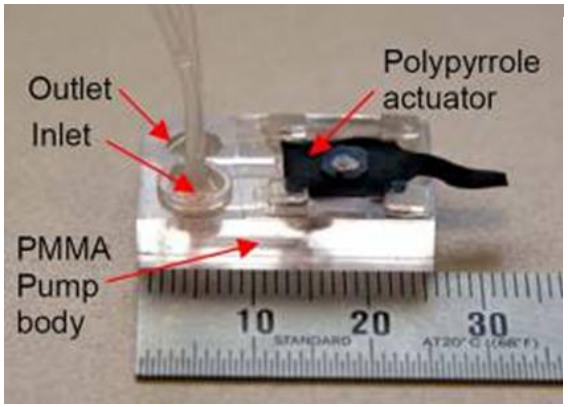
Future Work:

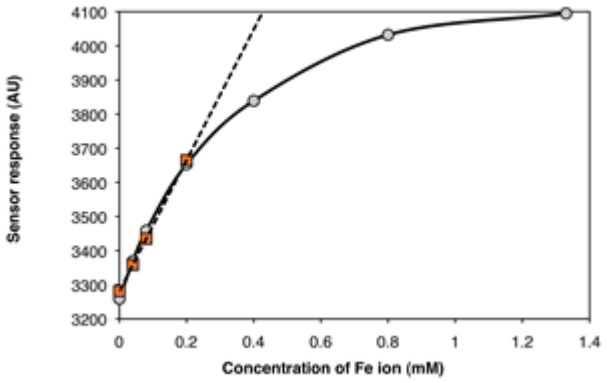
- Stability of reagents; hypochlorite
- Linear Range
- Integration into microfluidic platform following field deployment after appropriate lab testing

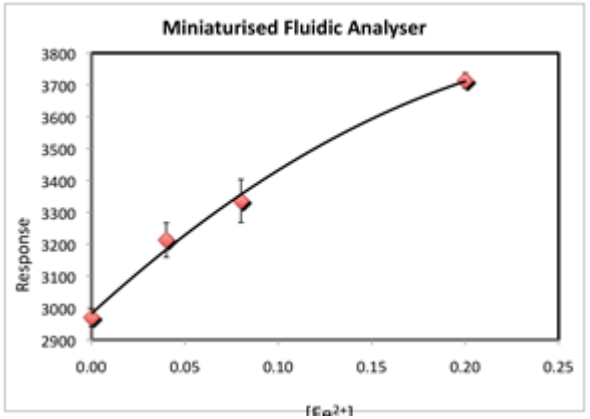
Future Work- Generation 3;
Futuristic Matchbox Analyser



- The goal is to integrate polymer actuator valves into the microfluidic chip, which will significantly drive down the overall cost of the platform.
- The main aims are to maximise the lifetime of these actuators through the use of ionic liquid electrolytes and optimisation of the pumping system (actuator stress/strain). This will achieve a fully integrated ‘matchbox’ analyser ready for field deployment.







‘From Ecosystem Function to Human Health'

NITRITE

NITRATE

AMMONIA

IRISHTIMES.com Tuesday, January 29, 2013

News | Sport | Business | Comment | Life | Society | Culture | Cars | Jobs

Ireland | World | Today's epaper | Generation Emigration | Video | Blogs | Galleries | Irish EU

Home » Ireland »

Recommend 0 Tweet 5 +1 0 Share 5 1

irishtimes.com - Last Updated: Tuesday, January 15, 2013, 12:08

State 'compliant' on septic tanks

Minister for Environment Phil Hogan said a septic tank inspection programme would be presented to teh European Commisson next week. Photograph: Dara Mac Donaill/The Irish Times

Related

- Septic tank payment rate lowest in Donegal | 24/12/2012
- Big Phil steps stoically through the muck and madding crowds | 27/09/2012
- Grants of up to EUR1000 for septic tank repairs | 18/12/2012
- Septic tank regime to be 'pragmatic' | 12/10/2012

CIARA KENNY

IRISHTIMES.com Tuesday, ..

News | Sport | Business | Comment | Life | Societ

Ireland | World | Today's epaper | Generation Emigration | Vide

Home » Ireland »

Recommend 60 Tweet 10 +1 0 Share

irishtimes.com - Last Updated: Monday, August 6, 2012, 19:21

North Dublin water alert issued

Mobile water tankers are in operation after warning . Photograph David Sleator/ The Irish Times 2010

OLIVIA KELLY

Residents of up to 1,400 houses in north Dublin have been warned not to c high levels of bacteria in the system.

Dublin City Council has issued a "major alert" to the homes and properties

RTÉ News / Ireland

Home | Ireland | World | Business | Watch & Listen | Special Reports

Ireland | Environment

Ireland fined €3.5m for environmental law failures

EIB lending €200m for Irish water projects

24.01.2013

Categories: Investment, Government, Water, Finance

Tags:

Share: Tweet 4 +1 0 + more

The European Investment Bank is providing a €200m loan to Ireland's Water Service Investment Programme (WSIP) to support 23 water investment projects across Ireland.

The projects include provision of new water mains, water and wastewater treatment facilities and reservoirs, as well as measures to improve water conservation.

"I am delighted that the EIB has decided to support my Department's Water Services Investment Programme with a loan of €200m which will assist in funding 23 water projects," said Minister for the Environment, Community and Local Government, Phil Hogan TD. "It is an indication of the bank's confidence in the Irish State and our recovery programme and is a good signal

EIB lending €200m for Irish water projects

Thank you for your attention

We acknowledge support for this research from The Questor Centre (grant code DCU9/11/14).