



Development of a Cost Effective Sensing Platform for the Detection of Phosphate in Natural Waters.

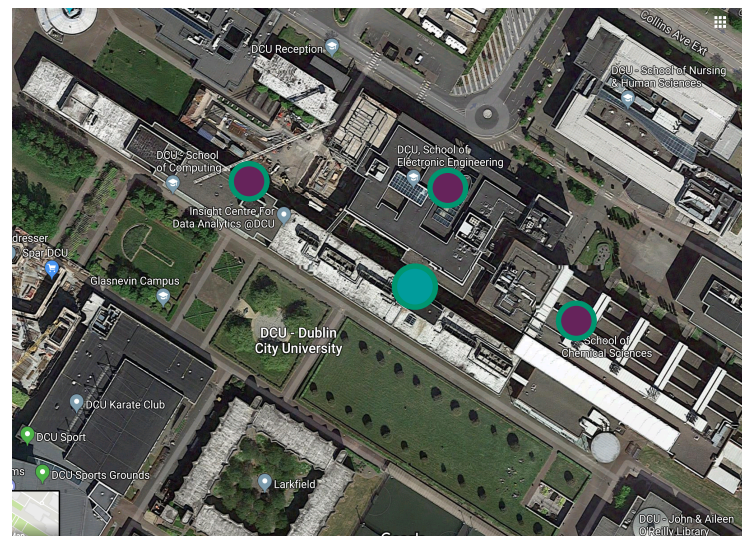
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Margaret McCaul, Dermot Diamond

Innovation Partnership IP 2016 0502

This Research is co-funded by the European Regional Development Fund (ERDF) under Ireland's European Structural and Investment Funds Programmes 2014-2020

PI Dermot Diamond

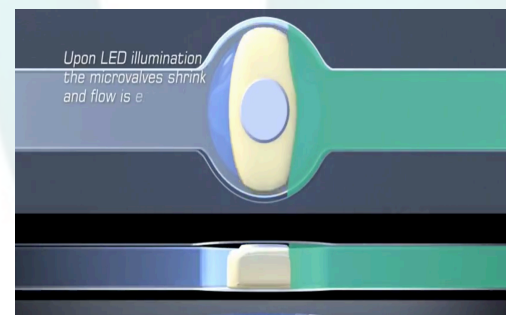
Multidisciplinary Team of
Analytical Chemists, Engineers,
Material and Computer
Scientists



Wearable
Sensors



Environmental
Sensors



Material
Science

Environmental Sensors

Create cost effective sensors that can obtain accurate, real-time information about environmental status from the highly local to global scale.

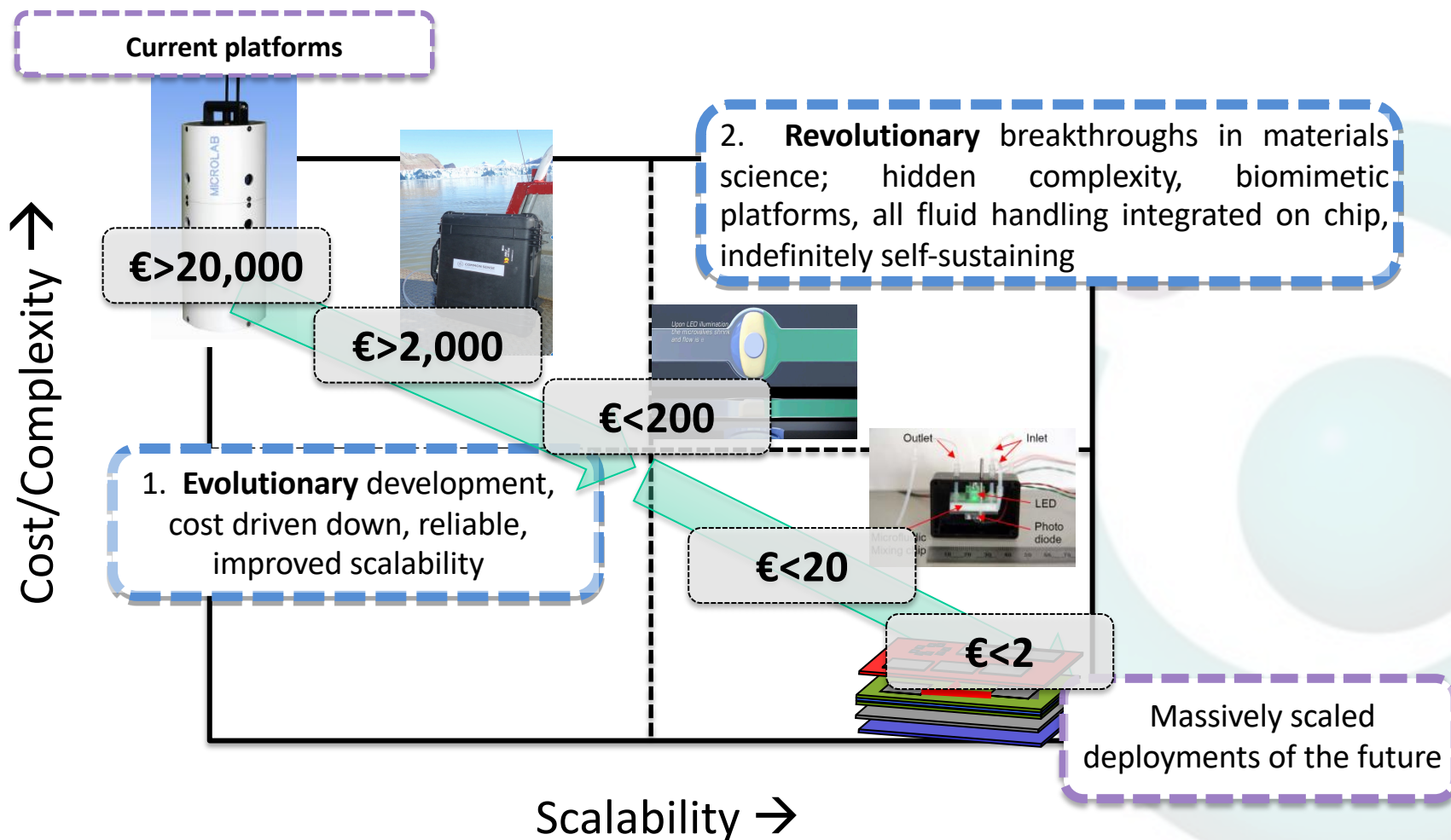
This can only be realised through 'deploy and forget' models of use, in which the analytical platforms are:

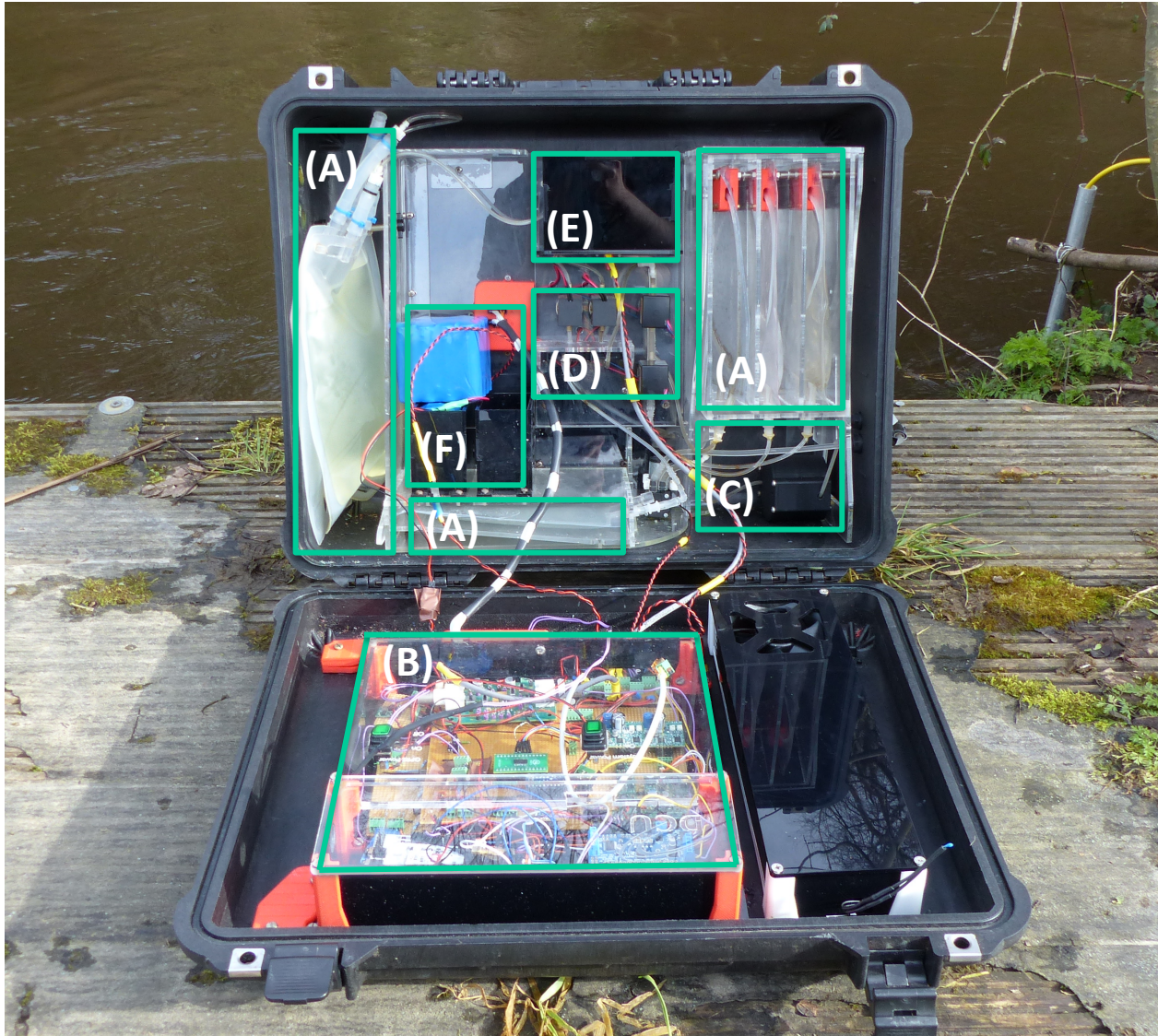
- i) capable of autonomous function for periods of months between servicing intervals;
- ii) provide validated analytical data over this period,
- iii) are relatively inexpensive to buy and maintain



- Water Framework Directive Marine Strategy Framework Directive, and other EU policies
- EU Copernicus programme invest almost €1 Billion 2014-2020
- Nutrient Challenge , Alliance Coastal Technologies (ACT)
- \$210 Billion spent annually in the USA on impacts to drinking water quality and aquatic ecosystems
- Autonomous Nutrient platforms have the potential to offer higher resolution data in comparison to traditional methods

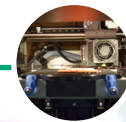
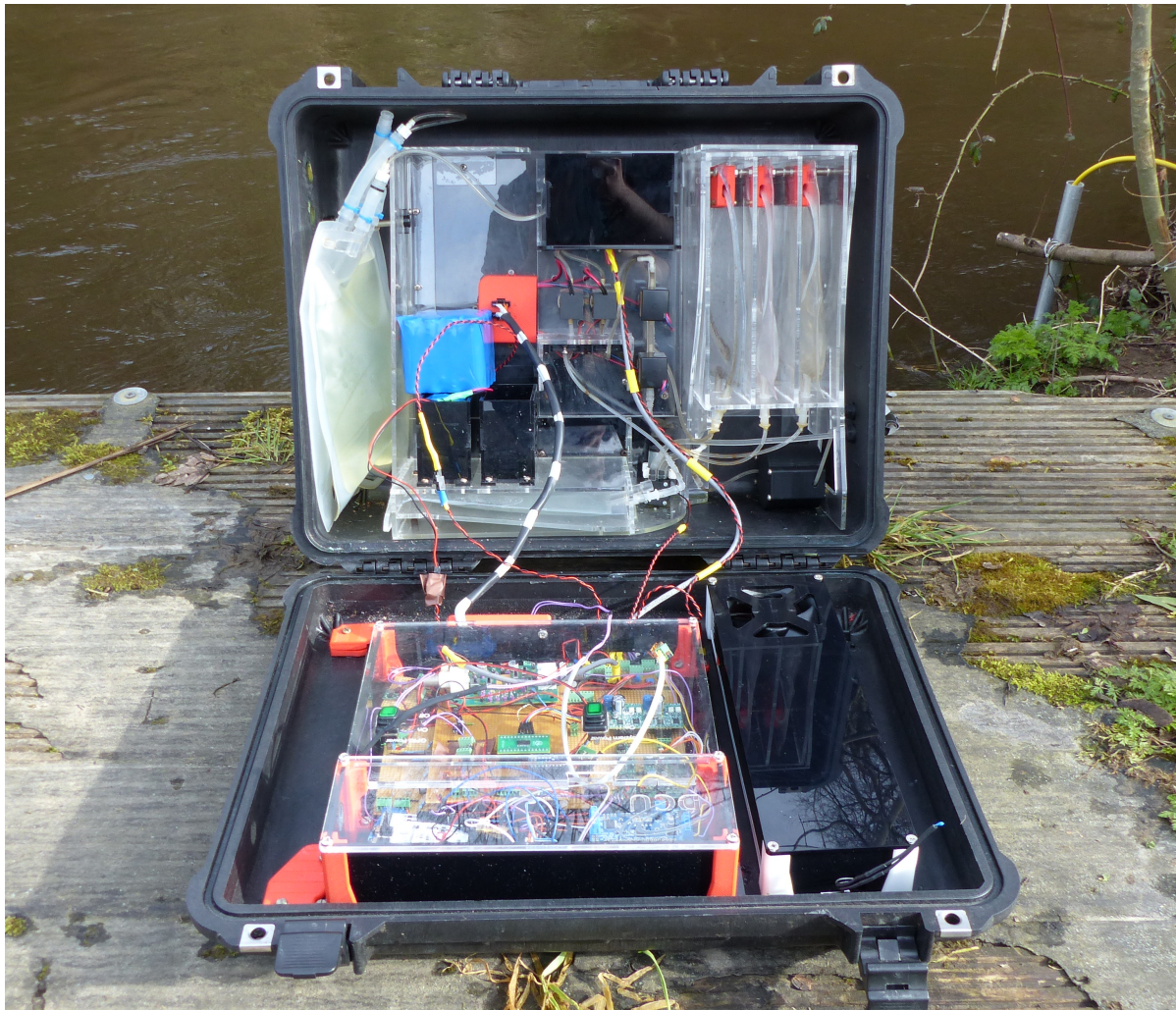




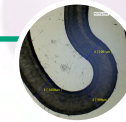


- A) Reagent, Calibration Standards, Waste**
- B) Electronics for Automation, Detection and Data Transmittance**
- C) Inlet System**
- D) Fluidic Handling**
- E) Fluidic Chip, LED, Photodiode**
- F) Battery**

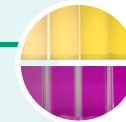
Nutrient Platform



**Rapid
Prototyping**



Microfluidics



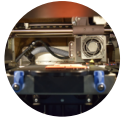
**Colorimetric
Chemistries**



**Optical
Detection**



Electronics



Rapid Prototyping

Rapid Prototyped Components

Use of 3D Printing, Laser Ablation and Micro milling techniques for rapid Prototyping

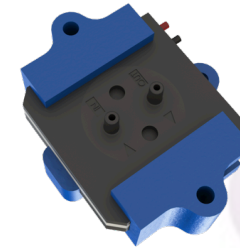
- Parts quickly and easily manufactured in house
- Reduces manufacturing time
- Reduces cost

3D Render

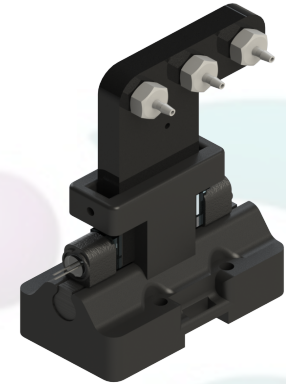
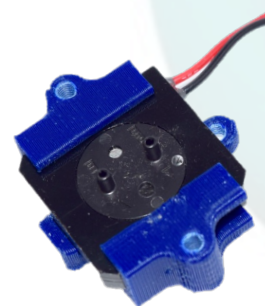


Cuvette Holder with Led Alignment

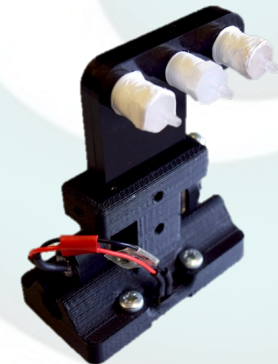
Manufactured part

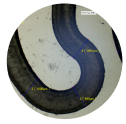


Piezo Pump Mountings



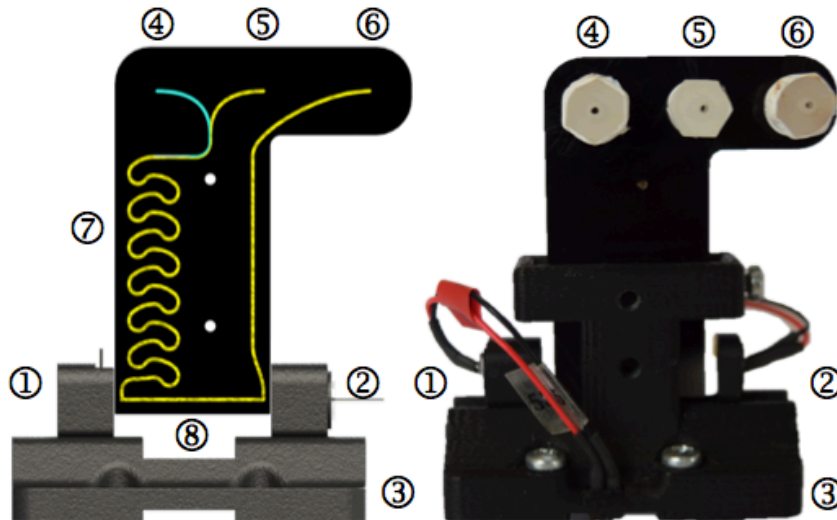
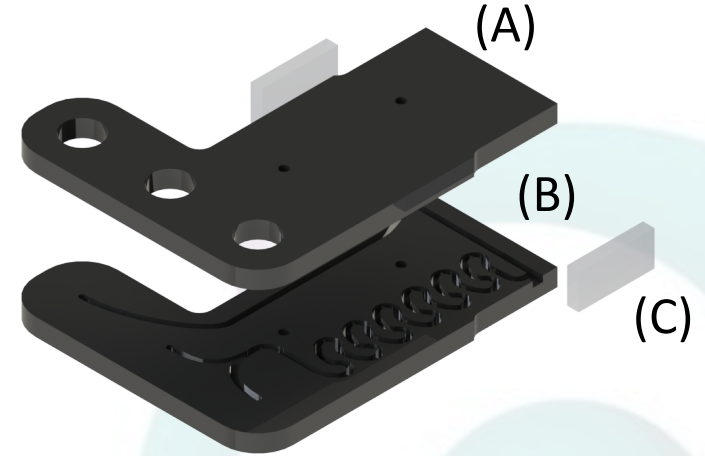
Microfluidic Optical Chip





Microfluidics

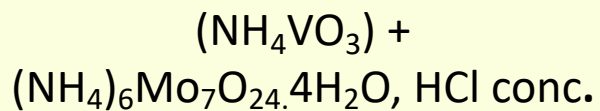
- 2 Layer PMMA Microfluidic Chip (A,B), Optical Windows (C)
- Manufactured using Precision Micro Milling
- Bonded using Heat and Pressure at transition temperatures
- Mixing Channels Induces chaotic advection
- 3D Printed Alignment Rail for Kinematic Stability



- ①. Photodiode
- ②. UV-LED
- ③. 3D Printed Mount and Rail
- ④. Sample Inlet
- ⑤. Reagent Inlet
- ⑥. Outlet
- ⑦. Serpentine Mixing Channel
- ⑧. Optical Detection Channel

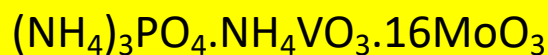
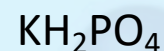


Mixture (Reagent)



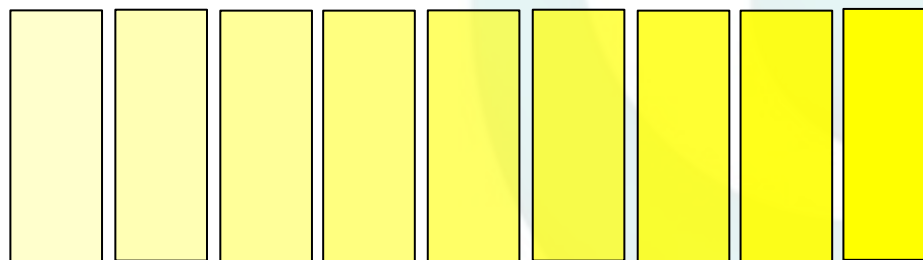
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Sample



Yellow Method –

Vanadomolybdophosphoric Acid is formed when ammonium metavanadate and ammonium molybdate (mixture) reacts with phosphate (acidic conditions)



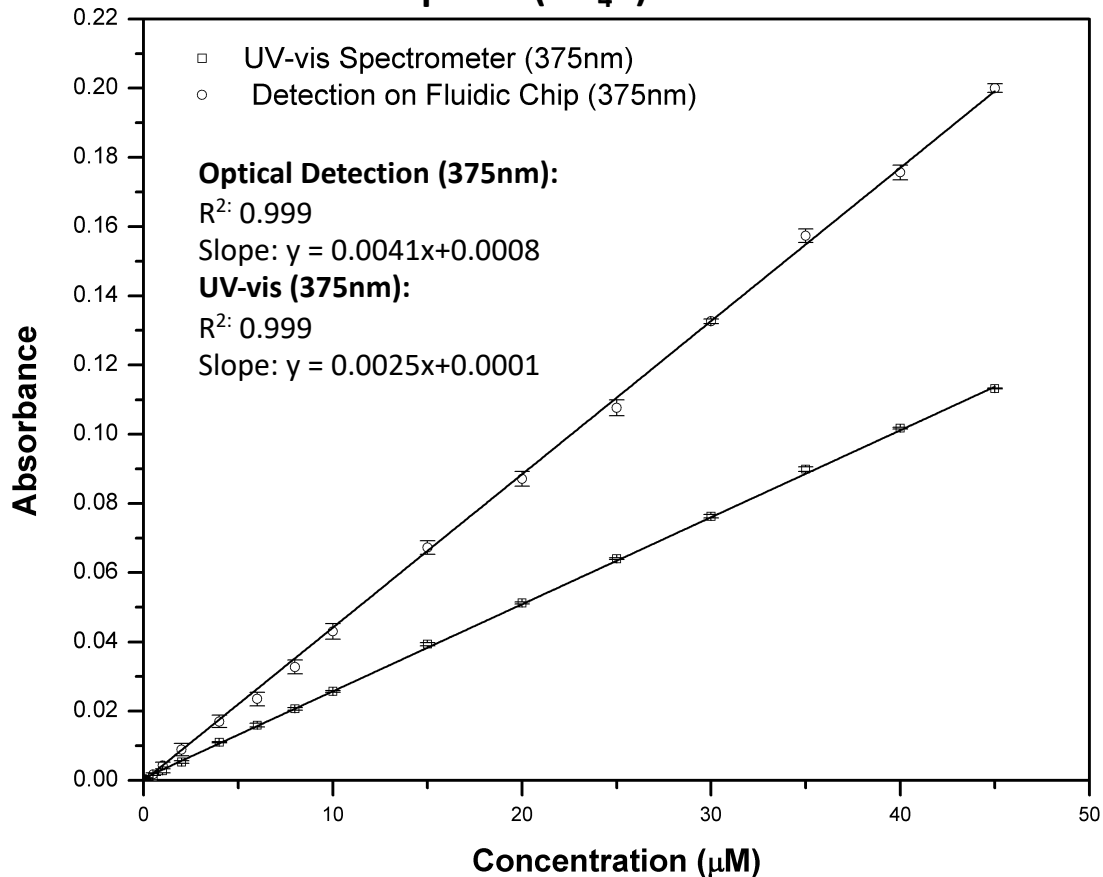
Increasing Nutrient (PO_4^{3-}) Concentration
Increasing Colour Intensity



Optical Detection

Optical Detection on Microfluidic Chip Vs UV-vis Spectrometer

Phosphate (PO_4^{3-}) Detection



LED (375nm) Photodiode optical detection carried out on Microfluidic Chip

Phosphate (PO_4^{3-}) Detected 0-45 μm on UV-Vis(375nm) and on Microfluidics

Increased Sensitivity when detected on Microfluidic Chip vs UV-Vis Spectrometer

1: Milan WWTP, Italy

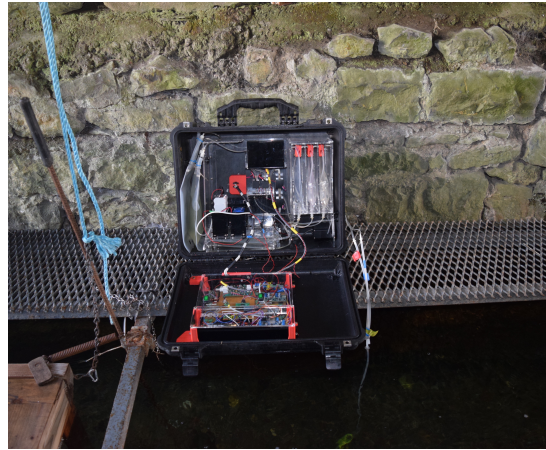


Water Type: Waste Water
after 2nd stage processing

**Number of
Measurements:** 14

Date Deployed: 4th – 5th
May 2017

2: Lough Rea, Galway

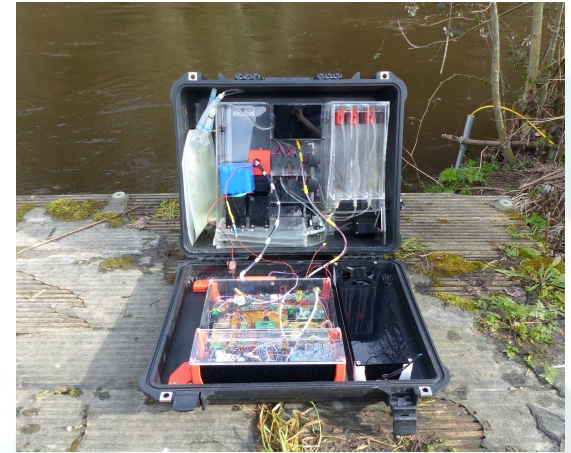


Water Type: Spring Fed
Freshwater Lake

**Number of
Measurements:** 55

Date Deployed: 5th – 10th
Dec 2017

3: River Liffey, Palmerstown, Dublin



Water Type: Freshwater
River

**Number of
Measurements:** 224

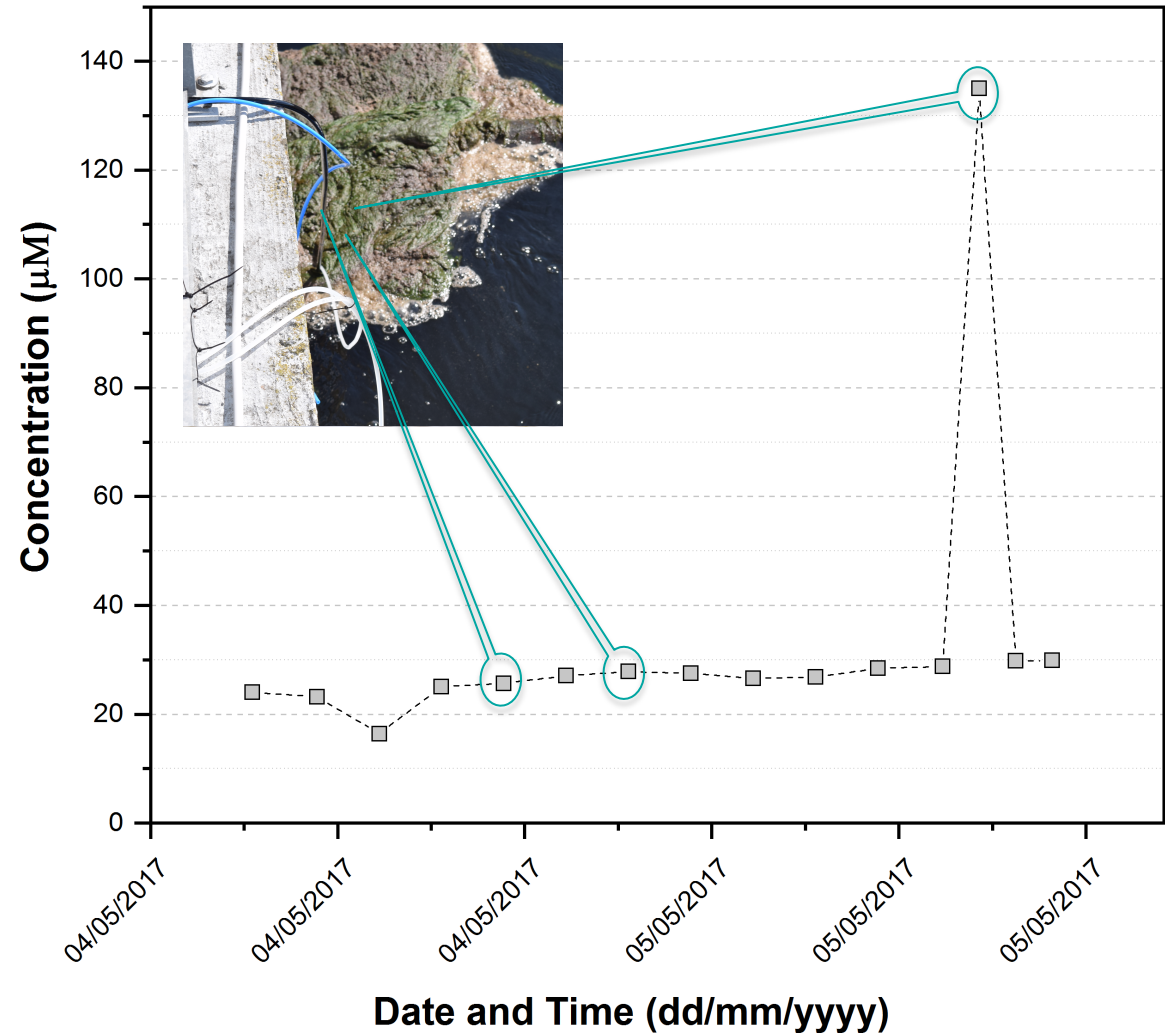
Date Deployed: 21st Feb –
20th Mar 2018

Nutrient Platform Phosphate (PO_4^{3-}) Detection



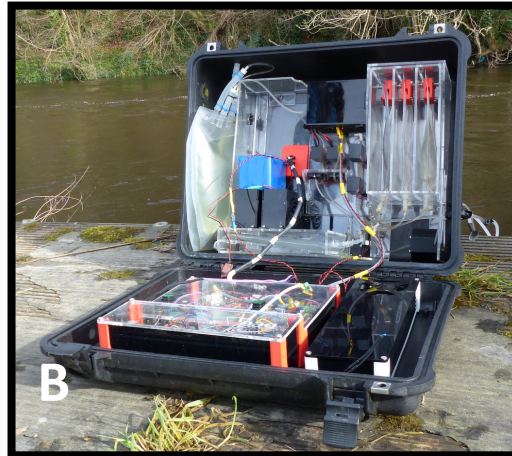
Milano San Rocco WTPP
Sampling Point:
Output Water after Clarifier

Typical levels:
10mg/L Suspended Solids
15 μM Phosphate (PO_4^{3-})



Deployment 3: River Liffey, Palmerstown, Dublin

- Sensor deployed on the River Liffey for 28 days (21/02/2018 – 19/03/2018)
- Measurements of Phosphate (PO_4^{3-}) detected every 3 hours
- Environmental Temperature, Rainfall and Water level recorded



Beast from the East: Status Red snow alert in place until Friday

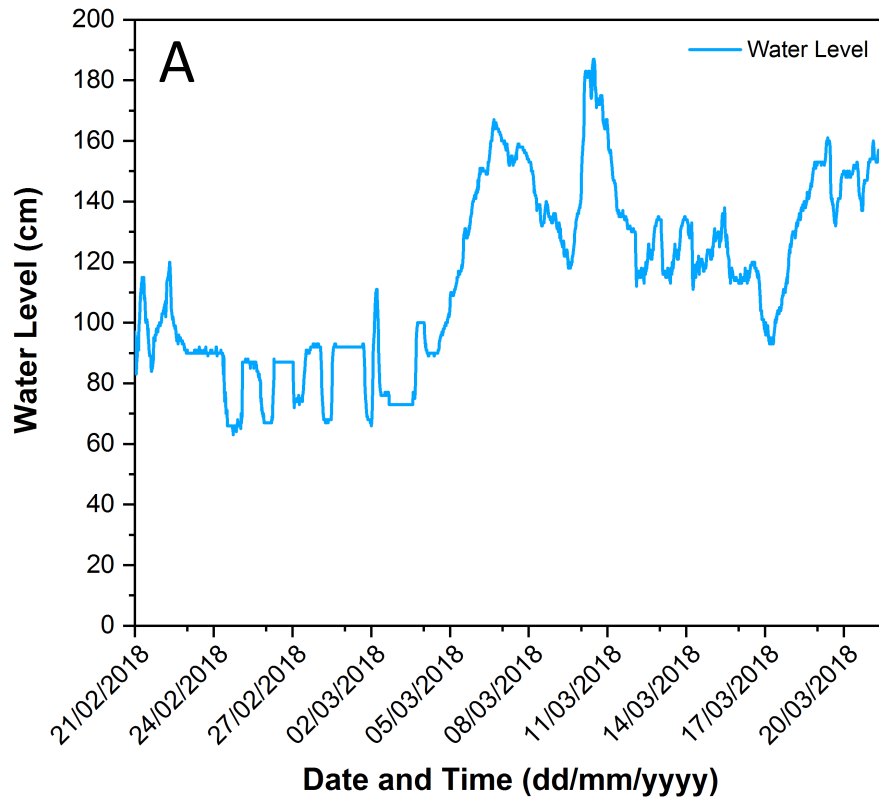
Varadkar says people 'should not venture out of doors' while the red level warning is in place

© Wed, Feb 28, 2018, 06:29 | Updated: Wed, Feb 28, 2018, 21:05

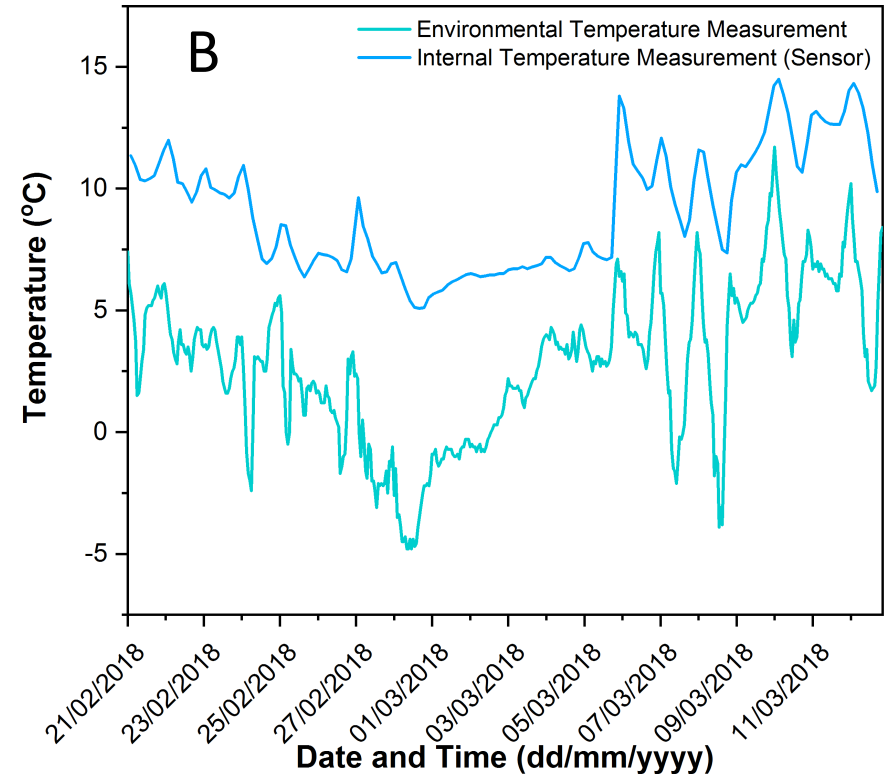
D

- A. Deployment Location
- B. Sensor Deployed
- C. Sensor Deployed by depth gauge
- D. Temperatures reach -4.5°C

Deployment 3: River Liffey, Palmerstown, Dublin

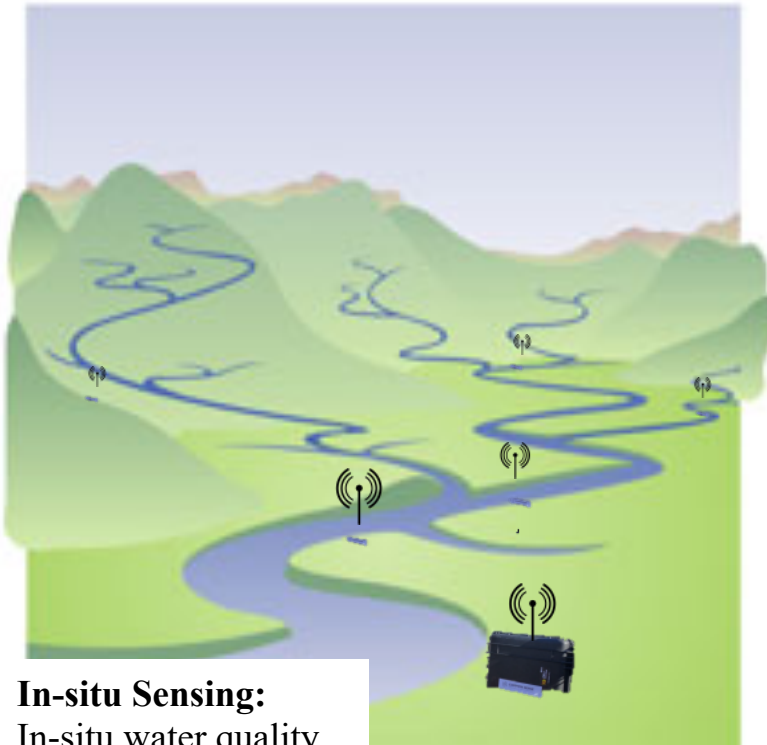


A. Water levels controlled by Leixlip Dam. Increasing water levels from the 5th Mar due to snow melt.



B. External vs Internal Temperature
External lows of -4.5°C.
Internal lows of 5°C.

Smart Environment Integrated Sensing Network



Data Analysis:
Combination of in-situ and satellite data. Statistical Algorithms to develop test models

Real time information and predictive Models on water quality,

Development and Integration of Detection for Nitrite (NO_2^-) and Nitrate (NO_3^-)

Further optimisation and cost reduction of autonomous nutrient platform

Dr Margaret McCaul, Prof Dermot Diamond and all in the
Adaptive sensors group
Enterprise Ireland
National Centre for Sensor Research



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