

ATWARM



PORTABLE LAB-ON-A-DISC SYSTEM FOR IN-SITU AQUATIC ENVIRONMENTAL MONITORING

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- **Introduction**
- **Water quality analysis techniques**
- **Our challenge**

- **Centrifugal Microfluidic Analysis System (CMAS)**
- **System design and performance**

- **Water quality analysis**
- **pH and turbidity measurements**
- **Nitrite detection**

- **Conclusions**



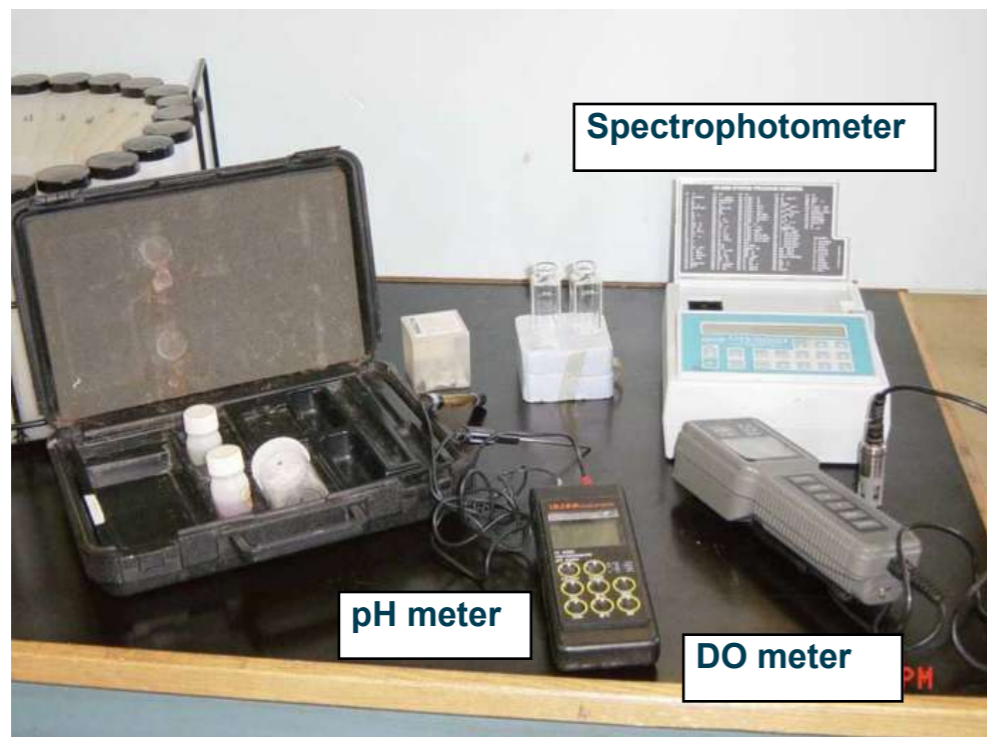
Water quality analysis techniques

Traditionally

- Current norm: manual grab samples 3 or 4 times a year.
- **Disadvantages:**
 - ✗ Low stability of natural water samples during long-term storage.^[1]
 - ✗ Expensive, time consuming and requires highly trained staff.

In situ measurements

- Can provide high-frequency data from a larger number of locations.



- ✓ portable
- ✗ single probe
- ✓ inexpensive
- ✗ no data saving

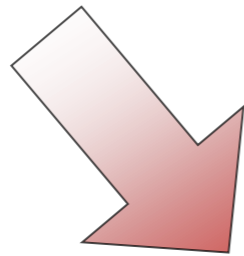


- ✓ multiprobe (temperature, pH, redox, DO, turbidity (TSS), NO₃, Na, F, etc.)
- ✗ €7000
- ✓ hand-held device

[1] G. Hanrahan, J. Environ. Monit. 6, 2004, 657.

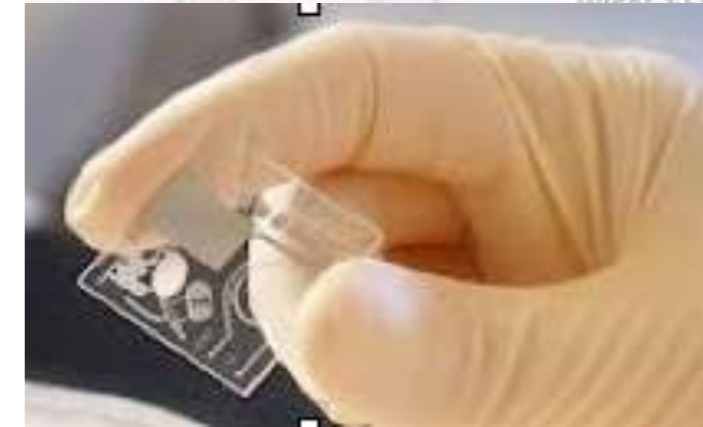
Sensor requirements

- **Reliable and sensitive detection system**
- **Wireless communication**
- **Small volumes of reagents**
- **Rugged and portable design**
- **Low cost, Low maintenance**
- **Low power consumption**
- **Simplicity**



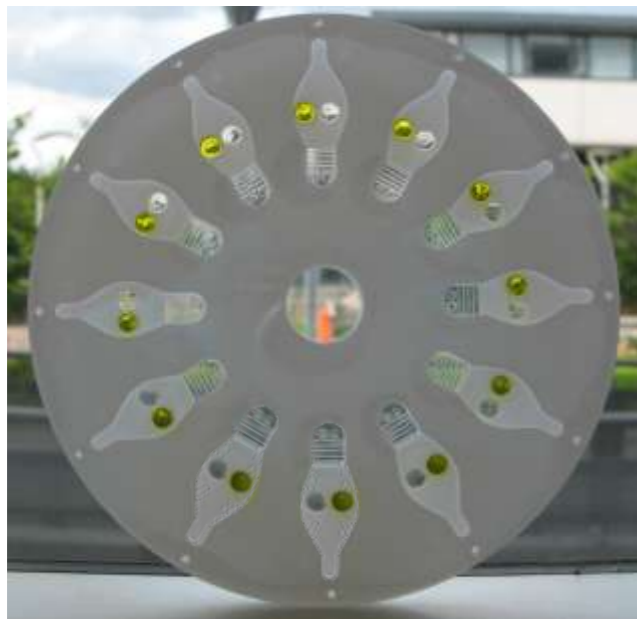
Solution:

- **Microfluidic technology**
- **Colorimetric reagent chemistry**
- **LED-based detection system**
- **Communication by Bluetooth**

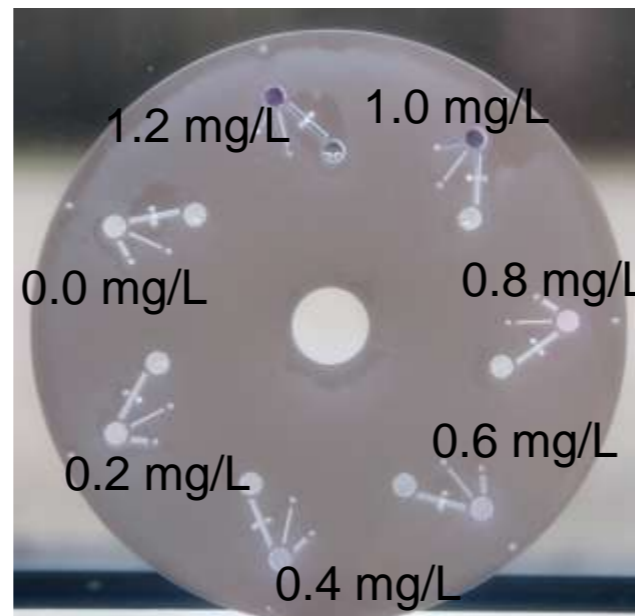


Why centrifugal microfluidic platform?

- Elimination of large power supplies and external pump. [2]
- Provides forces across the entire length of a fluid element.
- Multiple individual micro-fluidic systems can be placed on a single CD.
- Potential to include multi-parameter assays and/or multiple replicate assays with calibration.
- Potential for multi-stage assays involving several fluidic sub-compartments.



pH and turbidity^[2]



Nitrites



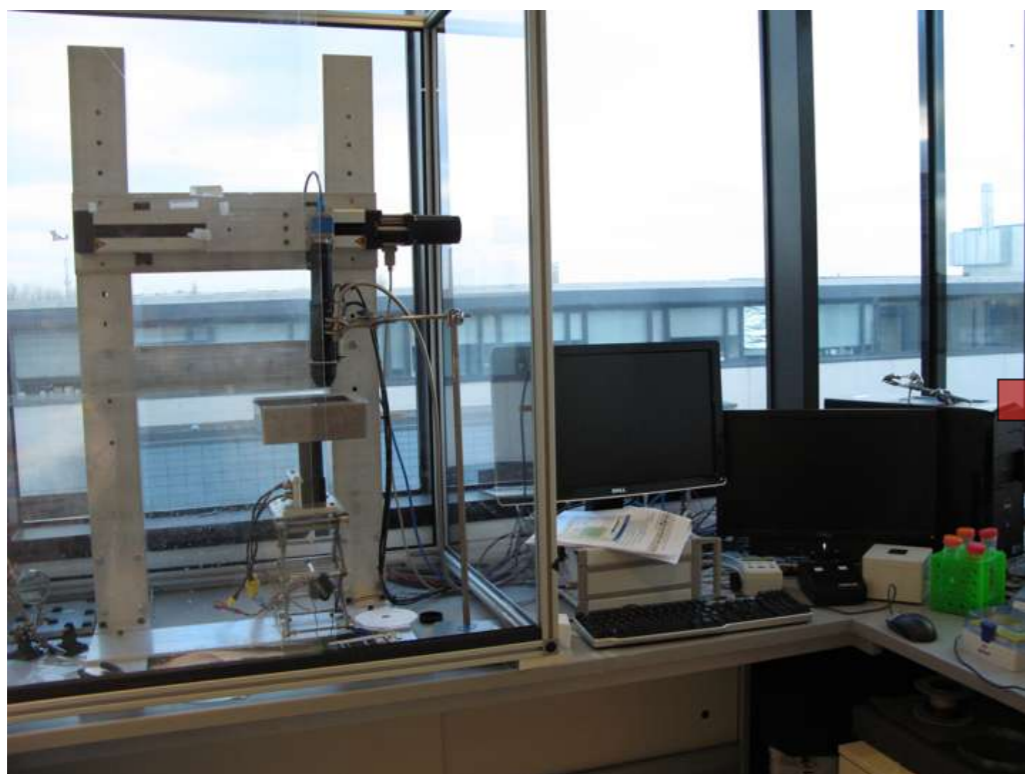
Multiparameter^[3]

[2] J. Siegrist et. al., *Lab Chip* 10, 2010, 363.

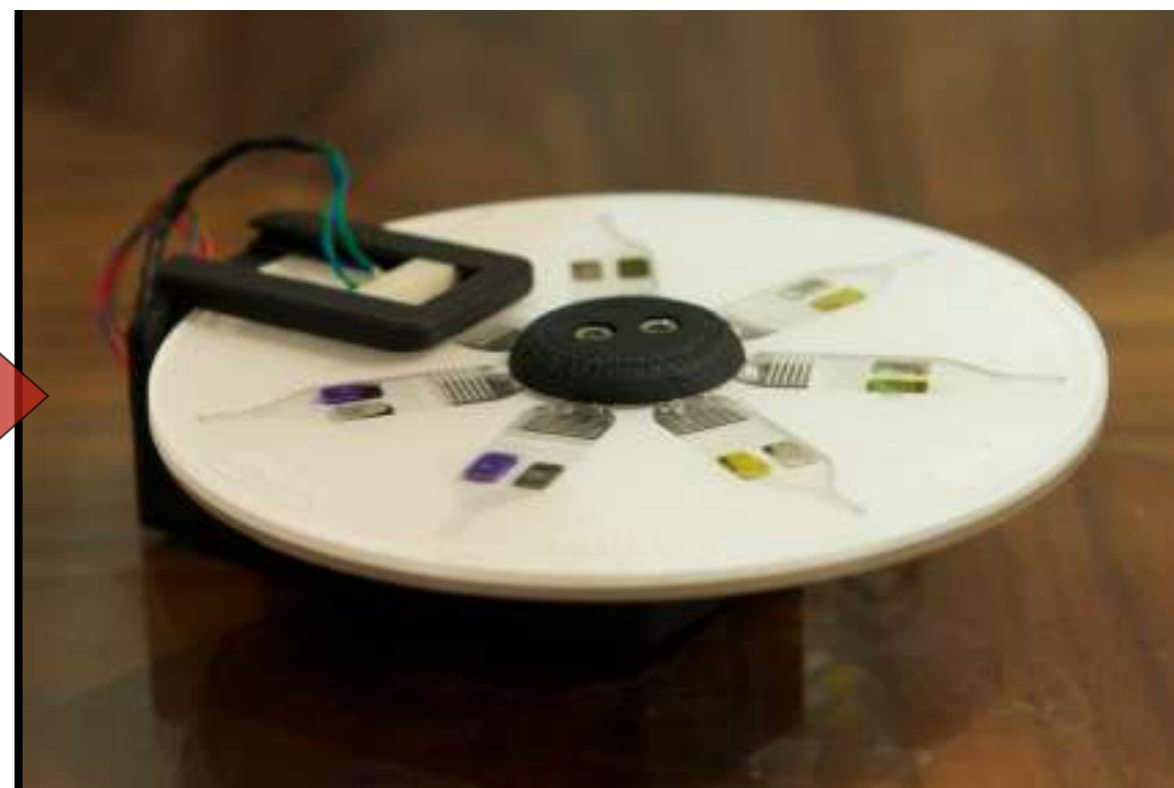
[3] M. Czugala et. al., *Lab Chip*, 12, 2012.

[4] H. Hwang et al., *Anal. Chem.*, 85, 2013.

First generation system



Fluid Manipulation



Colorimetric Analysis^[2]

[2] M. Czugała et al., *Lab Chip*, **12**, 2012.

Centrifugal Microfluidic Analysis System (CMAS)



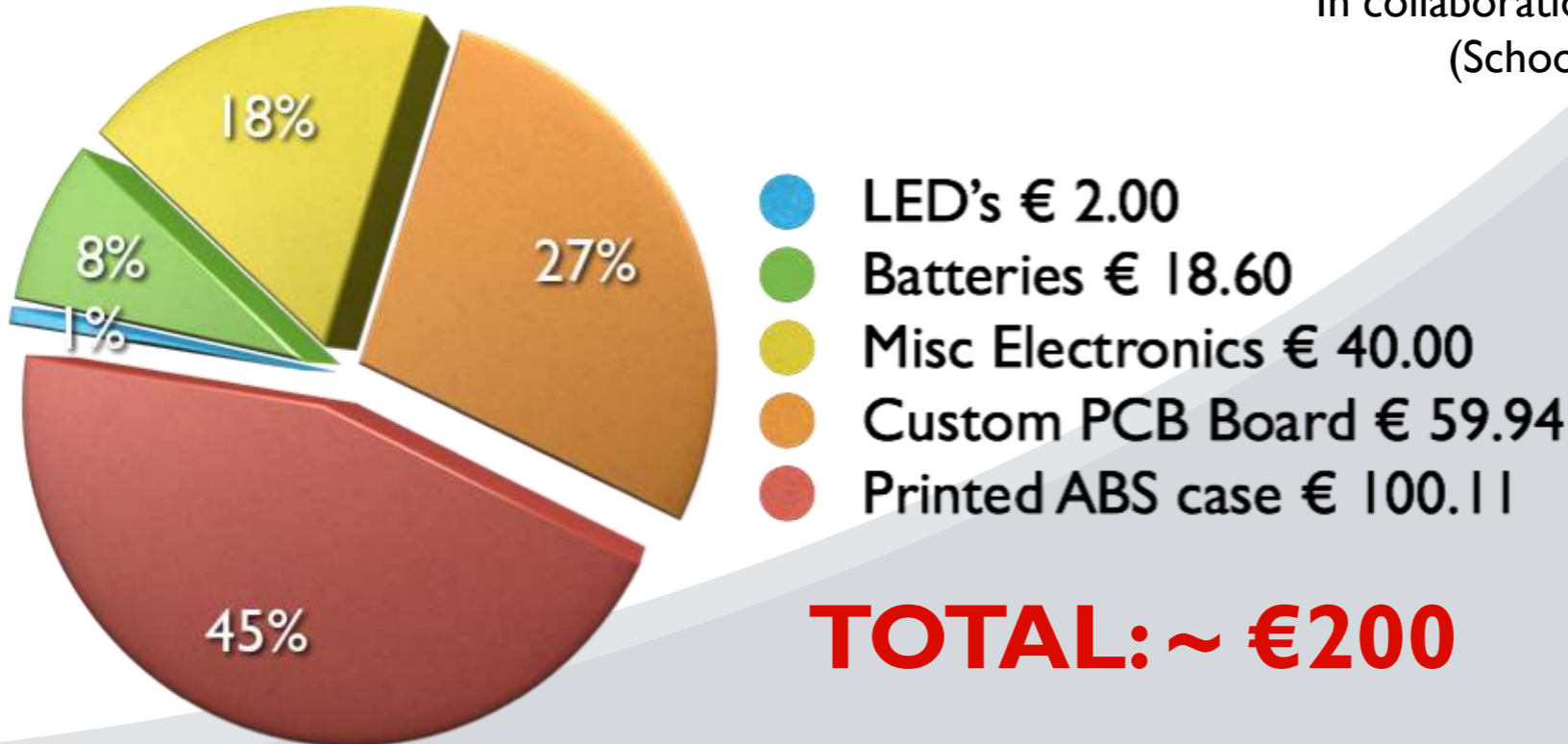
- ...the samples analysis in a single micro-fluidic device
...multiplexing capabilities (pH, turbidity, nitrite...)
- Portable system: sample analysis at the point-of-need
 - Wireless communication system - including cloud integration!

Patent Pending: Centrifugal Microfluidic Analysis System, K. J. Fraser, M. Czugala, D. Maher, F. Benito-Lopez, D. Diamond, 25 April, 2012, (GB)

Centrifugal Microfluidic Analysis System (CMAS)



In collaboration with Prof. Smeaton's group (School of Computing, DCU)



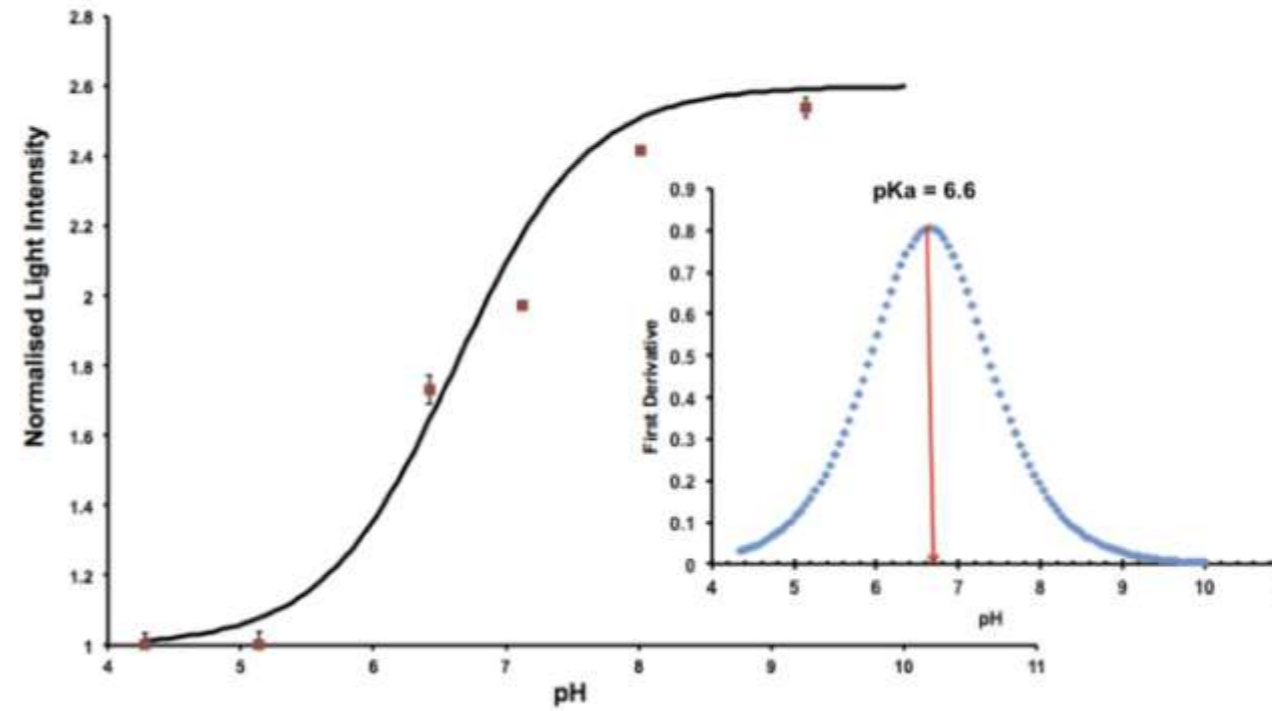
Patent Pending: Centrifugal Microfluidic Analysis System, K. J. Fraser, M. Czugala, D. Maher, F. Benito-Lopez, D. Diamond, 25 April, 2012, (GB)

CD for pH and turbidity analysis

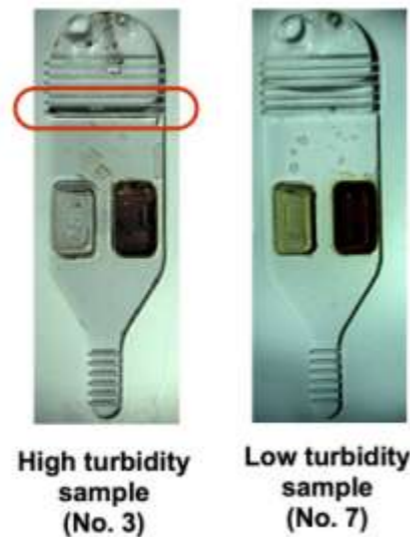
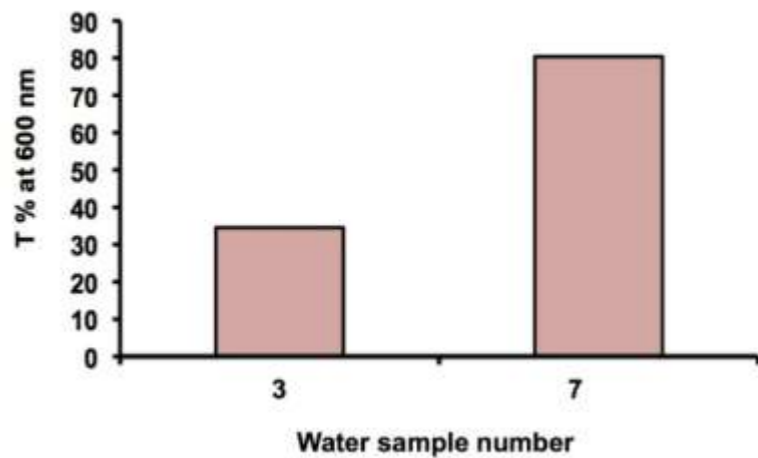
CD for pH and turbidity analysis



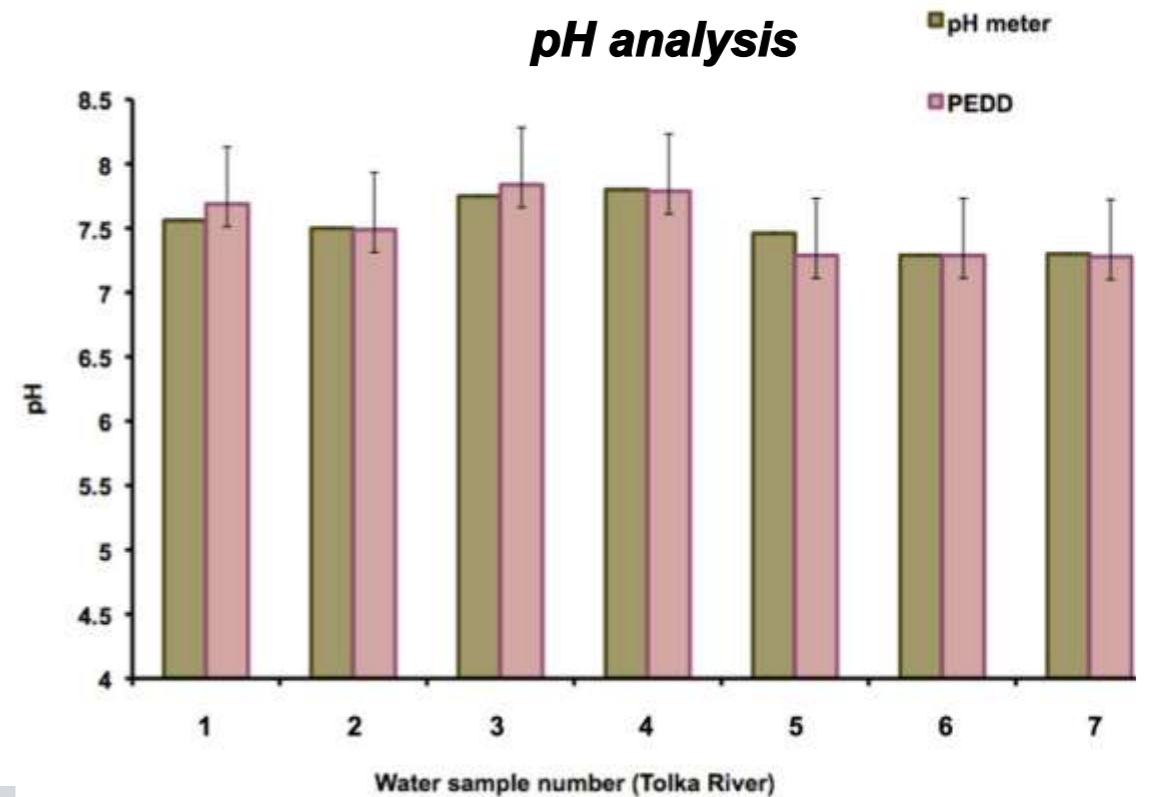
Calibration curve



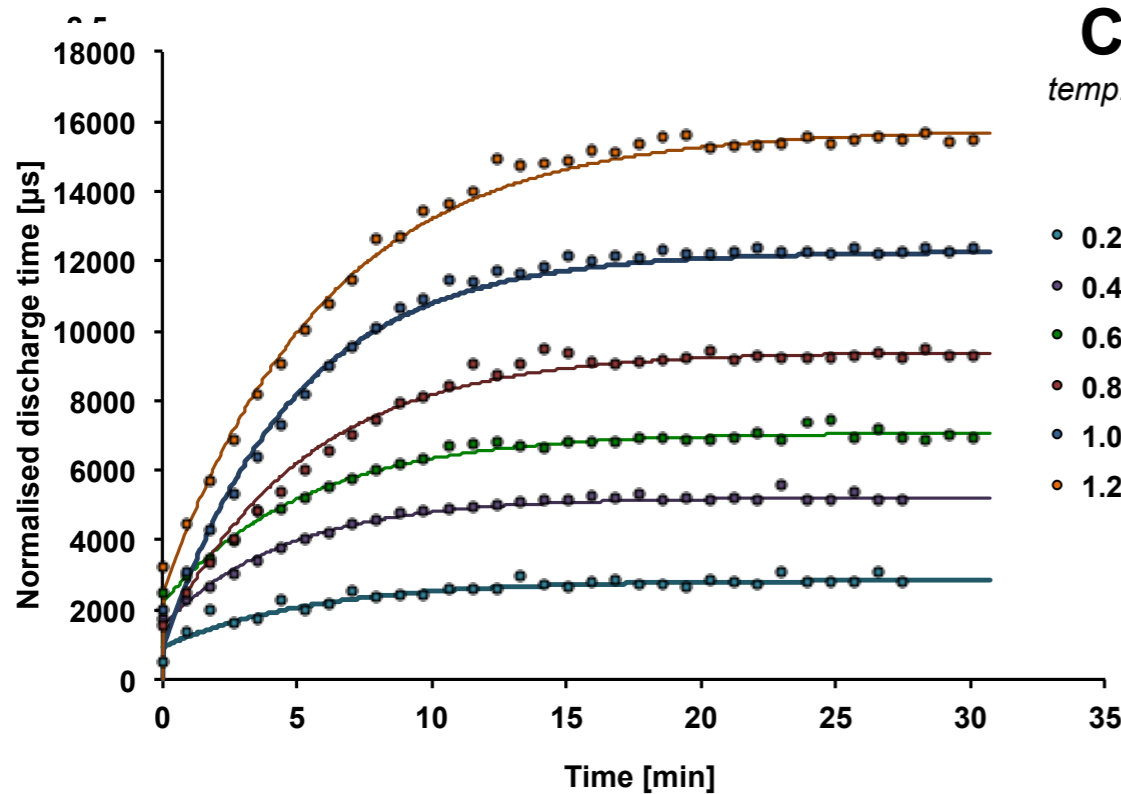
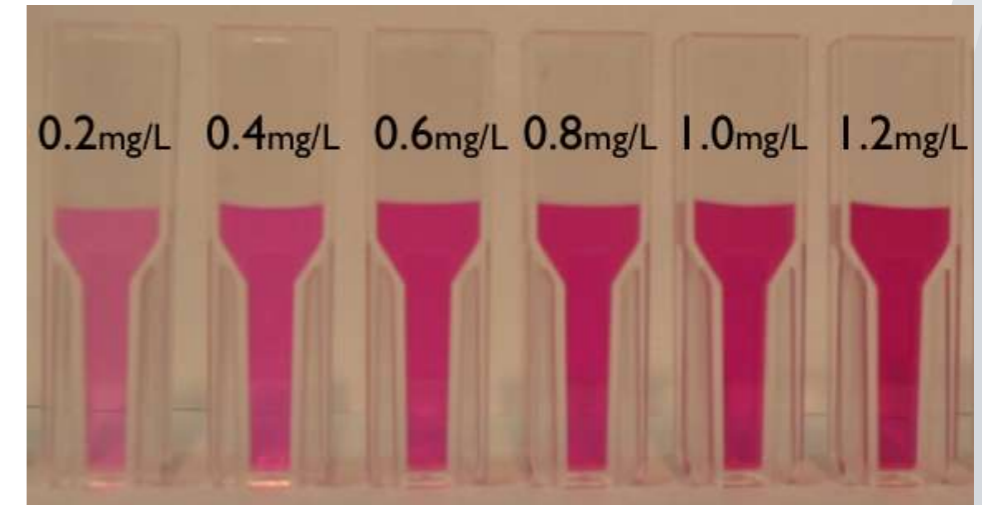
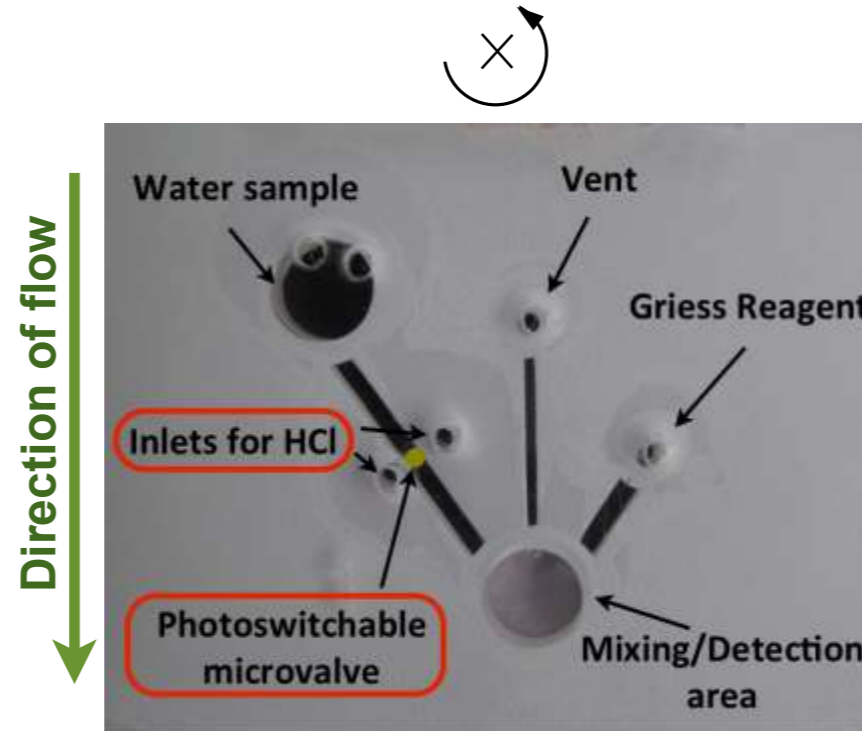
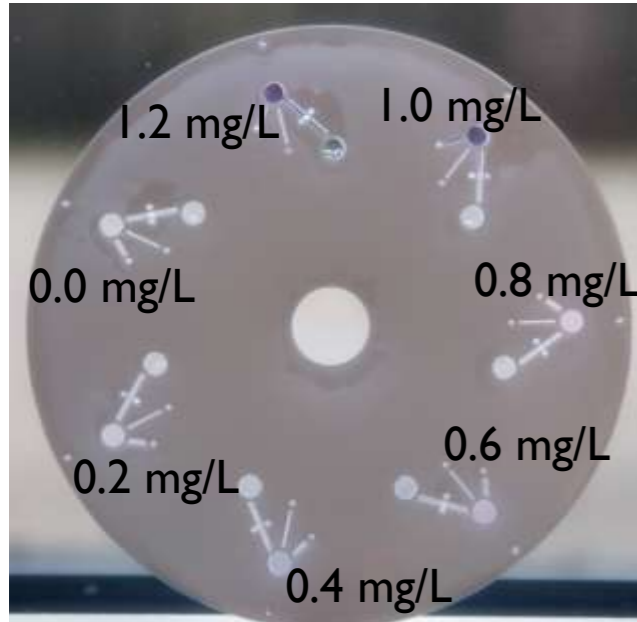
Turbidity analysis



pH analysis

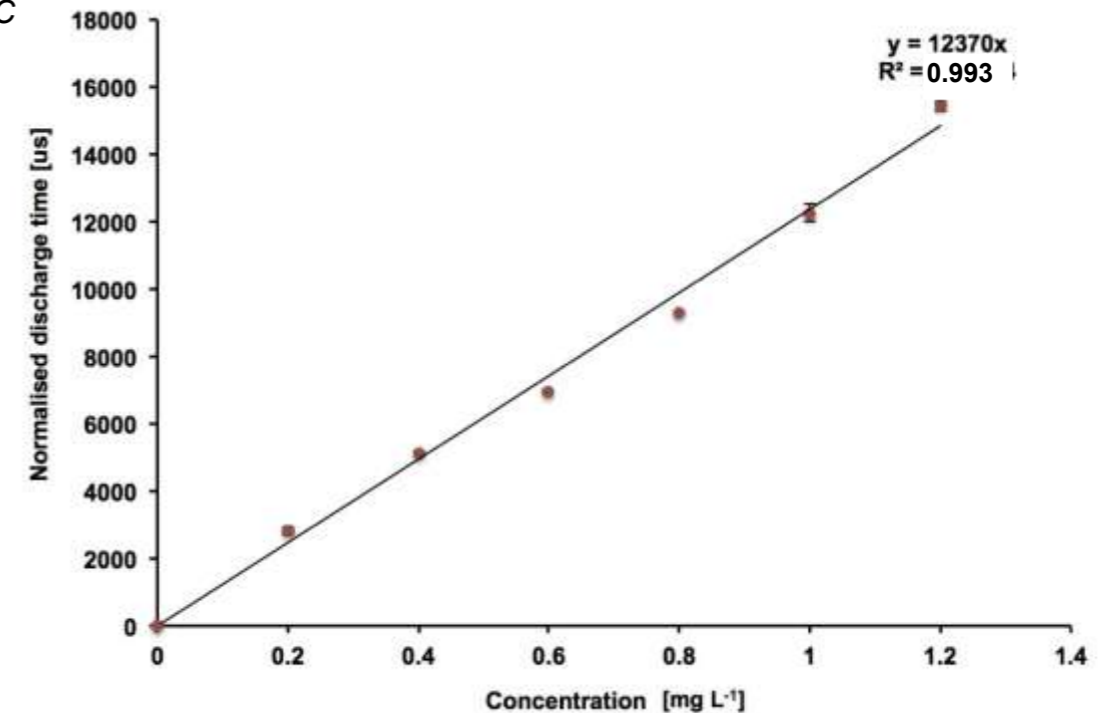


CD for Nitrite detection



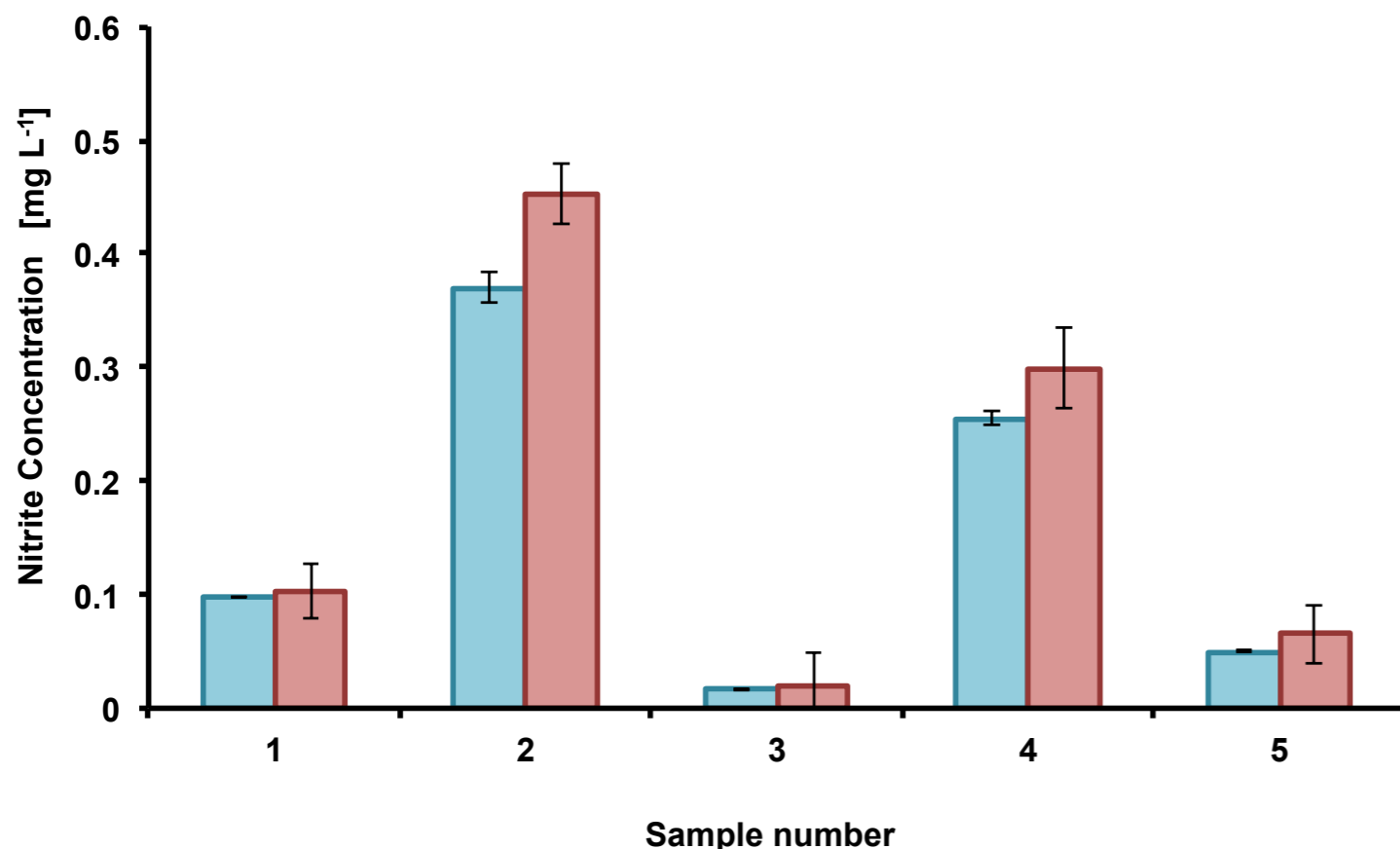
CMAS

temp. 20 +/- 0.5°C



Study of the colour formation between NO₂⁻ and Griess reagent (left side) and absorbance *versus* nitrite Griess reagent complex concentration (right side) using a UV-Vis spectrometer.

Nitrate detection in water samples



■ UV-VIS
■ CMAS

Water nitrite analysis using a bench-top UV-VIS spectrometer and the CMAS (n = 3)

LOD = 9 ppb



● Design



- A fully integrated, portable system for *in-situ* colorimetric water quality analysis has been developed.
- Easily interchangeable PEDD boards allowing a wide range of centrifugal microfluidic layouts to be implemented.
- Integration of a wireless communication device allows data acquisition according to individual needs.
- Cloud Integration / data management via Android tablet.
- CDs for pH, turbidity and nitrites analysis have been designed and successfully field tested using fresh water samples.

● Functionality



- We present the huge potential for the CMAS to be a cheap and versatile alternative as point-of-need optical detector for environmental applications.
- Great correlation between results obtained with bench top instruments and CDs



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Adaptive Sensors Group



Thank you for your attention!



- **Centrifugal platform design**
- **Photoswitchable valves**
- **Paired emitter detector diode (PEDD)**
- **Alignment of CD**
- **CMAS performance**
- **Reproducibility**
- **Validation of technique**
- **Water samples testing**