Development of a Sensitive, Low-Cost and User-Friendly Centrifugal Microfluidic Cartridge for Multi-Analyte Environmental Monitoring

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Outline

- *Introduction – Problem Statement*
- *Current Aims*
- *System Development*
- *Instrumentation Overview*
- *Conclusion*

Water Issues

Donegal Council to appear in court over local water quality

Examination of Letterkenny Regional Public Water supply showed treatment concerns

http://www.irishtimes.com/news/environment/donegal-council-to-appear-in-court-over-local-water-quality-1.1949881 **Accessed 10 Oct 2014**

Water in Ireland to cost more than in most EU states

Annual cost for unmetered household of two adults, two children will be €278

People with water meters installed will be charged €4.88 for every 1,000 litres of water used, but will have their bills capped for six months.

http://www.irishtimes.com/news/consumer/water-in-ireland-to-cost-more-than-in-most-eu-states-1.1884342 **Accessed 10 Oct 2014**

By Jimmy Woulfe Mid-West Correspondent

Irish Water yesterday was accused of failing to deal with the issue of water contamination from lead pipes throughout the country, as a second housing estate in Limerick had its supply blacklisted on health grounds.

http://www.irishexaminer.com/ireland/firm-failing-to-deal-with-lead-pipes-problem-282802.html **Accessed 10 Oct 2014**

Current Practice

1. Complex Sampling Technologies

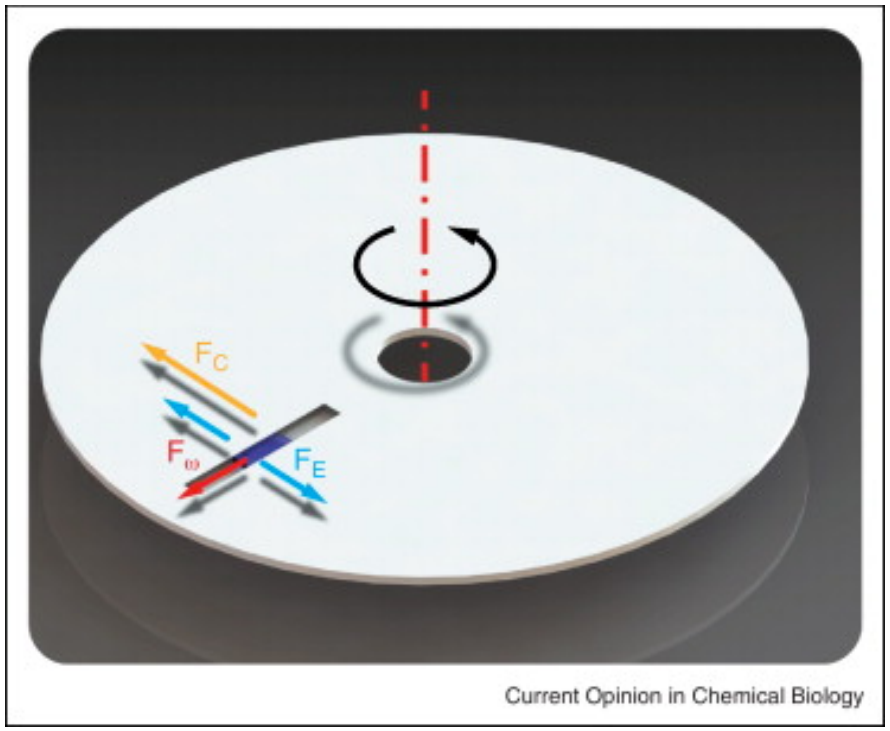
2. Requires Skilled Personnel

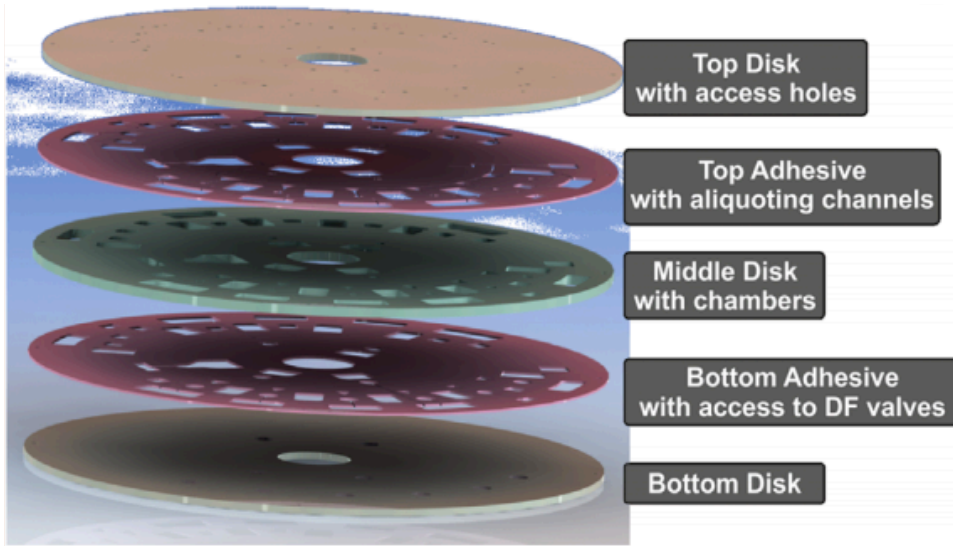
3. Large Amount of Laboratory Based Testing

Current Project

- Multi-Analyte Platform for Environmental Monitoring
  - ❖ Nitrite
  - ❖ Orthophosphate
  - ❖ Ammonia
  - ❖ pH

Centrifugal Microfluidics





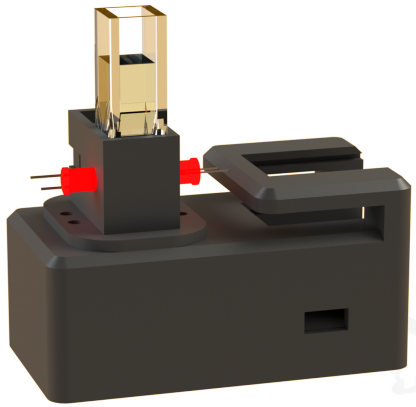
Burger, Robert, et al. "Centrifugal microfluidics for cell analysis." Current opinion in chemical biology 16.3 (2012): 409-414.

Nwankire, Charles E., et al. "A portable centrifugal analyser for liver function screening." Biosensors and Bioelectronics 56 (2014): 352-358.

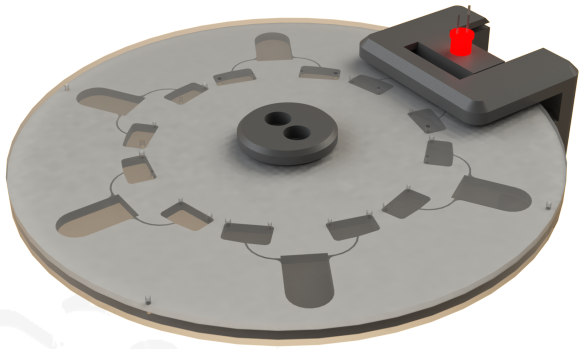
Platform Development

- Single Analyte Disks
- Cuvette and Disk Test Platforms
- LED Emitter and Photodiode Detection

10 mm pathlength



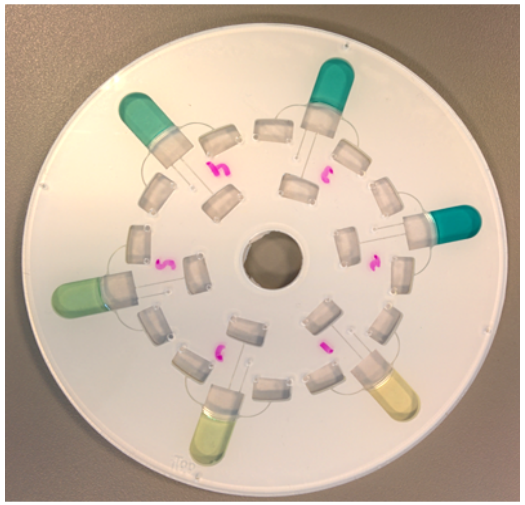
10 mm

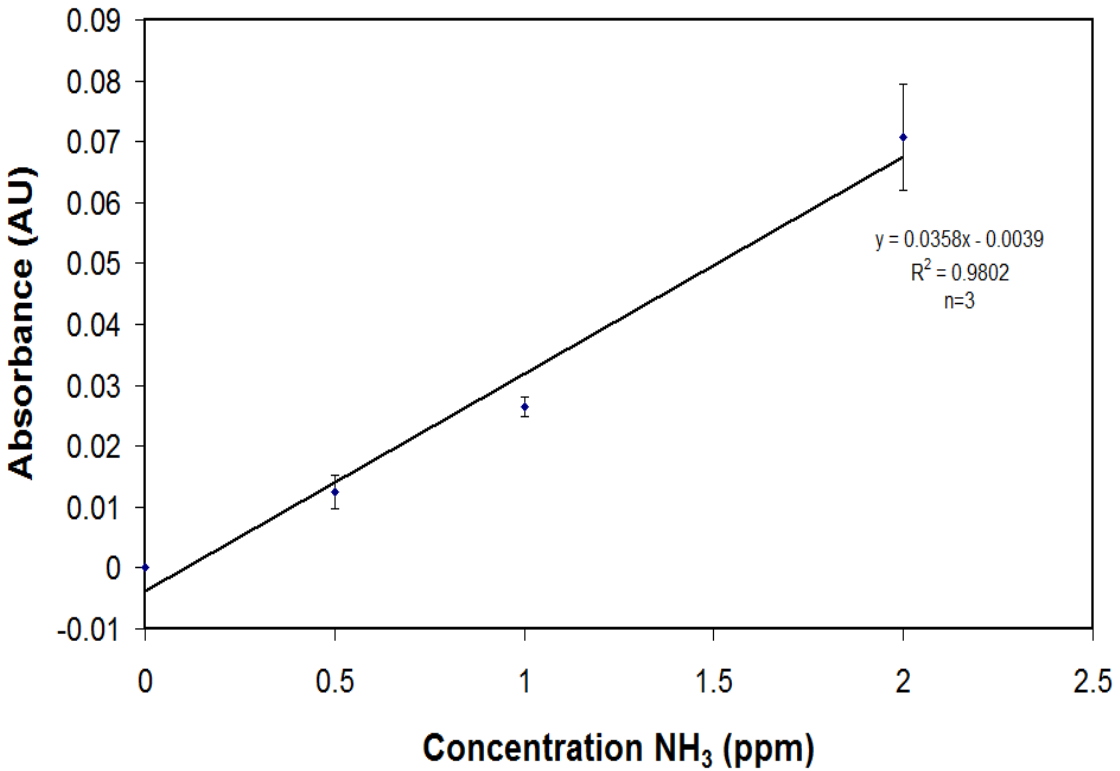


2 mm

Ammonia

- Simplified Berthelot Method
- LOD of 0.2 ppm
- 2 mm Pathlength
- Emitter Wavelength 660 nm



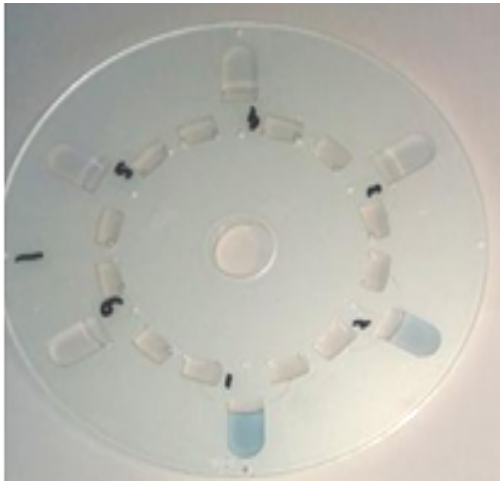


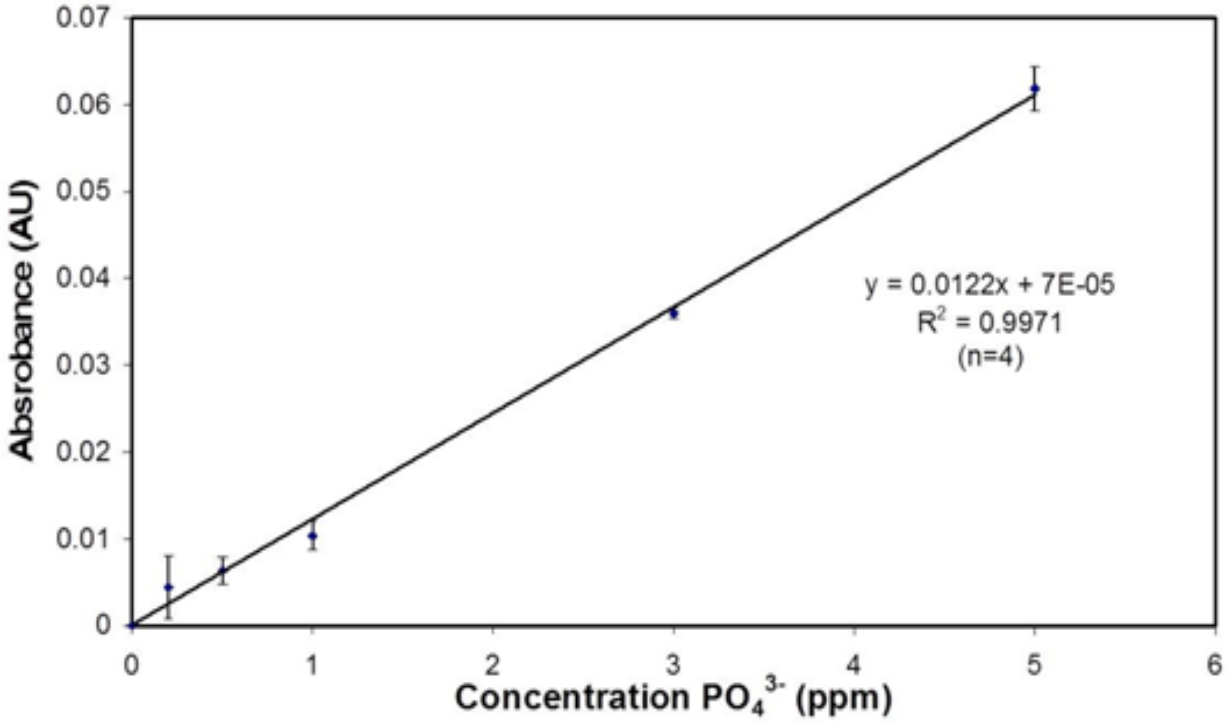
0 ppm 2 ppm 4 ppm 6 ppm 8 ppm 10 ppm

Cogan, Deirdre, et al. "The development of an autonomous sensing platform for the monitoring of ammonia in water using a simplified Berthelot method." Analytical Methods 6.19 (2014): 7606-7614.

Orthophosphate

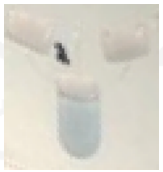
- Stannous Chloride Method
- LOD of 0.2 ppm
- Emitter Wavelength 690 nm









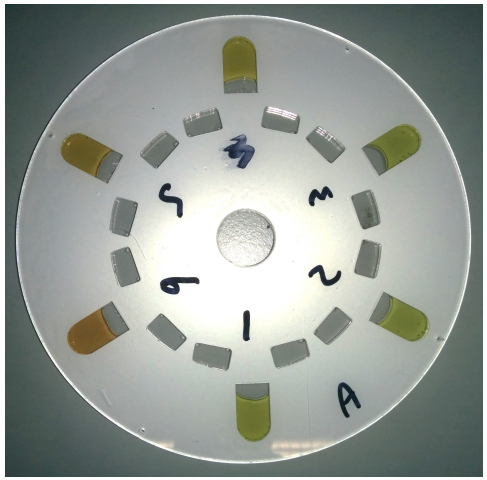


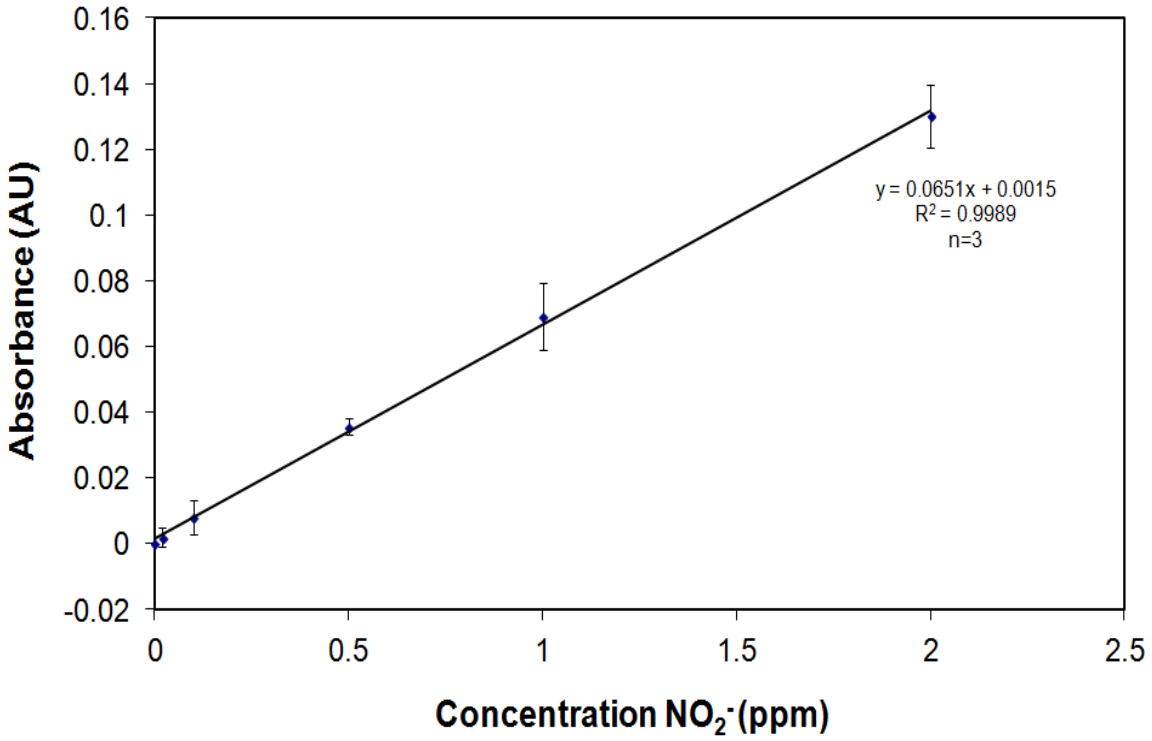

0 ppm **0.2 ppm** **0.5 ppm** **1 ppm** **3 ppm** **5 ppm**

A.E. Greenberg "Standard Method: For the Examination of Water and Wastewater", 18th Ed., 1992

Nitrite

- A Chromotropic Acid Method
- LOD of 0.050 ppm
- Emitter Wavelength 515 nm



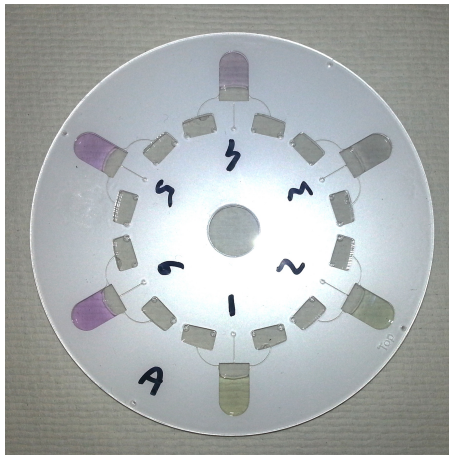


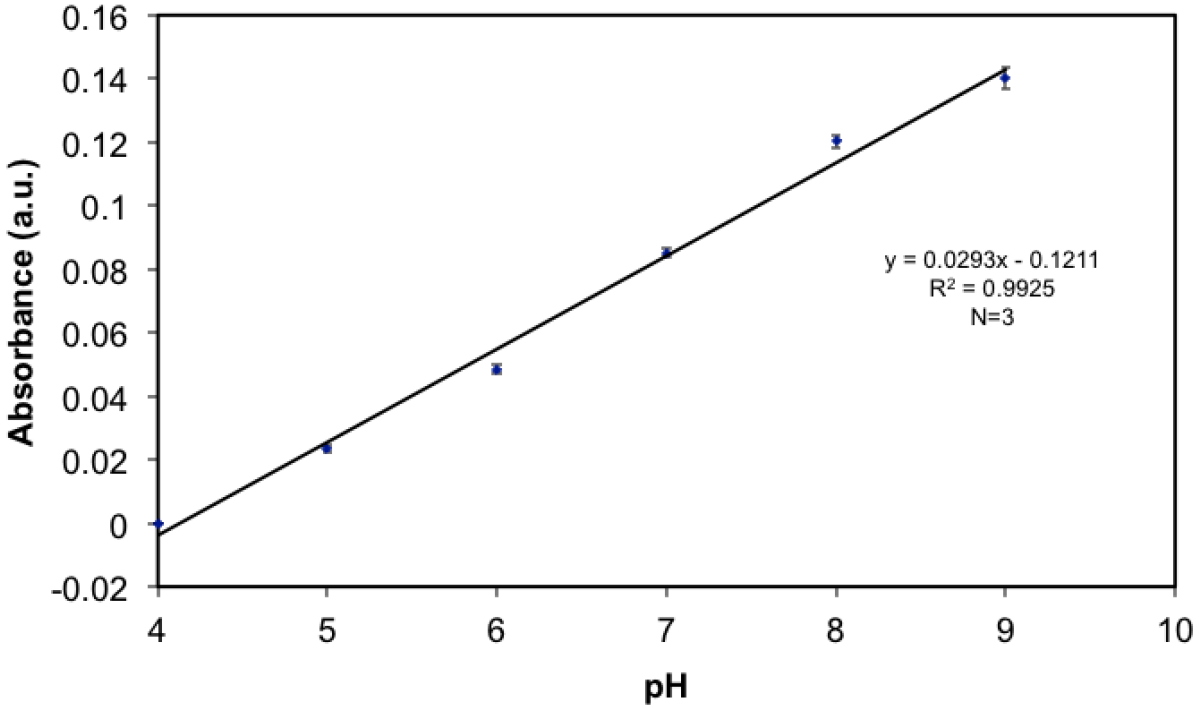
0 ppm 0.02 ppm 0.1 ppm 0.5 ppm 1 ppm 2 ppm

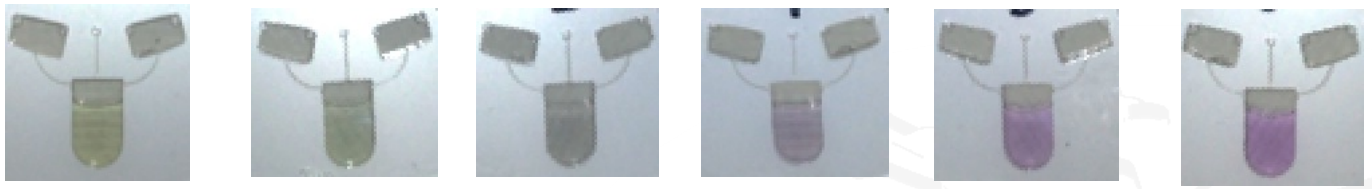
A.E. Greenberg "Standard Method: For the Examination of Water and Wastewater", 18th Ed., 1992

Acidity (pH)

- 3 Dye Mixture
- Range of pH 4-9
- Emitter Wavelength 570 nm







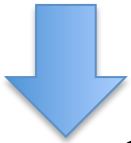
pH 4 pH 5 pH 6 pH 7 pH 8 pH 9

A.E. Greenberg "Standard Method: For the Examination of Water and Wastewater", 18th Ed., 1992

Multiple Analyte Disk

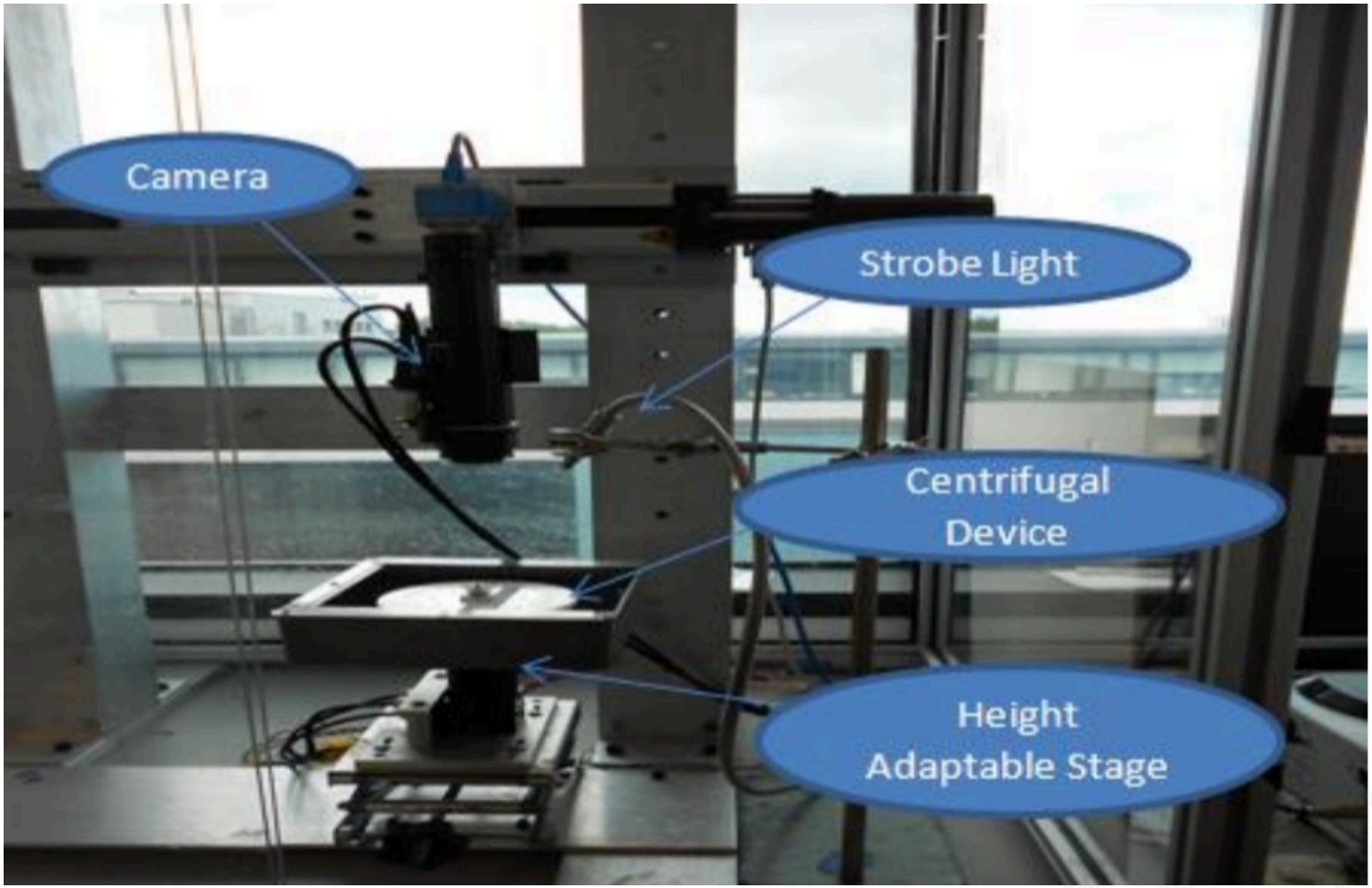
- *Combine 4 Methods*
- *Single Sample Chamber*

- *4 Aliquoting Chambers*

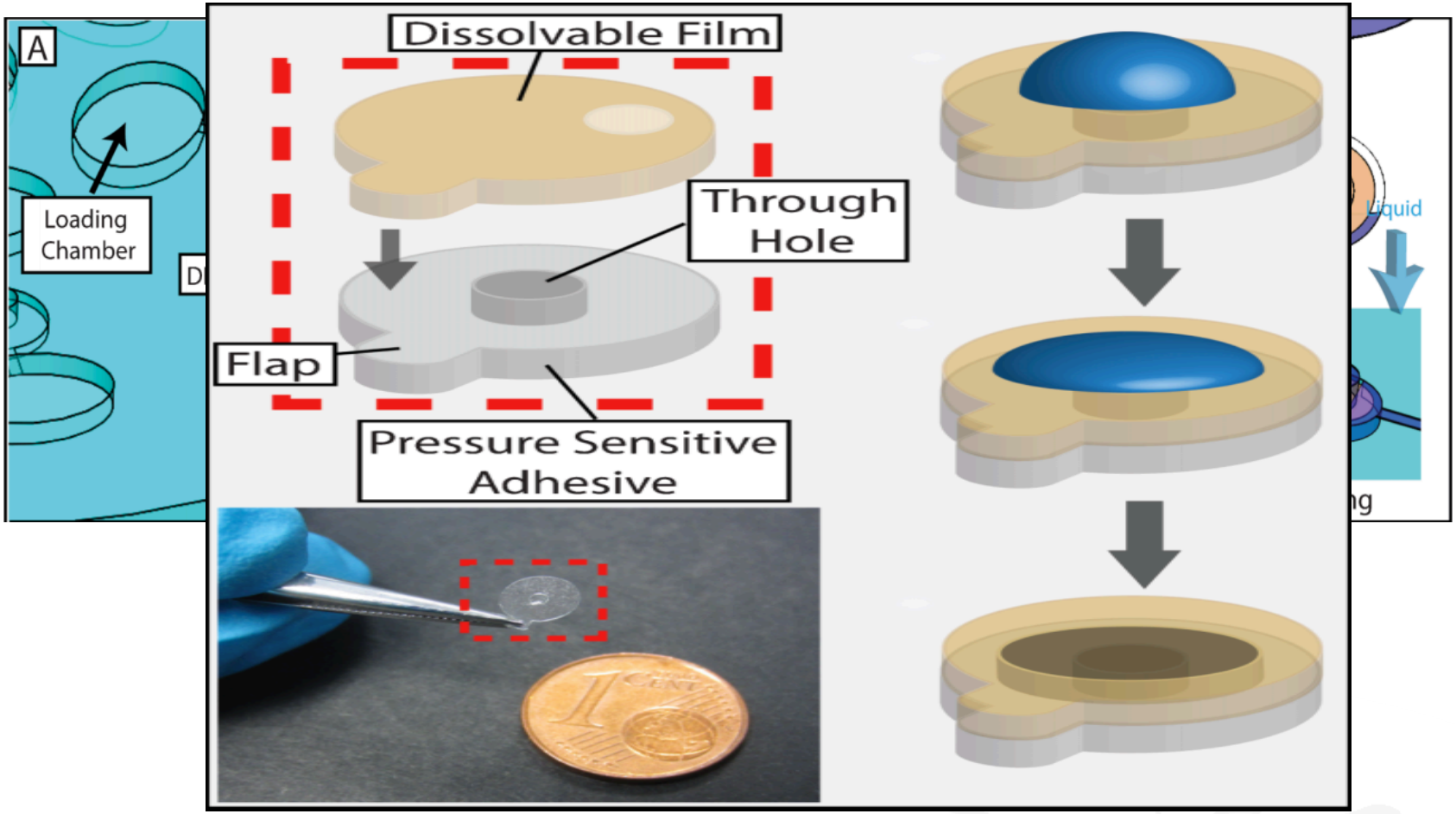


- *4 Detection Chambers*

Testing on Spinstand

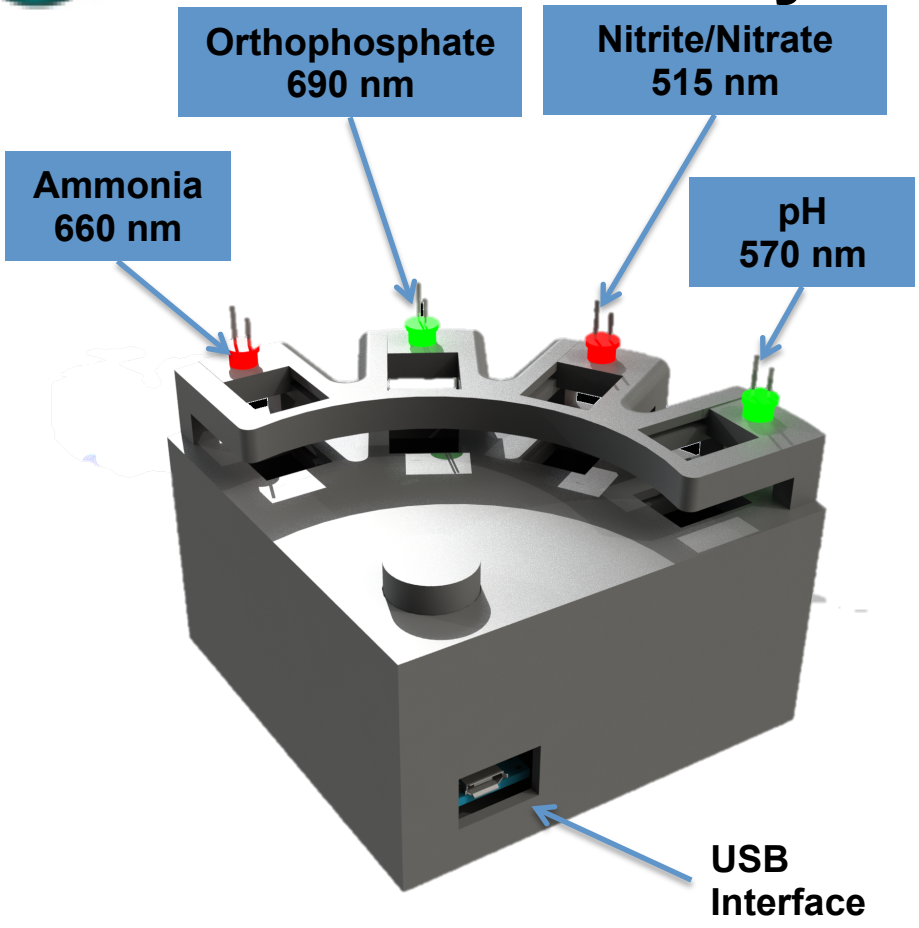


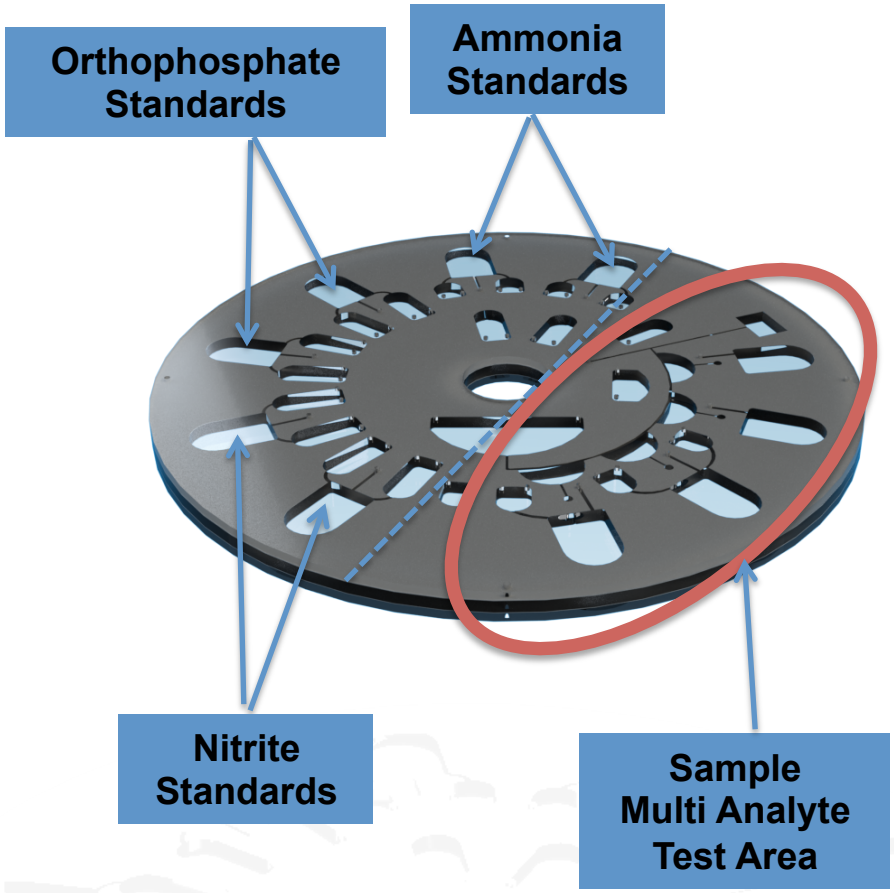
Dissolvable Film Valves



Gorkin III, Robert, et al. "Centrifugo-pneumatic valving utilizing dissolvable films." Lab on a Chip 12.16 (2012): 2894-2902.

Multi Analyte Development





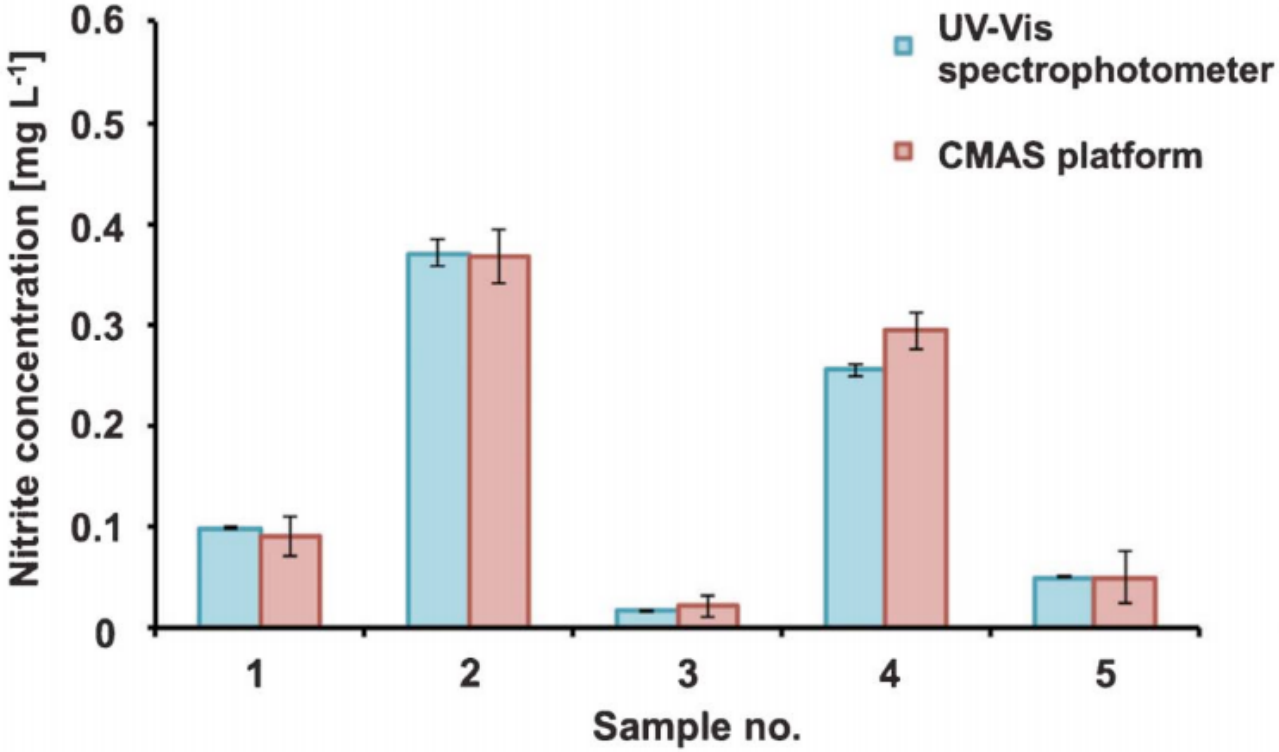
CMAS

- Centrifugal Microfluidic Analysis System (CMAS)
- Low cost/Portable colorimetric detector.
- Multiplexing capabilities
- Bluetooth communication system
- Operation via Android Application

CMAS In Action

Czugala, Monika, et al. "CMAS: fully integrated portable centrifugal microfluidic analysis system for on-site colorimetric analysis." RSC Advances 3.36 (2013): 15928-15938.

Environmental Study

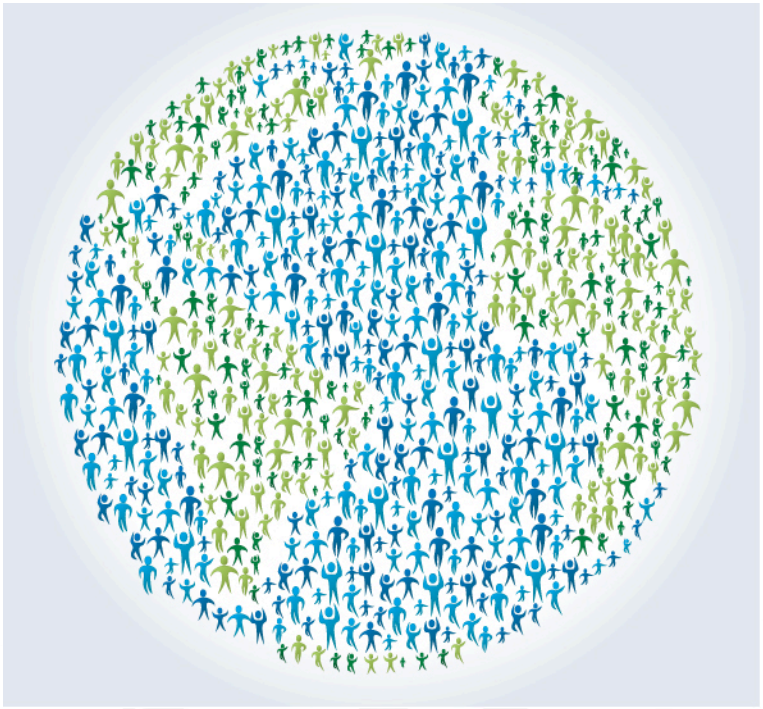


Czugala, Monika, et al. "CMAS: fully integrated portable centrifugal microfluidic analysis system for on-site colorimetric analysis." RSC Advances 3.36 (2013): 15928-15938.

CMAS Solution

Crowdsourcing of water sampling to provide comprehensive Nationwide early warning system.

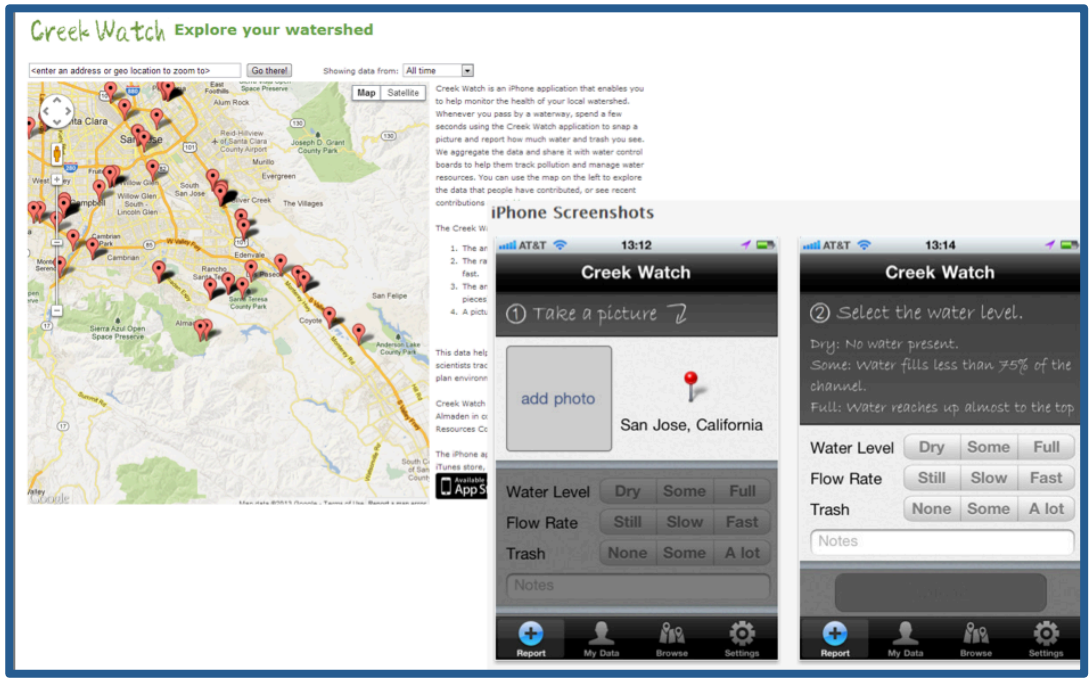
Enable non-scientists to do basic water sampling



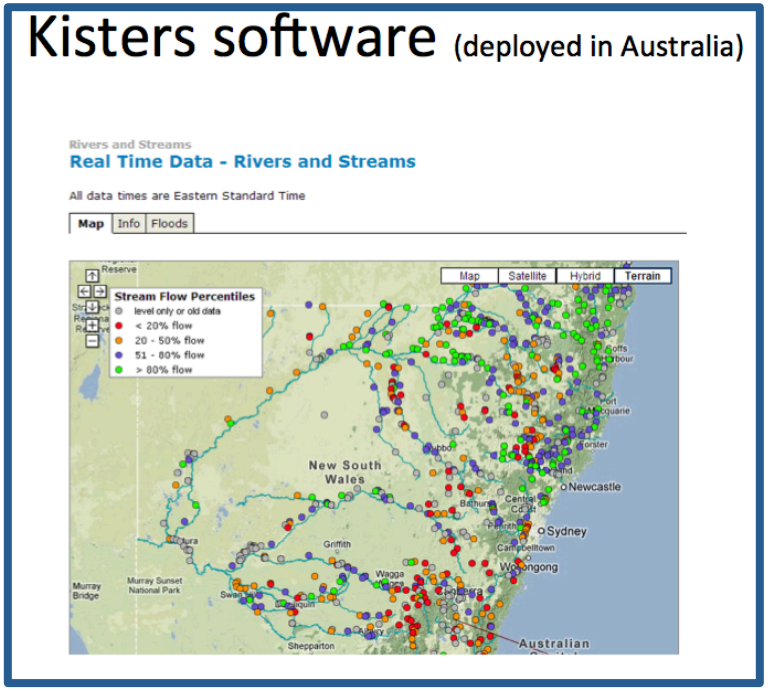
More people = More Data points

Image: Global Interconnectedness, Denis Cristo / Shutterstock.com

Data Mapping

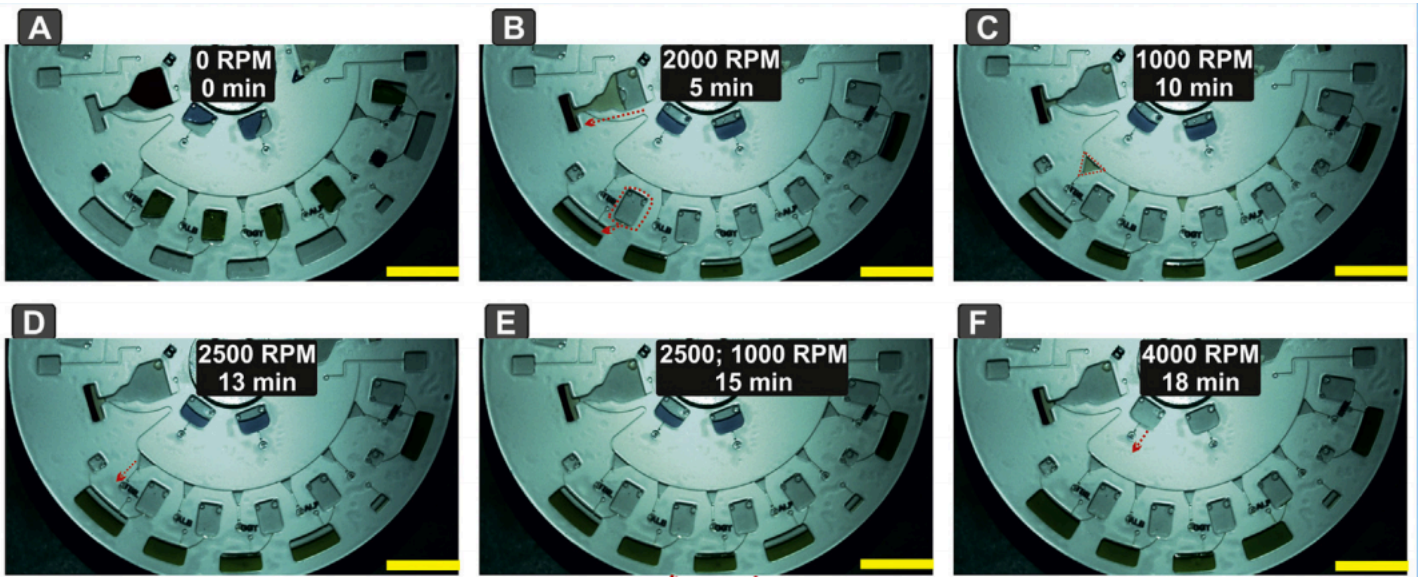


http://creekwatch.researchlabs.ibm.com
Accessed on 13/10/2014



http://www.kisters.net/
Accessed on 13/10/2014

Liver Assay Panel



- *Liver Function Test*
- *Single Blood Sample (150 µl)*
- *6 Analytes*

Nwankire, Charles E., et al. "A portable centrifugal analyser for liver function screening." Biosensors and Bioelectronics 56 (2014): 352-358.

Future Work

- Optimise CMAS in Terms of:
  - ❖ Cost Efficiency
  - ❖ Ease of Use
  - ❖ Data Analysis, Management and Presentation
- Reagent Storage
- Further Environmental and Biomedical Applications

The Team

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Mechanical
Engineering

Jiang Zhou
Software Development

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Thank You All for Your Attention!

Any Questions???