

# Autonomous Nutrient Detection for Water and Wastewater Applications



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### **Overview**



- $\circ$  Research background
- **O** Nutrient monitoring
- $\circ$  Phosphate Sensor
  - System Design & Operation
  - Deployments
- $\,\circ\,$  Nitrite and ammonia detection

## **Research background**



# **O CLARITY Centre for Sensor Web Technologies**

- CLARITY is a Science Foundation Ireland (SFI) Centre for Science, Engineering and technology (CSET).
- Partnership between Dublin City University, University College Dublin, and the Tyndall National Institute, Cork.
- More than 100 full-time researchers in partnership with industry, including major multinationals and emerging Irish companies.
- Harvesting and harnessing of large volumes of sensed information, from both the physical world in which we live, and the digital world of modern communications & computing.
- <u>http://www.clarity-centre.org/</u>



### **CLARITY Vision**



### Sensing Mind, Body & Place



Understanding and leveraging key sensory information channels

### Mind

Sensing people's preferences and intentions

### Body

Sensing physical status and wellness indicators

#### Place

Sensing interaction between people and their environment

### **CLARITY Partners & Collaborators**





# **Adaptive Sensors Group**



 $\,\circ\,$  Chemical sensing element of the CLARITY Centre

- Key research areas
  - Smart/Responsive Materials
  - Conducting Polymers
  - Optical & Electrochemical Sensors
  - Microfluidics / Lab on a chip
  - Autonomous Systems for Environmental Monitoring
  - Wearables
  - http://www.dcu.ie/chemistry/asg/





# **Autonomous nutrient monitoring**



- Targets:
  - Phosphate, Nitrate/nitrite, Ammonia
- **O** Applications: Wastewater, surface waters
- o Requirements:
  - Sensitive, selective and stable detection
  - Wireless communication of data
  - Low power consumption
  - Robust, portable
  - Low cost
  - Low maintenance
  - Deployable lifetime of 3+ months



# Approach

### Reagent based chemical detection

- Established chemistries
- Calibration protocols to ensure reliability
- Microfluidic technology: minimizes...
  - Reagent consumption
  - Storage space
  - Pumping power
- Optical detection
  - UV-LED and photodiode
  - Low powered, inexpensive & sensitive









# Phosphate analyser prototype



- Vanadomolydophosphoric acid method (yellow method)
- Simple, rugged microfluidic
   chip design
- **GSM communication**
- Solenoid pumps
- Robust casing



# Microfluidic chip design



- Fabricated from PMMA layers
- Channels formed using a micromilling machine
- $\,\circ\,$  Mixing channels 200x200  $\mu m$
- Cylindrical optical cuvette (1mm diam. x 5mm length)





### Operation











# Secure location for long-term testing Validation data from online P monitor

### **WWTP trial**





## **Redesigned system**





### $\,\circ\,$ Similar functionality with

- Reduced footprint
  - 2.3 vs. 15 L
  - 1.7 vs. 12 kg

### Extended battery life

- 12 vs. 2 months\*
- 3.6V LiSOCl vs. 12V lead/acid
- Zigbee radio
  - real time reporting
  - remote control
  - "sensor to database"
- Reduced component cost

## **WWTP** trial





- WWTP in Co. Kildare, Ireland
- Sensor installed in effluent discharge tank
- 45 min sample interval
- Autosampler collecting 24 samples/week for validation

# **Trial data**





## **Estuarine deployment**





### Meat processing discharges





# Nitrite system



- Analytical platform
- Colorimetric detection
- Modified Griess reaction

### Demo system



- 1. Reagent storage
- 2. Sample storage
- 3. Micro-pump
- 4. Mixing chip
- 5. Detector
- 6. Control board
- 7. Battery
- 8. Easy-Radio
- 9. Waste storage

**O Deployable unit** 





## **Ammonia detection**





- Ammonia detection using a paired LED detector.
- Log(discharge time) vs.
   concentration for a series
   of ammonia solutions.

### Partners



### • Funding agencies

- Enterprise Ireland
- Science Foundation Ireland
- Marine Institute
- Environmental Protection Agency



### ○ Industry

- Episensor Ltd.
- TE Laboratories Ltd.



