Aquatic Monitoring: Sensors 2011

Monitoring the Aquatic Environment using Sensor Technologies

Conference with Posters and Exhibition

Organised by the Automation and Analytical Management Group
Royal Society of Chemistry

A one day meeting on
Wednesday 19th October 2011

At The Royal Society of Chemistry,
Burlington House,
Piccadilly, London W1J 0BA

Email: conference@aamg-rsc.org
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RSC | Advancing the Chemical Sciences

Monitoring the Aquatic Environment
Using Sensor Technologies

Wednesday 19th October 2011
The Royal Society of Chemistry, Burlington House
Piccadilly London W1J 0BQ

PROGRAMME

09.00 – 09.30 Registration and coffee

Session 1 Sampling, Calibration & Data Validation

Chairman: **R.Narayanaswamy**

09.30 Advances in on-line water quality monitoring and early warning systems
Bram van der Gaag, *KWR Watercycle Research Institute, Netherlands*

09.55 Sensors - Challenges associated with sampling and calibration
Richard Greenwood, *University of Portsmouth, UK*

10.20 The monitoring of metals, nutrients and actinides in the aquatic environment using sensors and passive sampler technologies
Gary Fones*, University of Portsmouth, UK*

10.55 Does continuous water monitoring have a place in Port Management?
Ciprian Briciu-Burghina*, Dublin City University, Ireland*

11.15 Tea / Coffee

11.40 The collection of continuous water quality monitoring data: experiences with a range of data management systems
Antòin Lawlor, *Dublin City University, Ireland*

12.00 Efficient drinking water monitoring in the distribution network
Jan Mink, *2M Sensors Ltd, Netherlands*

12.20 Biofouling challenges in monitoring the aquatic environment
James Chapman, *Dublin City University, Ireland*

12.40 Continuous aquatic monitoring of Ireland's only marine reserve: current status and future needs
Timothy Sullivan, *Dublin City University, Ireland*

13.00 Lunch & Poster Session

Session 2 Monitoring Applications

Chairman: **Craig Roxburgh**

14.15 Monitoring of metals in seawater using voltammetric techniques and microelectrodes
Stan van den Berg, *University of Liverpool, UK*

14.40 Sensing systems for rapid characterization of water contamination
Varvara Kokkali*, Cranfield University, UK*

15.05 Polymer membrane-based potentiometric sensors in monitoring aquatic environment
Aleksandar Radu *University of Portsmouth, UK*

15.30 Sensor-Supported Understanding of the Aquatic Carbon Cycle
Susan Waldron*, University of Glasgow, UK*

15.50 Tea / Coffee

16.10 Combined ship-based and Stationary Monitoring of the Amsterdam Canals
Hans Korving, *Delft University of Technology, Netherlands*

16.30 Estimating sub-surface dispersed oil concentration using acoustic backscatter response
Chris Fuller*, Clarkson University, USA*

16.50 Optical trapping with a photonic crystal cavity: a new manipulation technique for microorganisms in water
Thijs van Leest*, Delft University of Technology, Netherlands*

17.10 Electrochemical sensors for defence and security
Mark Baron, *University of Lincoln, UK*

17.30 **Concluding Remarks and End of Conference**

ABSTRACTS

ADVANCES IN ON-LINE WATER QUALITY MONITORING AND EARLY WARNING SYSTEMS

Bram van der Gaag

KWR Watercycle Research Institute
The Netherlands

ABSTRACT

Over the last decades an increment of interest for on line or on side monitoring of water quality is noticed. Effort has been put into the research and development of new and improved sensor systems. A short overview of recent R&D will be presented. Both operational and early warning water quality monitoring will be included.

Nevertheless, hardware development is only one issue in water quality monitoring. Maintenance, operational performance, collection of data, dependability of data, processing data into information, dealing with provided information are also issues to be addressed when thinking of water quality monitoring. In recent years increased research has been initiated on these topics. Some highlights will pass in review.

In the past, sensors have been seen as THE solution for water quality monitoring. Nowadays, expectations have been adjusted. A picture will be drawn on future value of sensors in water quality monitoring and organizational adaptation to be undertaken to increase the value of use of sensors.

Finally, education on sensors will be addressed. Two aspects will be highlighted. Which influence has sensor education on the performance of high school students and in which way can education help future developments and implementation of sensors?

SENSORS - CHALLENGES ASSOCIATED WITH SAMPLING AND CALIBRATION

Richard Greenwood
University of Portsmouth

ABSTRACT

The driving force for routine monitoring of the quality of environmental water (surface waters, and ground water) is legislation. Regulatory monitoring is based on relatively infrequent (once per month) spot (bottle) sampling, and where there is geographical or temporal variability this may not provide representative information on water quality. Further, the estimates of concentrations of some analytes are operationally defined. The legislation specifies the fractions to be measured in terms of whole water samples or filtered samples to be compared with Environmental Quality Standards (both maximum allowable (EQS MAC) and annual average (EQS AAC) concentrations) for individual pollutants.

There are alternatives that can overcome these weaknesses. Frequent spot sampling, automated sampling, field-based analytical methods, passive sampling, and the use of *in situ* sensors. All of these have associated strengths and weaknesses. Passive samplers can measure average concentrations, but not maximum concentrations. The "Holy Grail" of environmental monitoring is the use of networks of remote field deployed sensors that transmit information on water quality in real time to the manager's desk top computer.

There are currently well-developed, commercially available sensor systems that can achieve this for a limited number of parameters (e.g. pH, pO_2, pCO_2, turbidity, chlorophyll concentration). Robust sondes with long-life power supplies, rapid local data handling, and transmission are used to house sensors with self cleaning and *in situ* calibration capabilities. However, there is a lack of sensors that can be used in this way to measure concentrations of legislatively relevant analytes (e.g., heavy metals, lipid soluble organic industrial chemicals and pesticides, and polar organic compounds of emerging importance (polar pesticides, components of personal and household care products)).

Many sensors are taken as far as the proof of concept stage but are not developed commercially. Major challenges include calibration, and quality control and assurance. There are no suitable reference materials for use with sensors. Potential solutions include the use of reference sites. Under the current legislation where EQS values are defined in terms of total or filtered samples, sensors could not be used, and this needs to be considered by legislators. There is a need for a framework for accreditation of sensor-based methods as for other analytical methods. There is also a need for funding the commercial development and validation phases of sensor research. Although passive samplers and sensors are not currently available to support the enforcement of legislation directly, they could be used in investigative mode to trace sources of pollution, and to increase the effectiveness of expensive spot sampling campaigns by focussing their use where necessary.

THE MONITORING OF METALS, NUTRIENTS AND ACTINIDES IN THE AQUATIC ENVIRONMENT USING SENSORS AND PASSIVE SAMPLER TECHNOLOGIES

Dr Gary Fones

SEES, University of Portsmouth

ABSTRACT

Cadmium (from metallurgic processes, fossil fuels and fertilisers), copper (from mining and antifoulants), lead (from mining and petrol), mercury (from fossil fuels, incineration and metallurgic processes) are the major heavy metal inputs into the aquatic environment. Radionuclides (caesium, uranium and technetium – from reprocessing plants and phosphate production) and nutrients (ammonia, nitrate and phosphate – from agriculture, aquaculture and sewage) are additional anthropogenically derived inputs that need to be monitored. The majority of chemical measurements in the aquatic environment are still based on water samples "spot samples" taken with bottles or pumps that are analysed later in the laboratory. Thus it is possible to miss important episodic events where levels can exceed those specified in the WFD and OSPAR regulations. With this method neither small scale processes nor transient events can be resolved adequately nor can long term datasets of chemical variability be gained from long term stations or moorings. To fill these gaps chemical in situ sensors and passive samplers are needed that exhibit similar spatial and temporal resolution as the physical sensors (e.g. for conductivity and temperature). In the long term these monitoring devices should reach the same accuracy, precision and resolution as the analysis in the lab. However, high resolution in situ measurements with reduced accuracy and precision can also give valuable hints at the involved processes and therefore guide an optimized sampling strategy.

This presentation aims to review the different approaches that have been made to fill this gap. Firstly the use of wet chemical analysers and physical-chemical methods will be reviewed in terms of advances for the measurement of nutrients and metals including flow injection, spectroscopic, electrochemical and biosensor techniques. Secondly the concept of passive samplers will be put forward as a tool for monitoring of metals, nutrients and actinides in the aquatic environment. Passive samplers consist of a receiving phase with a high affinity for the pollutant of interest that is exposed to the aquatic medium for a defined period of time. In some cases the receiving phase is separated from the bulk water phase by a diffusion limiting membrane. This can help decrease the rate of diffusion and in some environments limit the degree of biofouling of the surface of the receiving phase.

The two main passive samplers that have been extensively used over the last 15 years for the measurement of metals, radionuclides and some nutrients in natural waters, are the DGT (Diffusive Gradients in Thin-films) and Chemcatcher devices. The DGT technique is based on a simple device that accumulates solutes on a binding agent (e.g., for trace metals Chelex 100) after passage through a hydrogel that acts as well-defined diffusion layer. The other main passive sampler that has been used for metals is the Chemcatcher. Although this device has been used mainly for non-polar and polar organics, a particular configuration has been developed for measuring time weighted average concentrations of metals. It consists of a Teflon watertight sampler body to hold in position a cellulose acetate diffusion-limiting membrane (0.45 μm pore size and thickness of 0.135 mm) that is placed over a 3M Empore™ chelating disk (47 mm diameter) as the receiving phase. Metal accumulation in the sampler is similar to that of the DGT and is based on the diffusion of metal species across the cellulose acetate membrane. Examples of passive sampler use for measurement of metals (Cu & Ag), actinides (U) and nutrients (P) will be presented.

DOES CONTINUOUS WATER MONITORING HAVE A PLACE IN PORT MANAGEMENT?

Ciprian Briciu-Burghina, Fiona Regan

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National Centre for Sensor Research (NCSR), School of Chemical Sciences,
Dublin City University

ABSTRACT

Improvement in water quality depends on the availability of precise information that is representative of the water body in question. Emerging sensor technologies can provide additional information on temporal and spatial variability of pollutants as well as early detection of special events [1]. Further work is required to demonstrate the utility and reliability of these tools in field trials.

A successful demonstration project in Dublin Port from September 2010 to May 2011 shows how state of the art technology can be implemented for cost effective continuous monitoring. The site is known to be a dynamic, rapidly changing aquatic environment affected by tidal movement, ship traffic and Liffey river inflow. Data was collected every 15 min using two YSI multi-parameter sondes connected to a telemetry system. The measured parameters were: temperature (^{o}C), conductivity ($mScm^{-1}$), turbidity (NTU), optical dissolved oxygen (ODO) (mgL^{-1}) and pH. Data collected is processed and analyzed and the temporal fluctuations in the above mention water quality parameters are discussed. Trends arising from tidal movements, climate conditions, ship traffic and fouling of the sensors are presented, as well as the impact of the intense activity in the port, on the water quality. During this study, wireless sensor technologies have proved to be a reliable and cost effective tool, able to withstand harsh environmental conditions and to give a better understanding of the temporal resolution of the data into a complex and dynamic environment.

References: [1] B O'Flynn, F Regan, A Lawlor et al. (2010) Experiences and recommendations in deploying a real-time, water quality monitoring system, 124004. *Measurement Science and Technology* 21 (12).

THE COLLECTION OF CONTINUOUS WATER QUALITY MONITORING DATA: EXPERIENCES WITH A RANGE OF DATA MANAGEMENT SYSTEMS

Antóin Lawlor* & Fiona Regan.

NCSR, Dublin City University, Ireland

ABSTRACT

In response to the EU Water Framework Directive (WFD) monitoring of waterbodies will increase over the coming years. A large part of the compliance requirement in the WFD is based on chemical monitoring data. This along with the requirement for 'no deterioration' in existing water quality status and the increased understating of the complexity of processes in waterbodies has led to a growing demand for water quality information. Currently, the most commonly used method for measuring levels of chemical pollutants is the physical collection of a spot/grab samples. However, when persistent fluctuations occur, it is likely only to be detected through continuous measurements, which can generate a large quantity of data. This data is often complex, and users can be overwhelmed with information that may not be of use. This is described in the literature as the 'data-rich but information-poor syndrome'. Therefore, there is a requirement for data management systems to assist in managing data generated from continuous monitoring to provide more targeted, tailor-made, usable information.

Based on the project team's experience in sensor monitoring we have tested various commercially available data management systems, which enable efficient data manipulation and analysis, allowing organisations to fully utilise costly collected data. These data management systems can streamline data downloading; enable error checking, error correcting, trend detection, posting of processed data to the internet, standardisation of data flagging, and data interpolation, therefore minimising the time spent on data handling and allowing more time to be spent on spotting trends and identifying issues of concern.

EFFICIENT DRINKING WATER MONITORING IN THE DISTRIBUTION NET

Jan Mink (on behalf of SAWA collaboration)

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ABSTRACT

The Distribution monitoring project applies advanced sensor systems technology to the drinking water distribution systems in the North of The Netherlands. In this project the partners validate their sensors in a specially setup drinking water test lab called SENTEC and use the sensors to monitor the relevant characteristics of the drinking water distribution system.

The sensors that are made available by the partners measure microbiological, chemical and physical parameters. In 3 subsequent trial periods the sensors will be implemented and used in combination with simulation software to understand the behaviour of the drinking water network with respect to the characteristics of the supplied water and the consequences of the daily production activities. The implementation and development of a data acquisition and data analysis system is part of the project.

The umbrella project is called SAWA and constitutes of 3 sub projects:

1 - Monitoring and dynamic modelling drinking water in distribution network

2 - Continuously monitoring the quality of surface water for drinking water preparation

3 - Detection of bacterial regrowth in drinking water

SAWA is initiated by WLN and drinking water companies WMD and WBGR, NOM and Sensor Universe, NOM and Sensor Universe. It is a cooperation of 16 participants , of which there are 8 SME's, 3 knowledge institutes and 2 non SME's.

BIOFOULING CHALLENGES IN MONITORING THE AQUATIC ENVIRONMENT

***James Chapman*[*],** Tim. Sullivan, Ciprian. Briciu, Antoin.Lawlor and Fiona Regan

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ABSTRACT

Biofouling and biofilms exist as the undesirable accumulation of flora and fauna on a given substrate when immersed into an aquatic media. Its presence causes a range of deleterious effects for anyone faced in tackling the problem, which is more than often financially testing. Generally, the initial biofouling stage is stochastic and the attachment of microorganisms held fast in biofilm matrices is irreversible. Permanency occurs once exopolymeric substances (EPS) are produced forming a protective surrounding, ensuring the cohered microorganisms can colonise and thrive upon the surface. Therefore, if this initial stage of biofilm development can be prevented it could then be possible to prevent macro events that follow. Environmental monitoring is one area that faces this challenge and forms the impetus for the work presented herein. In order to improve a monitoring devices time of deployment and or monitoring lifetime, surface coatings with biocidal agents are applied to counteract these steps. This work shows the development of a range of novel materials, which demonstrate the ability to counteract and inhibit the initial stages of biofouling for monitoring devices. Natural bio-inspired surfaces have also been developed using nano-functionalised coatings along with novel polymeric coatings for optically clear-based platforms, all of which show extremely positive results in reducing the biofouling problem. The results from the deployment of antifouling materials, together with real-time, long-term water quality data from the test site are also shown.

CONTINUOUS AQUATIC MONITORING OF IRELAND'S ONLY MARINE RESERVE: CURRENT STATUS AND FUTURE NEEDS.

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ABSTRACT

Monitoring and maintaining the healthy status of protective marine reserves is vital against the backdrop of a general decline in coastal water quality. Lough Hyne Marine Reserve (Est. 1981) was Europe's first marine reserve and is currently still Ireland's only statutory marine reserve. In recent years, a decline in the water quality associated with increased eutrophication may have resulted in the occurrence of algal blooms and changes in the abundance of key species present within the Lough. Continuous monitoring of environmental parameters to discover the consequences and further reasons behind this decline has been highly desirable; however until recently the capacity to do such monitoring at the reserve has been limited to recording of temperature alone.

In this paper we present the results of the first continuous monitoring of a suite of environmental parameters (temperature, dissolved oxygen, turbidity, conductivity salinity, pH and depth) using autonomous sensor technologies at two sites within the reserve over a summer period. The results indicate that the data collected over a 4-month period can contribute to an improved overall scientific understanding of biological and hydrodynamic processes within Lough Hyne. Finally, using the Lough as a model system, we identify the current challenges and future requirements of continuous aquatic monitoring as a key conservation/management tool for remote marine reserves.

MONITORING OF METALS IN SEAWATER USING VOLTAMMETRIC TECHNIQUES USING MICROELECTRODES

Constant M.G. van den Berg, Conrad Chapman, Pascal Salaun,
Kristoff Gibbon-Walsh and Zaoshun Bi.

Earth and Ocean Sciences, Liverpool University

ABSTRACT

Trace metals tend to occur at low concentrations in seawater, typically less than ~10 nM, except Mo and U that occur at 100 and 15 nM respectively. Because of these low concentrations, and because the metals are also complexed with organic matter, it has not been feasible to determine these metals by non-stripping techniques such as by potentiometry or amperometry. The sensitivity is much improved by including a pre-concentration of the metals (by plating or adsorption) on the electrode followed by a stripping scan, which adds only minutes to a measurement. This is the way various metals are measured by anodic or cathodic stripping voltammetry (ASV or CSV), which is sufficiently sensitive to achieve picomolar levels. ASV involves plating at a negative potential, followed by a positive going potential scan, at high speed to eliminate interference by dissolved oxygen: this technique has an advantage in that no reagents are required and the apparatus is simple. CSV on the other hand requires addition of a specific chelating agent that binds the metal aids in its spontaneous adsorption on the surface of the electrode. The adsorption causes the formation of a monomolecular layer which is reduced in the voltammetric scan resulting in great sensitivity.

Mercury drop electrodes are commonly used because their surface is readily renewed. There is a move away from mercury because of its environmental effects and because solid electrodes have advantages with respect to portability. Various solid electrodes exist that have micro-properties which improves the sensitivity because of a thin diffusion layer. One of these is the gold microwire electrode which is easily made and has a surface that is readily activated without the need for polishing. Their combination with a vibrator gives a vibrating electrode with high sensitivity and robustness that makes them suitable for submersion. These electrodes facilitate monitoring in the field.

This talk will give examples of application of the gold microwire electrode to the measurement of copper, arsenic, manganese and zinc, and show a first deployment on a field station in the Irish Sea.

[1] Chapman CS, Van Den Berg CMG. Anodic stripping voltammetry using a vibrating electrode.Electroanalysis. **2007**, 19(13), 1347-55.
[2] Salaun P, Planer-Friedrich B, van den Berg CMG. Inorganic arsenic speciation in water and seawater by anodic stripping voltammetry with a gold microelectrode.Anal ChimActa.**2007**, 585(2), 312-22.
[3] Gibbon-Walsh K, Salaun P, van den Berg CMG. Determination of manganese and zinc in coastal waters by anodic stripping voltammetry using a vibrating gold microwire electrode. Environmental Chemistry. **2011**, in proof.

SENSING SYSTEMS FOR RAPID CHARACTERIZATION OF WATER CONTAMINATION

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ABSTRACT

The continual appearance of new toxic substances including radionuclides and xenobiotics produced through human activity, has led to higher demand for rapid and reliable monitoring methods over the past few years. Environmental monitoring tools, including biomarkers or biochemical responses of living organisms, have been developed for assessing the impact of contaminants and providing early warning signals. By 2005, the US Environmental Protection Agency - Environmental Technology Verification (EPA - ETV) Program has verified the performance of over 340 novel environmental technologies for monitoring pollution (Gray and Manix, 2005). This ongoing interest also led to the implementation of a novel device that accurately quantifies the mobility of invertebrates as indicator of toxicity. This device consists of a camera, a dark chamber with directional light, a novel digital image processing system for motion tracking and small containers with *Artemia salina* nauplii (Portmann *et al.,* 1998, Kokkali *et al*., 2011). This system proved very sensitive to a wide range of contaminants such as pesticides, pharmaceuticals, herbicides, organic and inorganic compounds and metals.

Furthermore, the results to mixtures of compounds for synergistic, additional and antagonistic effects were very promising as well as the results for more complicated samples of wastewater. This device offers a low-cost alternative to toxicity monitoring that could help in earlydetection of potential contaminants, early-intervention and prevention of their spread.

References:

Kokkali, V., Katramados, I. and Newman J.D., 2011. “Monitoring the effect of metal ions on the mobility of *Artemia salina* nauplii”, *Biosensors*, 1, pp. 36-45.

Portmann, R., Leumann, M., Thommen, S., 1998. “Method and Device for Determining Toxicity as Well as the Use Thereof”, WO95/25955. U.S. Patent 5,789,242, 4 August 1998. Gray, G. and Manix, B., 2005. “Protecting the environment”, *Innovation,* Volume 3, Number 6.

POLYMER MEMBRANE-BASED POTENTIOMETRIC SENSORS IN MONITORING AQUATIC ENVIRONMENT

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[§]During execution of this work authors were members of NCSR, DCU, Ireland

ABSTRACT

A recent editorial in *Analytical Chemistry* outlines the need for capabilities to monitor environment much more extensively and frequently then now possible as a grand challenge for analytical chemists [1]. This conjures up the image of large-scale networks of autonomous chemical sensors. While the advance is happening every day, realization of this vision is facing many challenges such as for example, cost of sensors, power, long-term stability, sensitivity etc.

Polymer membrane-based ion selective electrodes (ISEs) underwent a renaissance and are now among the most sensitive chemical sensors with routinely achieved detection limits in order of part-per-billion (ppb) [2]. The sensitivity coupled with their size and simple construction and virtually no power requirement present excellent properties for their integration in wireless sensing networks. Great advance in wireless electronic platforms allowed integration of ISEs with simple platform [3]. Such platform can also bear a degree of intelligence in order to help determination of sensors functionality.

Here we will demonstrate miniature sensor platform for wireless, *in situ* monitoring of water quality based on polymer membrane-based ISEs. This will be demonstrated using example how material science may help in devising new concepts for realization of miniature reference electrode [4] and suggest the use of electrical signal to estimate the functionality of sensor [5], followed by demonstration of this platform in the determination of pH and Pb^{2+} concentration in environmental waters. Moreover a potential for determination of speciation of heavy metals using ISEs will be presented [6].

1. Murray, R; *Analytical Chemistry*, **2010**, 82, 1569
2. *Radu, A;* Peper, S; Bakker, E; Diamond, D: *Electroanalysis*, **2007**, 19 (2-3), 144-154
3. Fay, C; Slater, C; Buda, ST; Cicmil, D; Anastasova, S; *Radu*[*], A; Diamond, D: *IEEE Sensors,* **2011,** 99, 1
4. Cicmil, D; Anastasova, A; Kavanagh, A; Diamond, D; Mattinen, U; Bobacka, J; Lewenstam, A; *Radu*[*], *A: Electroanalysis,* **accepted**
5. *Radu*[*], A; Anastasova, S; Paczosa-Bator, B; Bobacka, J; Lewenstam, A; Diamond, D: *Analytical Methods*, 2, (10), **2010**
6. Anastasova, S; *Radu*[*], *A*; Diamond, D: *Sensors Actuators B.*, **2010,** 146, 1, 199-205

SENSOR-SUPPORTED UNDERSTANDING OF THE AQUATIC CARBON CYCLE

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ABSTRACT

Quantifying C losses from terrestrial landscapes to aquatic systems is necessary to better understand controlling processes and project export response to changing land-use or climate. Detailed understanding can be only be generated by high resolution profiles that incorporate biological and hydrological variability, which are often seasonally-driven and thus extensive time series are needed to accommodate this seasonality. Generating such detail is usually too challenging for manual sampling characterisation, and more so in remote locations where terrestrial C stores may be large and aquatic C export poorly documented e.g. boreal peatland drainage systems. Thus sensor technology is vital to advancing our understanding.

Here we provide a brief overview of the sensors that are needed for the best understanding of the terrestrial-aquatic C cycle. Using the simple in-situ sensors of pH and temperature, we have constructed long-term records of excess partial pressure of CO_2 in a small order UK river system close to the terrestrial-aquatic interface. We will present this five-year profile and use it to i) demonstrate the insight that sensor technology can provide to mechanistic controls and b) discuss the challenges in modelling high-resolution (15 minutes) extensive time series.

COMBINED SHIP-BASED AND STATIONARY MONITORING OF THE AMSTERDAM CANALS

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ABSTRACT

The canal system in Amsterdam is flushed several times a week with water from the IJmeer in order to maintain its oxygen balance. Although this flushing seems inevitable, the quality of inlet water may affect the oxygen content in a negative way. To study the impact of flushing on the ecological condition of the Amsterdam canals and the possibilities of optimising the flushing regime, a monitoring network has been designed.

The project aims at developing an integrated, intelligent wireless sensor network for monitoring water quality of the Amsterdam canals by combining mobile, ship-based monitoring with stationary monitoring at strategic locations. Applications in marine water quality research show that ferry-based monitoring is cost-effective and provides a high yield of reliable high frequency water quality data. High resolution data in space and time provide more insight into transport of water types through the Amsterdam canal network, water quality processes and better understanding of the ecosystem.

Currently, a prototype of the mobile monitoring station is tested in the Amsterdam canals. Finally, the mobile system can be installed on continuously sailing Amsterdam cruise. Next to the ship-based stations, five stationary locations are planned. The monitoring parameters include oxygen, conductivity, temperature, redox potential and turbidity.

The authors present the first results of the sensor network based on ship-based and stationary stations. In addition, the design and construction of the ship-based monitoring station is presented.

ESTIMATING SUB-SURFACE DISPERSED OIL CONCENTRATION USING ACOUSTIC BACKSCATTER RESPONSE

Christopher Fuller, James Bonner, Shahidul Islam,
William Kirkey, Temitope Ojo

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ABSTRACT

The recent *Deepwater Horizon* incident resulted in a dispersed oil plume at an approximate depth of 1000 meters. Several methods were used to characterize this plume with respect to concentration and spatial extent including surface supported sampling, *in-situ* analysis with autonomous underwater vehicle (AUV) mounted instruments, and remote detection with echo sounders. We have shown linear acoustic backscatter (ABS) responses to clay particle volume concentrations with characteristically dynamic size distributions, demonstrating the potential to estimate the volume concentration of oil droplet suspensions using ABS response. This study evaluated use of an Acoustic Doppler Current Profiler (ADCP) to quantify oil droplet volume concentrations in a controlled laboratory study. Results from this study showed log-linear ABS responses to oil-droplet volume concentration measured with a Laser In-Situ Scattering Transmissometer (LISST). The inability to reproduce ABS response factors suggests the difficultly in developing meaningful calibration factors for quantitative field analysis. Evaluation of theoretical Rayleigh scattering intensity derived from the particle size distribution provided insight regarding method sensitivity in the presence of interfering ambient particles.

OPTICAL TRAPPING WITH A PHOTONIC CRYSTAL CAVITY: A NEW MANIPULATION TECHNIQUE FOR MICROORGANISMS IN WATER

M.M. van Leest, J.T. Heldens, J. Caro
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ABSTRACT

In the quality control of drinking water with respect to bacteria, there is a strong need for on-line sensors allowing real-time and quick identification of bacterium species. The combined field of photonics and microfluidics is promising in providing lab-on-a-chip solutions, as both fields rely on well established fabrication techniques. The goal of our research is to develop new trapping and Raman-sensing principles for microorganisms in water, based on photonic crystal cavities.

Photonic crystals are artificial periodic structures of dielectric materials, which allow one to engineer the propagation of light at the scale of its wavelength (1550 nm). By making a defect in the photonic crystal, an optical cavity is formed where light at the resonance frequency accumulates. The strong evanescent field of the resonance enables both optical trapping of single bacteria and enhanced Raman excitation. Integration of the crystal into a microfluidic channel provides a controlled aqueous environment, thus providing a platform for identifying individual bacteria.

The work presented focuses on the optical trapping aspect. Simulations are performed to design the photonic crystal cavity that is finally fabricated at the nanometer scale. A 50 μm wide fluidic channel is created over the crystal, using a photocurable dry-film resist and UV-lithography. Experiments are performed by exciting the cavity at resonance frequency, while 1 μm polystyrene beads in water, acting as force probes, are streaming across the cavity by in the controlled water flow. Optical trapping is observed and recorded with a microscope from top.

ELECTROCHEMICAL SENSORS FOR DEFENCE AND SECURITY

Richard Barrett, Dr. Jose Gonzalez-Rodriguez, ***Dr. Mark Baron***

University of Lincoln, School of Natural and Applied Sciences

ABSTRACT

This project focuses on the electrochemical detection of explosives and related compounds in solution using a homemade electrode array and differential pulse voltammetry. The multiple sets of voltammetric data will be integrated using multivariate analysis and matched with known substances. The homemade electrode consists of multiple pure metal wires set into a plastic rod. The detection of explosives and explosive related compounds is a subject of importance in several areas including environmental health, de-mining efforts (land and sea) and security and defence against terrorist activity. In these areas, a method of analysis that will work effectively “in the field” is sometimes preferable to lab based methods. The use of electrochemical sensors is one of many methods that can be employed in the field to effectively detect explosives and related compounds, such as chemical taggants added to aid detection in some explosive formulations. Many common explosives contain suitable chemical groups to be detected using electrochemical methods. Electrochemical detectors can be miniaturized and made portable, they are capable of fast, sensitive, reliable analysis, and are cheap and simple to use.

POSTER ABSTRACTS

MESTECH: DEVELOPING INNOVATIVE TECHNOLOGY SOLUTIONS FOR THE ENVIRONMENT

Antóin Lawlor* & Fiona Regan.

NCSR, Dublin City University, Ireland

ABSTRACT

The Marine and Environmental Sensing Technology Hub (MESTECH) was established at the National Centre for Sensor Research (NCSR), Dublin City University in 2010. MESTECH brings together a multi-disciplinary team of researchers with expertise in biosensors, sensor development, analytical science, engineering, computing, visual sensing and image processing and focuses their combined expertise on issues of importance concerned with the monitoring of our environment.

The drivers of MESTECH research include current national policy and international objectives such as, Strategy for Science, Technology and Innovation, Sea Change, Ireland's Smart Economy, the Water Framework Directive, the Flood's Directive, Europe 2020, the Quality Status Report 2010 and the World Ocean Review. Current research is supported through Science Foundation Ireland (SFI), QUESTOR, EPA, Marine Institute (MI) and other non-exchequer funded research. In 2010, DCU was awarded funding by the Higher Education Authority (HEA) Programme for Research in Third Level Institutions (PRTLI), for SmartBay, the national test and demonstration site at Galway Bay, in collaboration with other national academic institutions, the MI and industry partners. A full list of ongoing projects as well as collaborators can be found on the MESTECH website http://www.mestech.org.

DCU and the NCSR offer expertise and state of the art facilities to work closely with other research institutions and industry partners to solve real monitoring problems, develop new products, and realise new market opportunities related to marine and environmental sensing technology.

DEVELOPMENT OF A LAB ON A CHIP MINIATURISED EXTRACTION AND SEPARATION SYSTEM FOR AUTOMATED *IN-SITU* RIVER WATER MONITORING WITH CAPACITIVELY COUPLED CONDUCTIVITY DETECTION (C^4D)

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ABSTRACT

The aim of this project is to develop a lab on a chip based extraction and separation system for automated *in-situ* river water monitoring. The extraction and separation components are being developed by the Department of Chemistry whilst the detection and automation sub-systems are being developed by the Department of Engineering of the University of Hull. Measurement is performed using Capacitively Coupled Conductivity Detection (C^4D), which was chosen to match the separation method of ion chromatography. C^4D is a contactless, inexpensive technique which provides accurate analytical results. The advantages of the C^4D make it a preferred technique when a sensitive, low cost conductivity measurement is required[1].

Several approaches have been evaluated for on-chip analysis, with planar electrodes positioned near the channel being currently under investigation. Electronic baseline suppression is also being developed to increase the sensitivity of the detection system and to reduce the need for chemical suppression normally required in ion chromatography. The automation of the device will reduce human intervention and allow self calibration, auto-diagnostics and remote communications.

1. Kuban, P. and P.C. Hauser, *A review of the recent achievements in capacitively coupled contactless conductivity detection.* Analytica Chimica Acta, 2008. **607**(1): p. 15-29.

PHOTONIC LAB-ON-A-CHIP FOR RAMAN-SPECTROSCOPIC SENSING OF MICRO-ORGANISMS IN WATER

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ABSTRACT

We propose a lab-on-a-chip for spectroscopic diagnostics and biological analysis of micro-organisms in water. The working principle of the chip is optical trapping and Raman spectroscopic sensing of microscopic and nanoscopic objects of various nature, ranging from bacteria to viruses and aggregates of biomolecules. These functionalities are obtained by using a CMOS compatible photonics platform for the integration of miniaturized optical tweezers and an optical spectrometer in a single microfluidic chip. In more detail, the tweezers are formed as a dual-beam trap based on a pair of optical waveguides from which optical beams are launched, while the spectrometer is built in the same waveguiding layer. The assembly is designed to trap bacteria from a water analyte passing through a fluidic channel between the waveguide facets, and to generate Raman scattered photons in the trapped particles or cells. The photons are subsequently collected and analysed with respect to their wavelength by the integrated spectrometer, thus yielding the Raman spectrum in a time period of minutes. The fingerprint of the particle obtained in this way accurately reveals its molecular composition.

In the poster we discuss the geometry of the chip, the photonics of the counterpropagating beams and the capabilities of the dual waveguide assembly to trap particles. An inplementation in a photonic platform is indicated as well.