

# "Environmental Challenges and Solutions"

24th Irish Environmental Researchers' Colloquium

Delegate Handbook

Trinity College Dublin

26th-28th Feb 2014

Environ 2014



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DUBLIN



Environmental Sciences Association of Ireland

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Science Gallery

Museum Building

Edmund Burke Hall

Main Entrance

Arts Building

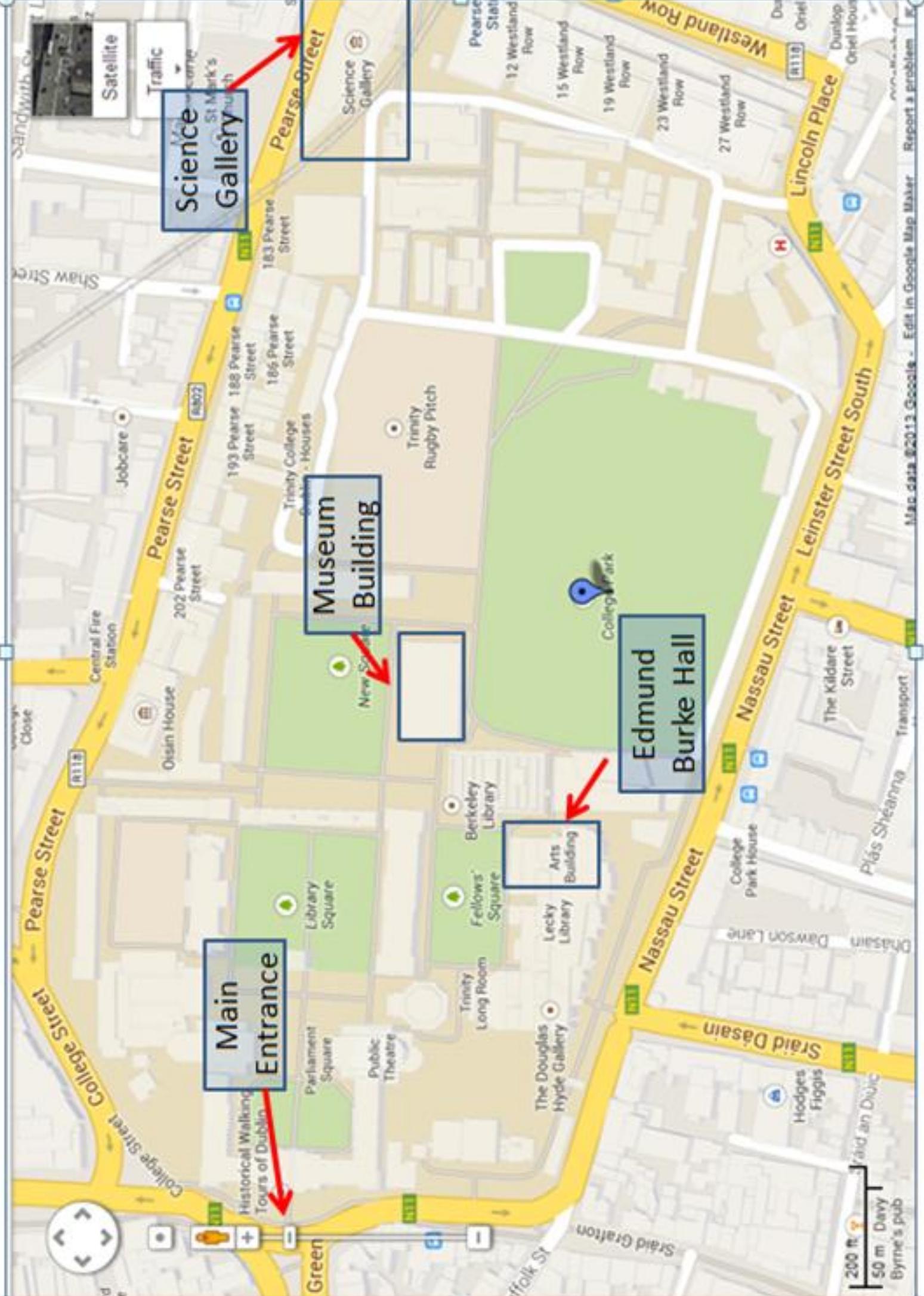
Science Gallery

Museum Building

Edmund Burke Hall

Main Entrance

Arts Building





# nviron 2014

**Trinity College Dublin**

**February 26<sup>th</sup>-28<sup>th</sup> 2014**

**[www.environ2014.org](http://www.environ2014.org)**



**The 24<sup>th</sup> Irish Environmental Researchers' Colloquium (ENVIRON 2014) is organised in a partnership between the Environmental Sciences Research Association of Ireland and Trinity College Dublin**

## **Table of Contents**

Welcome

Sponsors

Delegate Information

ENVIRON 2014 Programme Outline

Biographies:

    Debate

    Keynote Address

    Invited Speaker

    Keynote Chairs

    Workshop & Special Session Contributors

Workshops & Special Sessions Information

Oral Presentation Schedule

Oral Presentation Abstracts

Poster Presentation List

Poster Presentation Abstracts

ESAI Annual Review 2014

Index of Presenters

## Welcome to ENVIRON 2014

Dear delegate,

The ENVIRON 2014 Organising Committee welcomes you to the 24<sup>th</sup> Irish Environmental researchers' Colloquium (ENVIRON 2014), hosted this year in Trinity College Dublin. Trinity College last hosted the Colloquium in 1993 and as one of the original hosts of this event, we are now very pleased to welcome the colloquium back in 2014, which has been organised jointly by the Schools of Engineering and Natural Science.

The theme of this year's colloquium is 'Environmental Challenges and Solutions' which provokes delegates into considering how their research either investigates contemporary threats to the natural and human environment and/or contributes towards finding solutions. With the succession of recent winter storms fresh in everyone's minds it is clear that multidisciplinary approaches from scientists and engineers are needed to address the challenges of environmental pollution, energy security and sustainability of natural resources.

The ENVIRON colloquium is the largest annual gathering of environmental researchers across the island of Ireland, with over 300 delegates attending the event each year. It provides a venue for PhD students and postdoctoral fellows to exchange information on their most up-to-date findings with a large and diverse audience made up of academics, industry members and policy makers.

The conference will begin on Wednesday, 26<sup>th</sup> February 2014 with two workshops during the day on the following topics: How to Launch and Run a Smart Sustainable Campus and; Presentation and Technical Report Writing Skills. This is followed on Wednesday evening in the Science Gallery an anticipated energetic debate will be held around the provocative topic, "*Is green technology good for the environment?*" Trinity College has a long history of public debates with its oldest society, established in the 17<sup>th</sup> Century, the Philosophy Society still hosting weekly debates to encourage young people in public speaking, debating skills and the value of free speech.

The Colloquium will be formally opened on Thursday morning by the Provost Dr Patrick Prendergast followed by keynote lectures by three overseas speakers: Profs. Paul Younger, Pete Smith and Bob Ursem. Prof Paul Younger is the Rankine Chair of Engineering at Glasgow University as well as the Chair of the Global Scientific Committee of the Planet Earth Institute. His current research interests include low-carbon energy, notably deep geothermal energy, underground coal gasification with

carbon capture and storage, and hydropower. Prof. Pete Smith is the Professor of Soils & Global Change in the Institute of Biological and Environmental Sciences, University of Aberdeen as well as Science Director of Scotland's ClimateXChange, and a lead author on the recent IPCC report. His research interests include food security and climate mitigation. Bob Ursem is Scientific Director of the Botanic Garden Delft University of Technology and specialises in the application of plants in the development of technology, particularly in the materials science and engineering disciplines.

Running in parallel to the technical sessions, the ESAI is proud to announce its annual Environ Career Expo again to this year's ENVIRON Conference which will take place on Thursday afternoon. Attendees will get the chance to meet with representatives from NGOs, environmental consultancies, research institutes and semi state bodies to discuss job opportunities; internships; post doctorate and PhD programmes; and also receive career advice.

I hope you enjoy the Colloquium and find the talks stimulating, as well as using it as an opportunity for cross fertilisation of ideas between the different fields of environmental related research being carried out across Ireland.

Dr. Laurence Gill,

ENVIRON 2014 Colloquium Convenor,

On behalf of the ENVIRON2014 Organising Committes

## **ESAI Welcome to ENVIRON 2014 Delegates**

On behalf of the Environmental Sciences Association of Ireland (ESAI), the ESAI Council extends you a warm welcome to the 24<sup>th</sup> Irish Environmental Researchers colloquium (ENVIRON) at Trinity College Dublin (TCD).

When we were considering a host for ENVIRON 2014 a number of ESAI Council members suggested Trinity College Dublin as a potential host; I was very surprised indeed to hear that the last time ENVIRON was hosted in TCD was 1993 given its historic research strengths in the environmental sciences and engineering. We were therefore delighted when Professor Laurence Gill accepted the invite from the ESAI to host the event (perhaps with a little persuasion from former TCD postgraduate & ESAI Council member, Dr John Gallagher!). Laurence and his organising committee from the Schools of Natural Science and Engineering have put together a packed scientific programme for ENVIRON 2014. One of the strengths of the ENVIRON colloquium is the diversity and breadth of research presented at the parallel sessions – a cursory look at the list of oral and poster presentations illustrates that this is certainly the case at ENVIRON 2014.

The focus of this year's colloquium is very much around action and application of research. The theme of “Environmental Challenges and Solutions” asks delegates to consider how their research furthers our understanding of current threats to the natural and human environment and to develop solutions to combat these threats. To provide a measure of focus and continuity through over 100 diverse oral presentations at ENVIRON 2014 each speaker has been asked to dedicate their final slide to explain how their research relates back to the overarching theme of the conference. The TCD organising committee has also assembled an excellent panel of keynote lecturers from a variety of scientific disciplines for the plenary session to give their perspective on the theme of “Environmental Challenges and Solutions” which should provide a wonderful introduction and context for the remainder of the colloquium. The “action” theme of ENVIRON 2014 is also evident in the choice of workshops by the TCD organising committee with workshops on “How to Launch and Run a Smart Sustainable Campus” and “Communicating Research”. Finally following a very successful first outing last year the ESAI is delighted to host the second annual Environ Career Expo at ENVIRON 2014, which will take place on Thursday afternoon, where delegates will get the chance to potential future employers along with receiving career advice.

The ESAI wishes to sincerely thank Professor Laurence Gill, Mr Ian Douglas and the TCD ENVIRON organising committee for offering to host the ENVIRON and for assembling a very interesting and stimulating scientific programme. We also wish to thank Ms. Sinead Macken for providing administrative support to the event. We very much look forward to meeting you over the course of the colloquium. Before you leave please drop by the registration desk and to let us know what the highpoints (and lowpoints – not too many we hope!) of the colloquium were for you. Have a very enjoyable ENVIRON 2014.

Dr Paul Bolger  
ESAI Chairperson

The current ESAI Council members are:

Dr Cara Augustenborg  
Mr Damian Howard  
Dr David Bourke  
Dr Martina Prendergast  
Dr Tom Curran  
Dr Laurence Gill

Dr John Gallagher  
Dr Paul Bolger  
Mr Mark Nolan,  
Ms Emer Cosgrove  
Mr Kevin Ryan

Mr Alan Berry  
Dr Frances Lucy  
Dr Shane Colgan  
Dr PJ Purcell  
Ms. Aoife Delaney

Further ESAI information can be found at:



Connect with ESAI for regular updates on events and job opportunities on:

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## **ENVIRON 2014 ORGANISING COMMITTEE**

### **Conference Convenor**

Dr Laurence Gill      TCD Department of Civil, Structural and Environmental Engineering

### **Trinity College Dublin Planning Committee**

Dr Norman Allott

Prof Brian Broderick

Dr Catherine Coxon

Dr Ian Donohue

Mr Ian Douglas

Dr Donata Dubber

Dr Paul Johnston

Dr Aonghus McNabola

Prof Bruce Misstear

Prof Fraser Mitchell, Department of Botany, School of Natural Sciences, Trinity College

Dr Francesco Pilla

Dr Emma Siddall

Dr Liwen Xiao

### **Environmental Sciences Association of Ireland (ESAI)**

Ms Sinead Macken      ESAI Administrator

Dr Paul Bolger      ESAI Chairperson

ESAI Council

## Thanks to ENVIRON 2014 Sponsors & Exhibitors

### Thanks to Environ 2014 Main Sponsors



### Thanks to Environ 2014 Theme Sponsors



## UCD Earth Institute

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### Thanks to Environ 2014 Prize Sponsors



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## Thanks to Environ 2014 Stand Sponsors



## Thanks to Environ 2014 Conference Pack Insert Sponsors



## Thanks to Environ 2014 Keynote Sponsors



## Thanks to ENVIRON 2014 Sponsors & Exhibitors

The ESAI is proud to announce the addition of the second annual Environ Career Expo to this year's ENVIRON Conference. The Career Expo will take place beside the Edmund Burke Theatre in the Arts Block on Thursday 27th February from 1pm to 5pm. Attendees will get the chance to meet with representatives from NGOs, environmental consultancies, research institutes and semi state bodies to discuss job opportunities; internships; post doctorate and Ph.D. programmes; and also receive career advice. CV advice will be provided for ESAI members. There is no charge to attend the Environ career expo, which will provide an ideal venue to search for career opportunities within the Irish environmental sector.

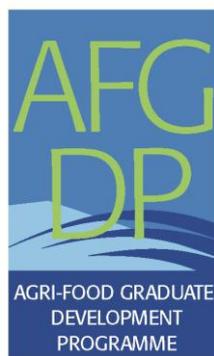
**When:** Thursday – February 27<sup>th</sup>, 2014 - 13:00-17:00

**Where:** M 17, Museum Building, TCD

[greencareersireland.com](http://greencareersireland.com)  
[Ireland's largest green jobs website]



Graduate career opportunities





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**DELEGATE INFORMATION**

## **REGISTRATION**

The ENVIRON 2014 Registration Desk will be open in the Edmund Burke Hall at the following times.

Wednesday Feb 26 <sup>th</sup>	10:30am to 5:30pm
Thursday Feb 27 <sup>th</sup>	08:45am to 5:30pm
Friday Feb 28 <sup>th</sup>	08:45am to 12:00pm

All enquires regarding the colloquium (including meals, finance, accommodation and social events) can be made at the registration desk. Check the registration area for notices and updates about events.

**Follow @environ2014 on Twitter for #ENVIRON2014 updates**



## **DELEGATE BADGES**

Delegates are asked to wear their badges at all times during the Colloquium.

## **LOCATIONS**

The campus map on the inside cover shows the location of the main rooms being used for the conference.

Registration	Edmund Burke Hall, Arts Block & Museum Building
Keynote Address	Edmund Burke Theatre, Arts Block
Poster Sessions	Drawing Office, Museum Building
Tea/Coffee	Drawing Office, Museum Building
Oral Sessions	M4, M17, M20, M21
Workshops	M21, Drawing Office, Museum Building
Debate	The Science Gallery

## **DELEGATES GIVING ORAL PRESENTATIONS**

After registration for the colloquium, All presentations for oral sessions should be uploaded well in advance of the session in which the presentation is given (no later than 2 hours before the session begins). Presentation titles should include the submitting author's surname for easy identification. Presenters are asked to introduce themselves to the session chairs in the assigned session at least 5-10 minutes before the session begins.

## **POSTERS**

The poster presentation area is in the Drawing Office of the Museum Building. When you arrive at the registration desk, please indicate that you have a poster for presentation and the registrars will direct you to the poster area.

## **WIRELESS INTERNET ACCESS**

### **TEA/COFFEE & LUNCH**

Teas and Coffees will be served mainly in the Drawing Office of the Museum Building during workshop and colloquium conference breaks (please refer to programme).

Vouchers will be made available to delegates to get hot lunches from the Buttery Food Court & Dining Hall on the Wednesday and Thursday. Soup and sandwiches will be available in the Edmund Burke Hall on the Friday.

## **BANK**

A branch of Bank of Ireland is located adjacent to the Atrium under the Dining Hall on campus. Alternatively there is an ATM at the Hamilton Building and numerous ones located just off campus on Nassau St and Graffton St.

## **PARKING**

Unfortunately there is no visitor parking on campus. Visitors and invited guests must park in the public car-parks in the vicinity of Trinity. These can be found at:

- Q-Park: <http://www.q-park.ie/ParkingatQPark/tabid/406/language/en-US/Default.aspx>
- Dublin Car Parks: [http://www.parkrite.ie/car\\_park.html#02](http://www.parkrite.ie/car_park.html#02)

## **LOCAL TRANSPORT**

There are a range of public transport options available to delegates and guest speakers coming to ENVIRON 2014. Information regarding public transport to and from Trinity College Dublin can be found on: <http://www.tcd.ie/Maps/directions.php>

Taxi Services available include:

ABC Taxis, 14A Wexford St, Dublin 2, Tel: (01) 2855444

Blue Cabs Ltd, 41 Westland Row, Dublin 2, Tel: 01 6761111

# The logo for 'environ 2014' features a stylized green leaf icon to the left of the word 'environ' in a lowercase, sans-serif font, followed by the year '2014' in a larger, uppercase, sans-serif font.

**Trinity College Dublin**

**February 26<sup>th</sup>-28<sup>th</sup> 2014**

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**ENVIRON 2014 PROGRAMME**



## Environ 2014 Programme, Wednesday February 26<sup>th</sup>



1:00pm -5:00pm	Registration – Museum Building Foyer
<b>Workshops</b>	
1:00pm – 2:00pm	Lunch – Dining Hall
2:00pm – 5:00pm	How to Launch and Run a Green Campus – Drawing Office, Museum Building
2:00pm – 5:00pm	Communicating Research – M17, Museum Building
<b>Reception and Q&amp;A Panel Discussion</b>	
6:00pm – 7:00pm	Wine Reception – Museum Building
7:00pm – 9:00pm	<p>Debate: <u>'Is Green Technology Good for the Environment'</u> followed by Q&amp;A Session, chaired by Paul Butler, Enterprise Ireland. Panellists include:</p> <ul style="list-style-type: none"><li>• Rory O'Donnell, National Economic and Social Council</li><li>• Prof Paul Younger, Rankine Chair of Engineering, Glasgow University &amp; Chair of the Global Scientific Committee of the Planet Earth Institute</li><li>• Prof Pete Smith, Professor of Soils &amp; Global Change in the Institute of Biological and Environmental Sciences, University of Aberdeen &amp; Science Director of Scotlands Climate XChange</li><li>• Bob Ursem, Scientific Director of the Botanic Garden Delft University of Technology, Netherlands.</li></ul> Other speakers TBC

<b>Environ 2014 Programme, Thursday February 27th</b>				
<b>8:15am – 5.00pm</b>	Registration – Edmund Burke Hall			
<b>Conference Opening &amp; Plenary Session</b>				
<b>9:15am - 9:30am</b>	Opening of Environ 2014. Guest Speakers: , Provost Trinity College Dublin			
<b>9:30am – 11:00 am</b>	Plenary Session & Keynote Address: Environmental Challenges and Solutions – Burke Theatre, Arts Block <ul style="list-style-type: none"> <li>• Prof Paul Younger, Rankine Chair of Engineering, Glasgow University &amp; Chair of the Global Scientific Committee of the Planet Earth Institute</li> <li>• Prof Pete Smith, Professor of Soils &amp; Global Change in the Institute of Biological and Environmental Sciences, University of Aberdeen &amp; Science Director of Scotlands Climate XChange</li> <li>• Bob Ursem, Scientific Director of the Botanic Garden Delft University of Technology, Netherlands.</li> </ul>			
<b>Research Presentations and Career Expo</b>				
<b>11:00am –12:00pm</b>	Coffee: Poster Session 1 & Meet the Exhibitors – Burke Theatre Area, Arts Block			
<b>12:00pm – 1:30pm</b>	Session 1	Session 2	Session 3	Session 4
<b>1:30pm – 2:30pm</b>	Lunch – Buttery Dining Hall: ESAI AGM (Drawing Office)			
<b>2:00pm – 5:00pm</b>	Career Expo: Burke Theatre Foyer, Arts Block			
<b>2:30pm – 4:00pm</b>	Session 5	Session 6	Session 7	Session 8
<b>4:00pm – 4:30pm</b>	Coffee: Poster: Session 2			
<b>4:30pm – 6:00pm</b>	Session 9	Session 10	Session 11	Session 12
<b>Reception and Dinner</b>				
<b>7:30pm-8pm</b>	Drinks Reception: Alexander Hotel			
<b>8:00pm</b>	Conference Dinner & Live Band: Alexander Hotel			

## Environ 2014 Programme, Friday February 28<sup>th</sup>

### Research Presentations and Prize Giving

<b>9:30am – 11:00am</b>	Session 13	Session 14	Session 15	Session 16
<b>11:00am – 11:45am</b>	Coffee: Poster Session 3			
<b>11:45am – 1:15pm</b>	Session 17	Session 18	Session 19	Session 20
<b>1:15am – 2:30pm</b>	Lunch, Student Prize Giving & Close of Environ 2013- Edmund Burke Hall, Arts Block			

The ESAI is proud to announce the addition of the second annual Environ Career Expo to this year's ENVIRON Conference. The Career Expo will take place in Room M17 of the Museum Building on Thursday 27<sup>th</sup> February from 1pm to 5pm. Attendees will get the chance to meet with representatives from NGOs, environmental consultancies, research institutes and semi state bodies to discuss job opportunities; internships; post doctorate and Ph.D. programmes; and also receive career advice. Participating organisations include Agapé Adventures, The Northern Ireland Environment Agency, McCarthy Keville O'Sullivan Planning and Environmental Consultants, The Department of Agriculture, Food and Marine, Evolution Environmental Services, OES Consulting, Intertrade Ireland, Teagasc, OxyMem, Alupro, Green Careers Ireland and Northern Ireland Environmental Link. CV advice will be provided for ESAI members. There is no charge to attend the Environ career expo, which will provide an ideal venue to search for career opportunities within the Irish environmental sector.

**When:** Thursday – February 27<sup>th</sup>, 2014 - 13:00-17:00

**Where:** Room M17 Museum Building, TCD



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**BIOGRAPHIES:**

**QUESTIONS AND ANSWERS PANEL**

**KEYNOTE ADDRESS**

**INVITED SPEAKERS**

**KEYNOTE CHAIRS**

**WORKSHOP & SPECIAL SESSION CONTRIBUTORS**



**Prof. Pete Smith, Professor of Soils & Global Change,  
University of Aberdeen**

Pete Smith is the Professor of Soils and Global Change at the Institute of Biological and Environmental Sciences at the University of Aberdeen (Scotland, UK), Science Director of the Scottish Climate Change Centre of Expertise (ClimateXChange) and Director of Food Systems for the Scottish Food Security Alliance-Crops. He leads the University of Aberdeen multi-disciplinary theme on Environment & Food Security. Since 1996, he has served as Convening Lead Author, Lead Author and Author for the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. He was the Convening Lead Author of the Agricultural Mitigation chapter of the IPCC Fourth Assessment Report and for the Agriculture and Forestry Mitigation chapter of the IPCC Fifth Assessment. He has coordinated and participated in many national and international projects on soils, agriculture, food security, greenhouse gases, climate change, mitigation and impacts, and ecosystem modelling. He is a Fellow of the Society of Biology, a Rothamsted Research Fellow, a Research Fellow of the Royal Society (London; 2008-2013), and a Fellow of the Royal Society of Edinburgh.

**[pete.smith@abdn.ac.uk](mailto:pete.smith@abdn.ac.uk)**



**Bob Ursem, Scientific director Botanical Garden, Technical University Delft**

[w.n.j.ursem@tudelft.nl](mailto:w.n.j.ursem@tudelft.nl)



**Prof. Paul Younger, Rankine Chair of Engineering, University of Glasgow**

Paul Younger holds the Rankine Chair of Engineering and is Professor of Energy Engineering at the University of Glasgow, where his research now focuses on geothermal energy, unconventional gas with carbon capture and storage and hydropower. From 1992 to 2012 he was at Newcastle University, where he latterly served as Pro-Vice-Chancellor for Engagement, as well as Founder Director of the Newcastle Institute for Research on Sustainability. By initial formation a geologist, he then pursued environmental engineering, working on myriad water supply and treatment issues, including environmentally-friendly techniques for remediation of mine water pollution. Author of more than 360 publications, his most recent book is “Water: all that matters” (Hodder, 2012) and is currently completing a companion volume on energy. Paul’s work has received many accolades, including the Queen’s Anniversary Prize for Higher Education (2006) and in 2007 he was elected a Fellow of the Royal Academy of Engineering (the UK’s top professional honour for engineers). He is a founder-Director of two pioneering companies in the energy sector: Cluff Geothermal Ltd and Five-Quarter. When not busy with all of the above, Paul is very much a family man and likes nothing better than traditional music and the Scots Gaelic language, in which he is fluent.

[paul.younger@glasgow.ac.uk](mailto:paul.younger@glasgow.ac.uk)



**Dr. Conor Sweeney, School of Mathematical Sciences, UCD, Belfield, Dublin 4**

**ENVIRON 2014 Climate Change Chair**

Dr Conor Sweeney is based in the Meteorology and Climate Centre, School of Mathematical Sciences, UCD, and his current research interests include improving forecast data by postprocessing and changes in weather intensity and occurrence due to climate change. He is involved in the EURO-CORDEX research project that aims to improve our understanding of how climate change will affect Europe. This type of research provides scientific data for climate change impact and adaptation studies.

In addition, he is also studying the nature of extreme climate changes in Ireland. The EPA-funded project, entitled ‘Extreme events in calibrated climate models: impacts for Ireland’ will use recently developed methods in statistical spatio-temporal Extreme Value Theory combined with state of the art regional climate models to assess the past, present and future behaviour of extreme weather events in Ireland.

Dr Karl Richards is head of the Environment, Soil and Land-Use department in Teagasc Johnstown Castle. He completed his BA(mod) in Natural Sciences (TCD) and PhD in Environmental Geology (TCD). His research focuses on contaminant fate and transport within agricultural systems with a focus on nitrogen loss to water and the atmosphere. To date he has published over 55 peer reviewed scientific papers in the area of agricultural sustainability. He is an associate editor in Soil Use and Management and an adjunct senior lecturer in Queens University Belfast.





## **How to Launch and Run a Smart Sustainable Campus**

**14.00-17.00:, Feb 26<sup>th</sup>, Drawing Office, Museum Building**

The theme is based on the successful Green Campus programme. The workshop will not tell participants how their campus will achieve Green Campus status as each campus has their own individual challenges to overcome. The workshop will provide the time and space for dialogue on experiences and challenges in an open and collaborative environment.

Key areas have been grouped together into four themes where delegates will get the opportunity to voice their opinions and ideas. The workshop is designed to encourage rich discussions and deep dives into the challenges and solutions that are facing each individual institution.

The four themes will each have a co-ordinator who will ensure that the discussion moves freely. At the end of the session the group will have an opportunity to present the challenges encountered and the possible solutions. Each participant will have the chance to get involved in two different themes that are of interest to them.

<b>How to Launch and Run a Smart Sustainable Campus</b>		
	<b>Theme</b>	<b>Co-ordinator</b>
<b>1.</b>	(Energy, Climate Change & Green House Emissions) + (Water and Wastewater)	Ciaran McGovern
<b>2.</b>	(Waste Management, Recycling & Litter Reduction) + (Resource Use)	Michael Keigher
<b>3.</b>	(Biodiversity & Trees)	David Hacket
<b>4.</b>	(Sustainable Transport) + (Sustainable Food) + (Green Procurement)	Noel McCann

<b>Time</b>	<b>Workshop: How to Launch and Run a Smart Sustainable Campus</b>
<b>2.00</b>	Opening – Noel McCann: “A reflection of TCD’s successful campaign to reach green flag status”
<b>2.15</b>	Group Session 1
<b>3.00</b>	Present Findings
<b>3.45</b>	Break (Tea/Coffee)
<b>3.50</b>	Presentation – Joe Borza: “Challenges and Solutions on running a smart sustainable campus”
<b>4.00</b>	Group Session 2
<b>4.30</b>	Present Findings
<b>5.00</b>	Finish











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## ORAL AND POSTER PRESENTATION SCHEDULE

**Oral Presentation Sessions (1-4)**  
**Thurs Feb 27th, 11.30-1.00**

<p><b>Session 1</b>  <b>Waste Water 1</b>  <b>Museum Building</b></p>	<p><b>Session 2</b>  <b>Water Quality &amp; Resources 1</b>  <b>Museum Building</b></p>	<p><b>Session 3</b>  <b>Climate Change 1</b>  <b>Museum Building</b></p>	<p><b>Session 4</b>  <b>Agriculture &amp; Environment 1</b>  <b>Museum Building</b></p>
<p><i>Opening Chair Address</i>  M. Keegan  EPA</p>	<p><i>Opening Chair Address</i>  B. Misstear  TCD</p>	<p><i>Opening Chair Address</i>  C. Sweeney  UCD Earth Institute</p>	<p><i>Opening Chair Address</i></p>
<p><b>Laura Brophy</b>  1. The Impact of effluent from Domestic Wastewater Treatment Systems on Rivers and Wells</p>	<p><b>Aisling Corkery</b>  7. Modelling quantified source specific microbial pollution from human sources during high flows</p>	<p><b>Md Saniul Alam</b>  13. Development of an improved modal CO2 emission model for Eco-driving</p>	<p><b>Florence Hecq</b>  19. Effects of scale and landscape structure on pollinator diversity and the provision of pollination services in semi natural grasslands.</p>
<p><b>Donata Dubber</b>  2. Clustered decentralised wastewater treatment systems as a sustainable solution to Ireland's septic tank problem?</p>	<p><b>Eve Daly</b>  8. Groundwater and Land Resources from the Tellus Border airborne survey</p>	<p><b>Emma Daniels</b>  14. Potential of amine-modified porous solids as carbon dioxide adsorbents in fossil-fuel fired power plants</p>	<p><b>Tamara Hochstrasser</b>  20. Diffusion of an Innovative Land Use – Private Afforestation in Ireland between 1990 and 2012</p>
<p><b>James Feighan</b>  3. Ecological Effects of Irrigation on Established SRC Willow Plantations with Municipal Wastewater and Dairy Washings</p>	<p><b>Louise Deering</b>  9. Smart Coasts = Sustainable Communities: Prediction of bathing water quality and identification of the biological sources of faecal pollution</p>	<p><b>Donna Hawthorne</b>  15. Fire, human and climate interactions throughout the Holocene</p>	<p><b>Mary Jo Hurley</b>  21. Effects of endophytic bacteria isolated from bioenergy crops on the biology and behaviour of entomopathogenic nematodes</p>
<p><b>Mohammad Jahangir</b>  4. Carbon and nitrogen dynamics: Greenhouse gases in groundwater adjacent to a constructed wetland treating municipal wastewater</p>	<p><b>Raymond Flynn</b>  10. Development of Water Quality Sampling Protocols for Wetland Ecosystems in Transnational River Basin Districts: Approaches and Challenges.</p>	<p><b>Barry O'Dwyer</b>  16. Ireland's Climate Information Platform (ICIP)- Facilitating Adaptation to Climate Change</p>	<p><b>Conor McGee</b>  22. The dose dependent effect of nano and micron sized silver particles on microbial community structure and function in grassland soil</p>
<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>

<i>Session 1 Continued</i>	<i>Season 2 Continued</i>	<i>Season 3 Continued</i>	<i>Season 4 Continued</i>
<p><b>Mary Keegan</b> 5. Modelling of Alternative Infiltration Systems Receiving Domestic Wastewater in Low Permeability Subsoils</p>	<p><b>Maebh Grace</b> 11. Development of filtration technologies for effective, cost-efficient and robust water treatment</p>	<p><b>Eleni Tsalaporta</b> 17. Experimental and modelling studies of CO2 capture via Pressure/Vacuum Swing adsorption for different experimental conditions and adsorbents</p>	<p><b>James Owens</b> 23. Controlling the abundance of tall herb Filipendula ulmaria on the River Shannon Callows</p>
<p><b>Eoin Syron</b> 6. Domestic Sewage Treatment by a Reed Bed without a Septic Tank</p>	<p><b>Siobhan Kavangh</b> 12. Widespread contamination of groundwater with Verotoxigenic E. coli (VTEC)</p>	<p><b>Jesko Zimmermann</b> 18. Assessing land-use change in Ireland using the Land-Parcel Identification System</p>	<p><b>Caroline Sullivan</b> 24. Identifying the distribution and extent of High Nature Value (HNV) farmland in Ireland</p>
<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>
<p>WW1:Mel Gavin WW2:Maebh Grace WW3:Andrea Paskuliakova WW4:Henry Winstanley</p>	<p>WQ1:John Gamble WQ2:Siobhán Kavanagh WQ3:Declan McGlade WQ4:Danny Rabbitt</p>	<p>CC1:Enda Cummins CC2:Emma Daniels CC3:Emily Gleeson CC4:Richard Lane CC5:John O'Sullivan</p>	<p>AG1: Lyubov Braginal AG2:Rachel Clarke AG3:Hannah Denniston AG4:Rochelle Fritch</p>
<b>12.40-13.30</b>	<b>Lunch &amp; Poster Session, Dining Hall</b>		
<b>13.30-14.00</b>	<b>ESAI AGM, Newman C110</b>		

**Oral Presentation Sessions (5-8) -  
Thurs Mar 8, 14.00-15.10**

<p><b>Session 5</b> <b>Energy 1</b> <b>Museum Building</b></p>	<p><b>Session 6</b> <b>Biodiversity &amp; Bioresources 1</b> <b>Museum Building</b></p>	<p><b>Session 7</b> <b>Environment &amp; Human Health</b> <b>Museum Building</b></p>	<p><b>Session 8</b> <b>Agriculture &amp; Environment 2</b> <b>Museum Building</b></p>
<p><i>Opening Chair Address</i> <i>Pearse Buckley (</i> <i>SEAI</i></p>	<p><i>Opening Chair Address</i> <i>Jim Martin</i> <i>BEC</i></p>	<p><i>Opening Chair Address</i></p>	<p><i>Opening Chair Address</i> <i>Karl Richards (</i> <i>Teagasc)</i></p>
<p><b>Eoin Ahern</b> 25. Power to Gas applied to Ireland</p>	<p><b>Ruth Boland</b> 31. Studying post glacial colonisation routes of Irish soil fauna through the phylogenetic analysis of <i>Oniscus asellus</i>.</p>	<p><b>Xiaolin Chen</b> 37. Environmental toxicity of ZnO nanoparticles: impacts on <i>Lemna minor</i></p>	<p><b>Linda Doran</b> 43. The impact of acute and chronic hydrochemical disturbances on stream ecology; implications for agricultural policy.</p>
<p><b>Eoin Allen</b> 26. Assessing the potential to produce Biomethane, from <i>Ulva lactuca</i> and dairy slurry using BMP and semi-continuous systems.</p>	<p><b>Susannah Cass</b> 32. Is the grass ‘greener’? Biodiversity impacts of legume-supported grasslands.</p>	<p><b>Aideen Dowling</b> 38. Examining the Occurrence of Antimicrobial Resistance in <i>E. coli</i> Isolated From Veterinary and Environmental Sources and Exploring the Relationship via Spatial Mapping</p>	<p><b>John Hyland</b> 44. Farmers’ attitudes towards climate change: identifying typologies</p>
<p><b>Brian Nugent</b> 27. Enhancing the Consolidated Bioprocessing (CBP) Activity of <i>Fusarium oxysporum</i> by manipulating a Hemicellulose Fermentation Enzyme</p>	<p><b>Louise Duignan</b> 33. The effects of non-native <i>Sarracenia purpurea</i> L. and <i>Darlingtonia californica</i> Torr. on vegetation communities and peat accumulation in Woodfield Bog, a raised bog in Co. Offaly</p>	<p><b>James Hodgson</b> 39. Using Tellus airborne geophysical and geological data to map radon risk potential</p>	<p><b>Lucas Jagodzinski</b> 45. Ecotoxicological case study of matrix conditioned ash from Ireland’s first industrial scale wooden biomass CHP boiler</p>
<p><b>Aine O’Driscoll</b> 28. Catalytic Hydrogenation of Furfural to Furfuryl Alcohol</p>	<p><b>Elaine Keenan</b> 34. The impact of the aquatic invasive weed species <i>Lagarosiphon</i> major on the seed banks of native Charophytes</p>	<p><b>Chui Sang Lee</b> 40. Development and Application of a Real-time PCR-based Method to Estimate Levels of Infectious Norovirus in Environmental Samples</p>	<p><b>John Murnane</b> 46. Evaluation of zeolite and chemical amendments to control phosphorus and nitrogen losses in runoff from agricultural wastewaters</p>

<p><b>Emma Smullen</b> 29. A Comparative Analysis of Pre-treatment Technologies for the Bioconversion of Willow, Miscanthus and Hemp</p>	<p><b>James Murphy</b> 35. Modelling biological invasion by the Asian kelp <i>Undaria pinnatifida</i> in European coastal habitats</p>	<p><b>Richard Manton</b> 41. Carbon footprint of travel to the Great Western Greenway</p>	<p><b>Ian Thomas</b> 47. Comparing LiDAR and conventional resolution digital elevation models for spatial modelling of nutrient loss pathways and critical source areas</p>
<p><b>David Wall</b> 30. The potential for biomethane from grass and slurry to satisfy renewable energy targets</p>	<p><b>Fionnula O'Neill</b> 36. A proposed new classification system for Irish semi-natural grassland communities</p>	<p><b>Tarha Westby</b> 42. Determination of Iodine in <i>Fucus Serratus</i> Seaweed Bathwater</p>	<p><b>Mike Whitfield</b> 48. Scaling soil process modelling to the national level</p>
<p><b>Poster Oral Presentations</b></p>	<p><b>Poster Oral Presentations</b></p>	<p><b>Poster Oral Presentations</b></p>	<p><b>Poster Oral Presentations</b></p>
<p>EG1:Angela Boyce EG2:Niall Dunphy EG3:Mel Gavin EG4:Mel Gavin EG5:Sean Keating EG6:Mark O'Connor EG7:Richard O'Hegarty</p>	<p>BB1:Siobhan Atkinson BB2:Conn Maguire BB3:Simona Paolacci</p>	<p>EHH1:Miriam Alonso Camarero EHH2:Enda McGrory</p>	<p>AG5:Blathnaid Keogh AG6:Graham McAuliffe AG7:Ganna Shutenko</p>

**Oral Presentation Sessions (9-12)**

**- Thurs Mar 8, 16:30-18:00**

<p><b>Session 9</b> <b>Waste Water 2</b> <b>Museum Building</b></p>	<p><b>Session 10</b> <b>Biodiversity &amp; Bioresources 2</b> <b>Museum Building</b></p>	<p><b>Session 11</b> <b>Marine &amp; Coastal 1</b> <b>Museum Building</b></p>	<p><b>Session 12</b> <b>Energy 2</b> <b>Museum Building</b></p>
<p><i>Opening Chair Address</i> <i>Paul Bolger</i> <i>ESAI</i></p>	<p><i>Opening Chair Address</i> Fraser Mitchel TCD</p>	<p><i>Opening Chair Address</i> Geoffrey O'sullivan Marine Institute</p>	<p><i>Opening Chair Address</i></p>
<p><b>Edelle Doherty</b> 49. Benchmarking and Mitigation of Resource Consumption in Irish Wastewater Treatment Plants</p>	<p><b>Nuria Prat-Guitart</b> 53. Study of the fine-scale spatial distribution of surface moisture content in Canadian and Irish peatlands</p>	<p><b>Aoife Duff</b> 57. Molecular Microbial Ecology of Ammonia Oxidation in Coastal Bay Sediments</p>	<p><b>Eimear Hassett</b> 61. Assessment of a Best-Practice Framework to Facilitate the Development of a Sustainable Energy Community in an Off-shore Island in Ireland</p>
<p><b>Lisa Jones</b> 50. Occurrence of Priority Pollutant Heavy Metals in wastewater treatment plant effluent in Ireland</p>	<p><b>Rory Sheehan</b> 54. Attack of the clones. Are all Asian clams in Ireland related?</p>	<p><b>Laura Foley</b> 58. Assessment of the physicochemical properties of karst-channelled submarine groundwater discharge, and their individual and synergistic impact on the structuring the macroalgal community.</p>	<p><b>Tracey Lydon</b> 62. Energy Efficiency of Water: Analysis of Pumps-as-turbines Replacing Pressure Reducing Valves in Distribution Networks</p>
<p><b>Fergus McAuliffe</b> 51. The application of a commercial mycorrhizal inoculum in a willow wastewater treatment system</p>	<p><b>Erin Jo Tiedeken</b> 55. The impacts of Rhododendron nectar toxins on Ireland's bee population: deadly meal or valuable forage?</p>	<p><b>Tara Kelly</b> 59. Analysing Submarine Groundwater Discharge (SGD)-borne Dissolved Organic Matter (DOM) in a karstic aquifer, Kinvara, Co. Galway.</p>	<p><b>Pauline Ryan</b> 63. "How To" support deep-retrofitting? Lessons from the SERVE Project, Tipperary, Ireland</p>
<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>	<p><i>Continued on next page</i></p>

<i>Session 9 Continued</i>	<i>Session 10 Continued</i>	<i>Session 11 Continued</i>	<i>Session 12 Continued</i>
<p><b>Thomas Phelan</b> 52. Improvement of resource efficiency within municipal waste water treatment plants in Ireland through process control optimisation</p>	<p><b>Aidan Walsh</b> 56. Rare plant records highlight the added value of conservation outside of designated areas</p>	<p><b>Agata Lisik</b> 60. Nitrate reduction in coastal sediments</p>	<p><b>Barbara Schaller</b> 64. Direct catalytic low temperature conversion of bio-methane to methanol via Cu-ZSM-5</p>

**Oral Presentation Sessions (13-16)**  
**- Fri Mar 9, 9.00-10.30**

<p align="center"><b>Session 13</b>  <b>Monitoring &amp; Instrumentation 1</b>  <b>Museum Building</b></p>	<p align="center"><b>Session 14</b>  <b>Environmental Policy &amp; Communication</b>  <b>Museum Building</b></p>	<p align="center"><b>Session 15</b>  <b>Marine &amp; Coastal 2</b>  <b>Museum Building</b></p>	<p align="center"><b>Session 16</b>  <b>Air Quality &amp; Urban Development</b>  <b>Museum Building</b></p>
<p align="center"><i>Opening Chair Address</i></p>	<p align="center"><i>Opening Chair Address</i></p>	<p align="center"><i>Opening Chair Address</i></p>	<p align="center"><i>Opening Chair Address</i></p>
<p align="center"><i>Paul Johnston</i> <i>TCD</i></p>			<p align="center"><i>Brian Broderick</i> <i>TCD</i></p>
<p align="center"><b>Deirdre Cogan</b> 65. Development of low cost autonomous chemical sensing platforms for the direct determination of ammonia and nitrate in water</p>	<p align="center"><b>Neal Haddaway</b> 70. Journalysis: increasing accountability in academic publishing</p>	<p align="center"><b>Brian Murphy</b> 75. The occurrence of PAH's and Faecal Sterols in Dublin Bay and their influence on sedimentary microbial communities.</p>	<p align="center"><b>Stephen Barry</b> 80. Uncertainty Analysis for the Irish NMVOC emission inventory Solvent and other Product Use sector</p>
<p align="center"><b>Fiachra Collins</b> 66. Autonomous remote gas sensing: Web-based monitoring of greenhouse gases in the waste sector</p>	<p align="center"><b>Nicola Dwyer</b> 71. Key Performance Indicators for the Effectiveness of Strategic Environmental Assessment in Ireland</p>	<p align="center"><b>Diarmuid O'Connor</b> 76. 'SmartBay – Ireland's test, demonstration and validation facility'</p>	<p align="center"><b>Michael Connolly</b> 81 Reducing the NOx gas emissions of a liquid fuel burning boiler through the prehumidification of the combustion air</p>
<p align="center"><b>Gillian Duffy</b> 67. A low-cost autonomous phosphate sensor for quantifying the influence of agriculture on river water</p>	<p align="center"><b>Tamara Hochstrasser</b> 72. A model of knowledge transfer and integration at the science-policy interface</p>	<p align="center"><b>Anna Phoenix</b> 77. Assessing the Hydro-Environmental Impacts of Tidal Turbines</p>	<p align="center"><b>Brian Doyle</b> 82. The spatial distribution of ambient atmospheric ammonia concentrations in Ireland</p>
<p align="center"><i>Continued on next page</i></p>	<p align="center"><i>Continued on next page</i></p>	<p align="center"><i>Continued on next page</i></p>	<p align="center"><i>Continued on next page</i></p>

<i>Session 13 Continued</i>	<i>Season 14 Continued</i>	<i>Season 15 Continued</i>	<i>Season 16 Continued</i>
<b>Anna Rymaszewicz</b> 68. Challenges of Monitoring of Suspended Sediment Fluxes: Turbidity Surrogate Method.	<b>John Gallagher</b> 73. Assessing the Environmental Impacts of Micro-hydropower in the Water Industry	<b>Jenny Ronan</b> 78. The Role of Passive Sampling in the Screening and Monitoring of New and Emerging Chemicals	<b>Maryann Harris</b> 83. Urban biodiversity management in Ireland - capturing the experience of practitioners
<b>Tom Shortle</b> 69. Mineral weathering rates for Irish forest soils using the models PROFILE and A2M	<b>Neal Haddaway</b> 74. Evidence Synthesis in the Environmental Sciences: A systematic review	<b>Silvia Saloni</b> 79. Impacts of multiple stressors on marine ecosystems during the establishment of assemblages.	<b>John Morrissey</b> 84. Spatial planning in Ireland: Can a transitions approach empower the NSS mark 2?
<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>
MI1:Enda Cummins MI2:Fionn Downes MI3:Helen Moran	EPC1: Kevin Feeney	MC1: Dannielle Green MC2: Chloe Kinsella MC3: Sinead Tangney	UD1: John Morrissey
<b>10.30-11.30</b>	<b>Tea/Coffee &amp; Poster Session, Drawing Office, Museum Building</b>		

**Oral Presentation Sessions (17-20) - Fri Mar 9, 11.30-12.45**

<b>Session 17</b> <b>Monitoring &amp; Instrumentation 2</b> <b>Museum Building</b>	<b>Session 18</b> <b>Water Quality &amp; Resources 2</b> <b>Museum Building</b>	<b>Session 19</b> <b>Waste Management</b> <b>Museum Building</b>	
<i>Opening Chair Address</i>	<i>Opening Chair Address</i>	<i>Opening Chair Address</i>	
<i>Laurence Gill</i> <i>TCD</i>	<i>Catherine Coxin</i> <i>TCD</i>	<i>Tom Curran</i> <i>ESAI</i>	
<b>Bas Boots</b> 85. $\mu$ AQUA – a universal microarray for the detection of waterborne pathogens	<b>Kate Kilroy</b> 90. The Impact of Traditional Septic Tank Soakaway Systems and the Effects of Remediation on Water Quality in Ireland	<b>Susan Byrne</b> 95. Appraisal of an Irish rural community to determine its resilience against the effects of a waste management facility	
<i>Continued on next page</i>	<i>Continued on next page</i>	<i>Continued on next page</i>	

<i>Session 17 Continued</i>	<i>Season 18 Continued</i>	<i>Season 19 Continued</i>	
<p><b>Brendan Heery</b> 86. A Continuous Fluorescence Assay based Sensor for the Monitoring of Faecal Indicator Bacteria in Marine Environments</p>	<p><b>Jean O'Dwyer</b> 91. Evaluating the effect of natural and human processes on groundwater pollution using a GIS based modelling approach.</p>	<p><b>Tara Duggan</b> 96. Amendment of peat-based and peat-reduced growing media with vermicompost: Effects on plant growth, development, and fruit yields of tomato (<i>Solanum lycopersicum</i> cv. Grande)</p>	
<p><b>Kevin Murphy</b> 87. An Optical Colour Sensor for Monitoring Marine and Aquatic Environments</p>	<p><b>Hisham Osman</b> 92. The hydrological impact from proposed road widening scheme on a blanket bog in Connemara</p>	<p><b>Niall Dunphy</b> 97. Process improvement through cleaner production in a material recovery operation : a case study</p>	
<p><b>Timothy Sullivan</b> 88. Autonomous Environmental Sensors As Tools In Marine Resource Management.</p>	<p><b>Uxia Sieira NãfÂ³voa</b> 93. A QMRA approach to estimate Public Health Risks caused by Microbes Associated with Beach Sands</p>	<p><b>Jan Gottsche</b> 98. A Critical Review of Construction Waste Management Practices on a Selected Case Study.</p>	
<p><b>Dian Zhang</b> 89. Smart Sensing for Marine Monitoring and Decision Making</p>	<p><b>Jean Wilson</b> 94. A combined remote sensing and geochemical tracing approach to localising and assessing groundwater discharge to lakes</p>	<p><b>Aidan Ware</b> 99. Production of biogas from slaughterhouse wastes in Ireland</p>	
<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>
MI1:Enda Cummins MI2:Fionn Downes MI3:Helen Moran	EPC1: Kevin Feeney	WM1: Susan Byrne WM2; Brian Hogan WM3: B. Conall Holohan WM4: Orla Myers WM5:Michael Ryan WM6. Aoife Vaughan	
<b>12.45-13.45</b>	<b>Awards Lunch &amp; ENVIRON2012 Close, Drawing Office, Museum Building</b>		

## **1. The Impact of effluent from Domestic Wastewater Treatment Systems on Rivers and Wells**

Christopher Fennell<sup>1</sup> and Laura Brophy<sup>1</sup>

<sup>1</sup>Department of Civil, Structural and Environmental Engineering, Trinity College, Dublin

In Ireland, the domestic wastewater of approximately 438,000 dwellings is treated by individual septic tanks, with a further 50,000 households using other individual sewerage systems (CSO, 2012). The objective of this project is to evaluate the impact of these Domestic Waste Water Treatment Systems (DWWTS) on the microbial and chemical quality of untreated water extracted from private groundwater wells, and of surface water. Currently, with the aid of GIS mapping, a site selection methodology is being employed by which potential study areas will be delineated for both the private well and surface water study.

Appropriate study sites for evaluating the impacts of DWWTS on surface water quality will feature low permeability subsoil (i.e. clayey subsoils) and dense clusters of DWWTSs situated close to the river bank, in a headwater catchment. One study site will be located in arable cropland, while a second will feature pasture as the dominant landuse. In catchments with low permeability subsoil, DWWTS effluent is more likely to migrate horizontally from the treatment area and flow overland or via shallow subsurface routes towards the nearest surface water body.

With regards to site selection for the groundwater aspect, appropriate sites will be located in areas of extreme groundwater vulnerability. Aquifers underlying such areas are naturally classed as being more susceptible to contamination. This natural susceptibility coupled with the fact that private wells in Ireland are largely unregulated and are often poorly located and constructed can make DWWTS effluent a potential threat. In addition, private wells will also be studied in the aforementioned surface water study catchments.

The project will also examine a number of chemical and microbiological tracing techniques (using fluorescent whitening compounds, sterols, anions, FRNA phages and Bifidobacterium) in order to evaluate their potential use as economic tracers of environmental contamination by domestic effluent.

## **2. Clustered Decentralised Wastewater Treatment Systems as a Sustainable Solution to Ireland’s Septic Tank Problem?**

Donata Dubber<sup>1</sup>, Francesco Pilla<sup>1</sup> and Laurence W. Gill<sup>1</sup>

<sup>1</sup> Department of Civil, Structural and Environmental Engineering, Trinity College  
Dublin

Corresponding author: Donata Dubber<sup>1</sup>

The wastewater of approximately one third of Ireland’s population is treated on-site by domestic wastewater treatment systems (DWWTSs) of which more than 87% are septic tanks. Large areas in Ireland have been proven to be unsuitable for effluent discharge to ground due to insufficient subsoil depth, high water tables or low subsoil permeability. Legacy DWWTSs that have not been situated correctly are therefore representing a pollution threat to either groundwater and/or surface water. While alternative DWWTS technologies are being tested for their application in low permeability subsoils, it emerges that the consented surface water discharge of treated effluent might need to be reconsidered.

In view of the commencement of inspections and upcoming remediation of existing legacy sites this study assesses the feasibility of clustered decentralised wastewater treatment systems within the Irish context. To ensure the compliance with EU and national water quality discharge limits the study reviews treatment technologies currently available for small scale wastewater treatment plants and assesses their performance and suitability for direct surface water discharge. Furthermore, GIS analyses were carried out to identify potential clusters in four test counties. The results show that especially in densely populated counties a decentralised treatment solution could be used to remediate a large proportion of houses that currently are likely to pose a threat to human health and the environment. Moreover, cost estimations indicate that in areas of dense settlements where existing septic tanks are failing, such a community solution could be economically favourable compared to alternative single house solutions. However, decentralised wastewater treatment with consented surface water discharge can only be environmentally sustainable where appropriate regulations and a suitable management plan are in place. Also the ownership as well as other related financial and legal issues still need to be overcome before this will become a more widely accepted solution.

### **3. Ecological Effects of Irrigation on Established SRC Willow Plantations with Municipal Wastewater and Dairy Washings**

<sup>1</sup> Feighan. J

Sligo Institute of Technology, Sligo, Ireland

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This two year study investigates the effect of irrigation with wastewaters on the abundance of earthworms and micro-arthropods (collembola and acari) in established short rotation coppice (SRC) willow. Two different sites were used. Site one covers an area of 21,600m<sup>2</sup>; selected plots within this area were irrigated with primary effluent from a local wastewater treatment plant at a constant rate of 8.75 m<sup>3</sup>/ha in the period between April and September each year since 2011. Site two covers an area of 42,480m<sup>2</sup>; selected plots in this area were irrigated with dairy washings (at variable rates of 18, 34 and 44 m<sup>3</sup>/ha/day) from an on-site farm between April and September each year since 2008. This investigation covers the years 2012 and 2013. An in-situ chemical extraction method was used to determine the abundance of earthworms while a heat extraction method was used to determine the abundance of micro-arthropods. Soil pH, moisture and temperature were also recorded

Findings from the study indicate that abundance of earthworms is not affected by irrigation with municipal wastewater at a rate of 8.75m<sup>3</sup>/ha/day but are affected by irrigation with dairy washings at rates greater than 34m<sup>3</sup>/ha/day. Dairy wastewater affects the abundance of collembola at a rate of application of 44 m<sup>3</sup>/ha/day but not at lower rates. They were also affected by irrigation with municipal wastewater at a rate of 8.75m<sup>3</sup>/ha/day but recovered when irrigation ceased. No change in the abundance of acari was evident for both effluent types across all irrigation rates.

**Key words:** Waste-water Irrigation, Short Rotation Coppice (SRC), Earthworms, Micro-arthropods

#### **4. Carbon and nitrogen dynamics: Greenhouse gases in groundwater beneath a constructed wetland treating municipal wastewater**

Mohammad M. R. Jahangir<sup>1,2</sup>, Karl G. Richards<sup>2</sup>, Owen Fenton<sup>2</sup>, Paul Carroll<sup>3</sup>, Rory Harrington<sup>4</sup>, Paul Johnston<sup>1</sup>

<sup>1</sup>Dept. of Civil, Struc. & Environ. Eng., Trinity College Dublin.

<sup>2</sup>Teagasc Environment Research Centre, Wexford.

<sup>3</sup>Waterford County Council, Waterford; <sup>4</sup>Vesi Environmental Ltd., Cork.

Constructed wetlands (CW) act as nitrogen (N) sinks and reactors facilitating a number of physical, chemical and biological processes. The N removal efficiency of through-flowing water in such systems when used to treat municipal wastewater is variable. Their overall removal efficiencies do not specifically explain which N species have been removed by physical attenuation, and by biological assimilation or transformation to other forms. A wider understanding of how N removal occurs would help elucidate how losses of N and associated gases from CW impact on water and air quality. The objective of this study is to investigate the C and N cycling processes in the porewater of soils immediately adjacent, up-gradient and down-gradient to helophyte –vegetated CW cells. The CW site (0.32 ha in size, containing 3 cells treating municipal waste) is part of a 5-cell Integrated Constructed Wetland (ICW) located in Dunhill village, Waterford, Ireland. Multilevel piezometers (0.025 m inner diameter; 1 m screen interval at base) were installed in the CW at two depths: 2 m below ground level, (bgl), representative of shallow groundwater, and at 5 m bgl representative of deeper groundwater. Water table depths were  $0.90 \pm 0.06$  and  $1.34 \pm 0.07$  m (mean  $\pm$  SEM) bgl in shallow and deep groundwater, respectively. Starting in Nov-2013 to present, groundwater samples were collected bi-weekly for geochemistry and C and N species analyses following USEPA Low Flow sampling procedures. Dissolved greenhouse gases ( $N_2O$ ,  $CO_2$  and  $CH_4$ ) were extracted using a headspace equilibration method. Denitrified  $N_2$  was measured using Membrane Inlet Mass Spectrometry. Groundwater nitrate ( $NO_3^-$ -N) and nitrite ( $NO_2^-$ -N) concentrations were  $<0.5$  mg/L at both screened depths. The concentrations of ammonium ( $NH_4^+$ -N) significantly decreased with depth: shallow ( $10.1 \pm 2.5$  mg N/L) and deep groundwater ( $2.1 \pm 0.5$  mg N/L). Mean  $N_2O$  was higher in shallow ( $2.90 \pm 0.6$   $\mu$ g N/L) than in deep groundwater ( $0.52 \pm 0.1$   $\mu$ g N/L). Mean denitrified  $N_2$  was lower in the shallow groundwater ( $0.40 \pm 0.2$  mg N/L) than the deep groundwater ( $0.64 \pm 2$  mg N/L). Mean dissolved organic C was higher in shallow ( $16 \pm 11$  mg/L) rather than in deep groundwater ( $12 \pm 3$  mg/L), but mean  $CO_2$  and  $CH_4$  were higher in deep groundwater ( $137 \pm 38$ ;  $2.2 \pm 0.7$  mg C/L) than in shallow equivalents ( $97 \pm 16$ ;  $2.0 \pm 0.5$  mg C/L). Initial geochemistry results indicate that groundwater adjacent to the CW is microbially dynamic, contributing to the attenuation of compounds such as  $NH_4^+$  in groundwater recharge.

## **5. Modelling of Alternative Infiltration Systems Receiving Domestic Wastewater in Low Permeability Subsoils**

Mary Keegan<sup>1</sup>, Laurence Gill<sup>1</sup>, Donata Dubber<sup>1</sup>

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The goal of this field study was to investigate the potential improvements with respect to hydraulic loading and treatment performance of low permeability subsoils receiving on-site domestic strength wastewater effluent, through the installation of two alternative infiltration systems. For this study two sites with traditional septic tank systems discharging into inadequately performing soakaways were upgraded through the installation of drip distribution (DD) and low pressure pipe (LPP) systems in combination with secondary treatment units. These systems were then monitored over a 14 month period in order to determine their ability to distribute and treat the effluent loading in subsoil deemed inadequate for traditional gravity fed percolation areas.

At both sites the DD and LPP systems were installed in parallel with the household effluent load split equally between each distribution system. Soil moisture potential and soil moisture content were measured beneath each of the systems at a range of depths through the installation of tensiometers and soil moisture probes. Rainfall recharge, potential evapotranspiration and applied effluent load were also measured in order to determine the total hydraulic load applied to the system. The hydraulic conductivity of the subsoil at each site was determined by means of a constant head and falling head test.

These field results were then used to calibrate first a long term (steady state) model of vertical flow and soil moisture distribution of each system using the finite element based HYDRUS-2D software and then a model which simulated the transient annual conditions. The calibrated models are currently being used to predict the response of each system in the event of a higher hydraulic loading/lowering of subsoil permeability in order to establish robust design criteria for DD and LPP systems for use in an Irish soils context, which can then augment the existing EPA Code of Practice.

## **6. Domestic Sewage Treatment by a Reed Bed without a Septic Tank**

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With the introduction of registration and certification of domestic wastewater treatment systems in Ireland, there is a growing emphasis on effective treatment systems with low energy and low maintenance. In France, where certification has been the norm for many years, a novel reed bed domestic water treatment system has been developed which doesn't require pre-treatment by a septic tank. The Aquatiris Sanitation Garden, is a two stage reed bed, consisting of a vertical reed filter with Phragmites reeds as the first stage and a horizontal filter consisting of a variety of plants as the second filter. The solids in the sewage are filtered out on top of the first reed bed where they are broken down by aerobic processes. No de-sludging is required, while the aerobically degraded organic material is removed from the filter on average every 10 years. The sanitation garden was installed at the Buildings Scientific and Technical Centre (CSTB), Nantes, where it was tested for 48 weeks under varying flow and loading conditions. The system consistently achieved greater than 80% of the COD and TSS removal even when tested at twice the normal loading, while total nitrogen removal ranged from 40-60%. After 2 weeks of a holiday simulation during which no sewage was sent to the reed bed, lower removal efficiencies were observed but the treated water never exceeded limits. Following the evaluation test, the Aquatiris Sanitation Garden was certified by the French Ministry of Health and Environment. To date, sanitation gardens have proved successful in a wide range of environments, from the Alps to the Mediterranean.

## 7. Modelling quantified source specific Microbial Pollution from Human sources During high flows

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Modelling the transport of source specific faecal bacteria in rivers can be particularly useful for rivers from which potable water is extracted, particularly where domestic waste water treatment systems are an issue, or where rivers discharge to coastal zones where bathing or aquaculture is prominent and where the evaluation of human health risks is of primary importance.

The MIKE11 hydrodynamic model was used to evaluate the fate of faecal bacteria from human sources within the Dargle catchment, Co. Wicklow. The Dargle is a spate river and the upper catchment is characterised by steep slopes incorporating peat bogs and land used for forestry and agricultural purposes. Residential dwellings within the area are predominantly single detached units that rely on septic tanks for wastewater treatment and in the context of faecal bacteria of human origin, malfunctioning systems are of concern. The MIKE11 model was calibrated in a two stages process. Firstly, the model was calibrated for prediction of discharge and microbial water quality parameters, namely *E. coli* and Intestinal Enterococci (IE), using data from a real-time sensor network within the catchment that comprised rain gauges, weather stations and water level recorders. *E. coli* and IE concentrations were determined from high resolution sampling during storm events. Following this, water quality samples taken during storm event sampling were used to identify and quantify the human gene marker HF183f using quantitative polymer chain reaction (qPCR) techniques. Results from the qPCR analysis were used to further calibrate the model at sub-catchment level for the transport of microbial bacteria derived from human origins. Domestic sources have been calculated based on the number of septic tank units and average daily faecal gene marker concentrations per household.

Results indicate modelling the transport of source specific faecal bacteria from diffuse groundwater sources can be achieved using the calibrated MIKE11 model.

**Keywords:** Catchment Modelling; Microbial Source Tracking; Human Gene Marker, Water Quality.

## **8. Groundwater and Land Resources from the Tellus Border airborne survey**

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Tellus Border is an EU INTERREG IVA-funded regional mapping project that collected geo-environmental data on soils, water and rocks across six border counties - Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth - and continued the analysis of existing data in Northern Ireland. It combines both physical soil sampling and remotely sensed airborne Geophysics data, (including magnetics, radiometrics and electromagnetics), to achieve its goal of generating integrated, high quality data on the environment of the border counties.

Specifically our work focuses on using the airborne Geophysical data from the coastal zones of Dundalk Bay and Carlingford Lough to detect edges of bodies and lineaments associated with bedrock geological trends, fracture zones and igneous dykes that have the potential to identify structurally controlled groundwater pathways. Identifying groundwater pathways in the coastal zone is important for the management of fresh water resources in coastal aquifers, and protection against land-based sources of organic and inorganic contaminant plumes which can be transported via these pathways to the sea. Detailed analysis of the airborne geophysical data has facilitated the detection and mapping of numerous features such as previously unmapped basalt dykes, many traversing the coastal zone, faults and NE-SW trending structures within the bedrock. The data analysis has also detected saline influences into gravel aquifers along the coast in addition to the possible outflow of fresh groundwater to the sea.

The results of this research demonstrate the potential of airborne Geophysics to act as a reconnaissance tool for future ground based environmental sensor technology to examine water fluxes and water quality in real time. Other potential applications of these datasets include wetland and soil type mapping.

**9. Smart Coasts = Sustainable Communities: Prediction of bathing water quality and identification of the biological sources of faecal pollution**

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Faecal contamination of ground, surface and coastal waters from human and animal sources may pose a significant threat to human health, in addition, this may result in a significant economic loss for example when the 'Blue Flag' status of a bathing water is lost.

Real-time prediction of coastal water quality protects public health and produces more 'excellent' quality bathing waters. "Smart Coasts", a European Union Interreg funded project allows University College Dublin and Aberystwyth University in liaison with several other contributing stakeholders (in Ireland: Department of the Environment, Community and Local Government, Environmental Protection Agency, Marine Institute, Wicklow County Council) to undertake work in this area.

As part of the project, practical management models have been developed at two exemplar sites in Ireland and Wales. At these sites high quality data to underpin credible model design have been collected. Two types of models were investigated; a simple black-box model where water quality compliance is related to, for example, rainfall or river flow thresholds; and a more complex process-based model that links land surface runoff with near-shore flow patterns producing pollutant concentrations at impacted bathing sites. The modelling tools are designed to be generic, transferable and incorporate considerable practical operational input to their design from contributing stakeholders in Wales and Ireland.

As spin-off of the work, tools have been developed that allow a determination of the relative contributions of different faecal pollution sources (e.g., human vs. animal) to the receiving waters at the two demonstration sites.

## **10. Development of Water Quality Sampling Protocols for Wetland Ecosystems in Transnational River Basin Districts: Approaches and Challenges.**

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The Water Framework Directive's requirement to approach integrated water management on a river basin district basis across the EU poses substantial logistical challenges for protecting groundwater dependant ecosystems in transnational catchments. This is particularly problematic in heterogeneous physical and geochemical settings. The highly variable geological conditions encountered in counties on either side of the border between Northern Ireland(NI) and the Republic of Ireland(RoI) result in large contrasts in hydrological regimes and the development of a wide variety of wetland habitats. Water quality monitoring programmes provide valuable data for understanding the functioning of these habitats and assessing their sensitivity to anthropogenic activity. However, monitoring protocols employed for flowing surface waters/lakes may not be transferable to wetlands. A six month investigation, funded through the Tellus Border programme, aimed to investigate physical and chemical influences on nutrient levels encountered in wetlands around the southern part of the NI/RoI border region. Compilation of spatially distributed data into a GIS permitted screening of 86 wetland catchments using geological, landuse and topographic datasets and subsequent selection of 19 sites, displaying contrasting levels of eutrophication risk, for further field-based investigations. Grab sampling during once-off site visits revealed no significant correlation between estimated risk levels and nutrient (nitrate and phosphate) concentrations detected in water samples collected from the wetlands and their surroundings. By contrast the range of site-specific variation in nutrient levels observed declined with decreasing risk. The results are believed to reflect the range of hydrological delivery mechanisms supplying water to individual wetlands, and contrasting attenuation processes operating along different pathways. Study results help underscore the challenges faced in developing coherent water quality monitoring programmes, including the need for consistent datasets in the jurisdictions making up transnational RBDs and the need for further more detailed investigations to permit the development of a scientifically defensible monitoring rationale.

**Keywords:** Wetlands, Water Quality, Transnational River Basins

## 11. Development of Filtration Technologies for Effective, Cost-Efficient and Robust Water Treatment

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Clean water is a finite resource, demand for which is increasing rapidly due to urbanisation, technological developments and population growth. Treatment of water can be an expensive process, requiring capital and expertise. Recently, increasing attention has focused on contaminants such as metals, disinfection by-products and nutrients. Consequently, there is a need for efficient water treatment technologies that can provide a sustainable, flexible, low maintenance alternative, targeting a variety of contaminants in drinking water supplies.

Contaminant removal techniques can be physical, chemical, biological, or combinations thereof. This project focuses on physical mechanisms, comprising filtration and adsorption. This project investigates the use of novel filter media, including industrial waste products, for the filtration of nutrients (nitrogen, ammonium and phosphorus) and metals (aluminium and copper) from water sources. The focus is on developing technologies that are sustainable, with low life cycle impacts, and the reuse of waste products, where possible.

Bench-scale adsorption studies were carried out on a variety of media at various temperatures and pH values. Determination of the efficacy of various media in the adsorption of specific contaminants of interest allows for the optimal design of filters. The media were rated against each other and the most efficient were carried through to the next phase of the project. These included Bayer residue, fly ash and zeolite, as well as coarse and fine sand for use as a control.

To further test the novel media, 1m-deep laboratory-scale filters, using combinations of media, positioned over one another, were constructed in triplicate. Two types of operational regimes were investigated: slow and intermittently loaded sand filters. The results of this study will be used to develop design guidelines for filters, including optimized hydraulic loading regimes and appropriate configurations of filter media, which will remove a variety of major water contaminants.

**Keywords:** Water treatment, emerging contaminants, potable water, filtration, mixed media filters

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## 12. Widespread contamination of groundwater with Verotoxigenic *E. coli* (VTEC)

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Verocytotoxigenic *Escherichia coli* (VTEC) represent a major threat to public health. Approximately 18% of the Irish population receive their water from private rural group water supplies or private wells that may be particularly vulnerable to contamination with VTEC. This study examined source and treated waters of five group water supplies (GWS) for VTEC by novel and standard methods. A filtration enrichment method for screening large volumes of water for VTEC, involving capture and enrichment of bacteria from 30L water samples, was developed by the ARME Group, NUI Galway. Enrichments are screened for *eae*, *vtx 1* and *vtx 2* and antigenic determinants for *E. coli* O157 and O26 by real-time PCR. Strain isolation on CHROMagar™ STEC with and without immunomagnetic separation (IMS) is also carried out. Raw and treated waters were tested from five GWS on three occasions between August and October 2013. A separate 1L sample was collected in parallel for examination by standard immunomagnetic separation methods (ISO 16654:2001). All suspect VTEC colonies were screened using real-time PCR. VTEC was detected in raw water from 4 out of 5 GWS on each sampling occasion by the novel method. The *E. coli* O157 target was detected in every scheme and the *E. coli* O26 target was detected in 4 out of 5 schemes. VTX 1/2 positive *E. coli* O157 and *E. coli* O26 were isolated from 3 schemes testing positive for VTEC by real-time PCR. The standard protocol detected VTEC from one scheme on two occasions. VTEC was not detected by either method in treated water. VTEC is commonly present in groundwater in the region under investigation. In the GWS the treatment systems effectively eliminated VTEC from the water. The novel method detected VTEC in a higher number of samples than immunomagnetic separation methods alone.

**Keywords:** VTEC, groundwater, real-time PCR

### **13. Development of an improved modal CO<sub>2</sub> emission model for Eco-driving**

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A precise CO<sub>2</sub> emissions model in second-by-second resolution was developed for Eco-driving applications. Modal modelling is the most appropriate approach for CO<sub>2</sub> emission modelling of eco-driving, taking account of traffic congestion and aggressiveness in driving. The modelling approach adopted using high resolution speed and acceleration data, was improved with additional localised data. Both vehicle specific power (VSP) and Neural Network based approaches were compared. This paper, outlines the methodology of the research and model development, as well as the results of the initial stages of modelling. The results were derived from real world driving data obtained using a diesel powered van and a petrol powered car travelled around Dublin city. The vehicles were equipped with a handheld GPS (Garmin) for speed & acceleration data acquisition, a portable emissions monitoring device (Auto-Logic) and a weather monitoring device (Kestrel) for wind-speed data. Road grade data was also obtained using GPS. Road grade and wind speed have an impact on automotive aerodynamics, and it is expected that the addition of these data will improve the output of modal models. This pilot study is based on a limited number of sample trips and thus, information about an improved methodology of second-by-second vehicle emission modelling, and a better understanding of emission dynamics of the vehicles is expected as an outcome.

**Keywords:** Modal Model, Emission, Driving, Neural Network, VSP

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## 14. Potential of amine-modified porous solids as CO<sub>2</sub> adsorbents in fossil-fuel fired power plants

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Planet Earth is able to support life because of the “natural greenhouse effect”. This refers to the absorption of radiation by certain gases which is subsequently emitted as heat. Humans exacerbate this natural effect by altering the natural flows of energy through the atmosphere by increasing the amount of greenhouse gases in the atmosphere. Human activities such as the burning of fossil fuels are the main contributor to the increased amount of CO<sub>2</sub> in the atmosphere. Fossil-fuel fired power generating plants account for 40% of the world’s carbon-derived emissions. The effects of climate change include: more frequent extreme weather such as drought, heat waves, storms, disruption to usual rainfall patterns, habitat destruction. It is possible to remove CO<sub>2</sub> emissions from power plant flue gas streams by employing amine-CO<sub>2</sub> chemistry. The acidic CO<sub>2</sub> reacts with the basic amine to form carbamates and bicarbonates. At some power plants this is already being utilised by the use of liquid amines such as monoethanolamine (MEA) to strip CO<sub>2</sub> from the flue gas. The MEA solvent is regenerated by heating, releasing CO<sub>2</sub> which is pressurised for use as a feedstock or for storage as part of carbon capture and storage projects. However the regeneration of the liquid solvent can reduce a power plant’s efficiency by up to 30% and lead to corrosion of plant infrastructure. This project has focused on the amine modification of mesoporous solid supports such as SBA-15 and AlSBA-15 as potential solid sorbents for CO<sub>2</sub> capture from power plants. These would reduce the energy requirements during regeneration. These amine-modified solids have shown good potential in terms of CO<sub>2</sub> adsorption ability and stability.

**Keywords:** CO<sub>2</sub> capture, impregnation, amine modification of mesoporous solids

## **15. Fire, human and climate interactions throughout the Holocene.**

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Significant changes in global and regional climate as well as changes in vegetation, land use, agriculture and policy, have promoted an increase in fires in the Irish landscape. To understand these changes the interrelationship between fire, climate and people will be explored. Past climatic oscillations have been studied at 8 sites throughout Ireland in an attempt to understand the current climatic changes which may mirror future patterns in climate. The landscape character and fire regime of each of these sites will be reconstructed and will seek to develop a model of risk assessment and management for future fire in the Irish landscape. The data span from the early Holocene to the present day, drawing on charcoal and pollen data, radiocarbon dating, and mineral and chemical data from lacustrine sediments, as well as the historical record from a number of sites in Killarney National Park. This work presents the first chronological comparison of regional fire activity across various locations throughout Ireland, and provides a base line level of data which can be drawn on in future scenarios when fire frequency is expected to increase. This work is in its third year of a four year PhD programme and preliminary discussions and results will be presented.

**Keyword:** Fire, charcoal, climate. Holocene, Ireland

## **16. Ireland's Climate Information Platform – Facilitating Adaptation to Climate Change.**

Authors: Barry O'Dwyer, Stefan Gray, Jeremy Gault and Ying Wu.

Climate is changing and regardless of our attempts to limit the magnitude and rate of climate change, its impacts are now inevitable in the short to medium term and adaptation is required. Until recently, climate adaptation has not been considered a high priority for decision making in Ireland. However, the publication of Ireland's National Climate Change Adaptation Framework (2012) has made the incorporation of adaptation into spatial and sectoral planning practices a mandatory requirement and this poses a challenge to decision makers. In response, the Irish EPA-funded project 'Ireland's Climate Information Platform' (ICIP) is designing and developing a one-stop online resource of climatic and adaptation information for Ireland to facilitate decision makers in planning and managing for climate change adaptation.

For Ireland, there is now considered adequate climate information and data to begin the process of planning for climate adaptation. However, this data is disparate, being developed by a number of different institutions, with differing means of access, and using different techniques, models and scenarios. As a result, the employment of this information by decision makers is problematic. In order to make best use of available information, ICIP is collating and tailoring existing and relevant climate information for Ireland thus enabling users to redefine the problem of climate change for their specific area or sector of operation and begin to develop an understanding of the range of climate change impacts that they might face. Moreover, ICIP is developing a range of tools to allow decision makers scope for the direct and indirect impacts of climate change on their area/sector of operation, identify their vulnerabilities and develop flexible management strategies to deal with an uncertain future.

**Keywords:** Climate Change, Adaptation, ICIP.

## **17. Experimental and modelling studies of CO<sub>2</sub> capture via Pressure/Vacuum Swing adsorption for different experimental conditions and adsorbents**

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The capture of carbon dioxide via Pressure/Vacuum Swing Adsorption (PSA/VSA/VPSA) has been examined experimentally and mathematically. The adopted method was a two bed/four step process, known as the Skarstrom Cycle. Experimentally, the performance of seven different adsorbents (zeolites 3A/5A/13X, carbon molecular sieves, APTES-modified H-Beta 25, SBA-15 and Linear PEI SBA-15) for different experimental conditions (cycle time, pressure ratio, feed/purge ratio) have been examined. For comparative purposes, two mathematical models have been employed in the numerical simulations of the two bed/four step process: the first model was originally suggested by Doong and Yang (1987)\* and is based on linear diffusion within bidisperse porous media coupled with the linear driving force (LDF) approximation; the second approach is a more advanced model of linear diffusion coupled with a non-linear driving force approximation. Finally, the results demonstrate that, for this relatively simple process, capture of up to 99.9% of the CO<sub>2</sub> in a gas feed containing 10% carbon dioxide can be achieved with a three-fold increase in the average composition of the CO<sub>2</sub>. Improvement of the latter will be discussed with regard to future work on more complex process designs.

\*Doong, S.J., Yang, R.T., *AIChE J.*, **33**, 1045-1049 (1987).

**Keywords:** Carbon Dioxide capture, Pressure/Vacuum Swing Adsorption, Skarstrom Cycle, Mesoporous Silica, Zeolites, Modelling-Simulations

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## 18. Assessing land-use change in Ireland using the Land-Parcel Identification System (LPIS)

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Carbon dynamics linked to Land-Use and Land-Use Change (LULUC) are considered a major factor in the global Greenhouse Gas (GHG) budget. While the effects of different types of land-use change on the GHG budget have been well studied, assessing land-use change at a national level is subject to uncertainty.

In Ireland LULUC are currently modelled using national statistical data on total land-uses and socio-economic data. This may lead to bias as it neither provides information on direct land-use change trajectories nor spatially explicit information such as soil properties. The aim of this study is to assess the suitability of the land-parcel identification system (LPIS) to assess overall inter-annual land-use change as well as the immediate trajectory of change reported, and to provide tools for this purpose.

For the available LPIS datasets (2000 to 2012) a number of issues have been identified. (1) Duplication of parcels led to a major overestimation of the agricultural area, (2) no continuous identification of parcels through time complicates tracking land-use change, and (3) parcel outline changes over time without indication if the changes represent real-world changes or corrections of the LPIS database.

Geographic Information Systems tools have been developed to address those issues, including a tool to remove duplicate parcels and a tool that assigns unique parcels identification codes based on spatial stability. To differentiate between real-world change and corrections in the database minimum criteria based on differences in parcel area and shifts in the parcel centroid over time have been introduced. Using the newly assigned parcel identification codes it could be shown that parcel stability between consecutive years is very high (90.5 %  $\pm$ 3.2 of the parcels in any year are present in the following year). These results indicate that LPIS has a strong potential for identifying inter-annual land-use change between consecutive years.

**Keywords:** Greenhouse gas emissions, land-use, land-use change, climate change, agriculture

**19. Effects of scale and landscape structure on pollinator diversity and the provision of pollination services in semi natural grasslands.**

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Over recent decades, humans have been changing the environment more rapidly than in any other period of history. Technological advances and new agricultural policies have led to a simplification of landscape structure resulting in the loss and fragmentation of habitats for flower-visiting insects which play an important ecological role as pollinators. Pollinating insects are very mobile and are influenced by the availability of flowers and nest sites over a scale of several kilometres.

In this study, we investigated the effects of the complexity of landscape structure on the diversity of four pollinating taxa (solitary bees, bumblebees, butterflies and hoverflies) and on the provision of pollination services to four plant species. Pollination data were collected in 19 semi-natural grassland sites in north midlands region of Ireland and related to the composition and configuration of surrounding landscape at two spatial scales (500m and 1km radius around sampling sites). Landscape structure was characterised by digitising each landscape feature with aerial photographs and GIS, and then ground-truthed using field-based surveys. Preliminary results indicated that each pollinator group responds in a different way to the landscape structure at the two studied scales in function of the resources they need.

Knowledge of these pollination/landscape scale relationships is crucial for a better understanding of pollinator diversity patterns in extensive agricultural system areas of Ireland and should be helpful for future conservation management decisions; ensuring essential levels of pollination services to wild plants are maintained.

**Keywords:** biodiversity, extensive agricultural system, landscape composition, landscape configuration, pollinator diversity, pollination services, spatial scales, semi natural grasslands.

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## 20. Diffusion of an Innovative Land Use – Private Afforestation in Ireland between 1990 and 2012

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Ireland has experienced an upsurge in private afforestation from the mid 1990's onwards. Farm households are incentivised to establish forestry plantations through a variety of financial inducements including establishment grants, annual premiums and a tax concession on forestry income. Despite these financial benefits, the rate of farm afforestation was and remains below national target levels. Whilst some of this research has pointed to the geographically uneven nature of participation in the afforestation scheme, the role of place in understanding the decision of farm households to plant, or not, forestry remains under-researched. In this paper we apply a novel approach to determine whether the local context influences adoption rates. The Poisson-based Kulldorff scan statistic coupled with the Visual Inquiry Toolkit is used to test whether this innovation diffused randomly through all farm households or in clusters of high adoption (hot spots) or low adoption (cold spots). Covariates specifying the suitability of Irish agricultural land for afforestation as set out in the Indicative Forestry Statement (2008) were included in the Kulldorff scan statistic to remove potential bias. On average 40 per cent of all new forestry stands occurred in hot spots and 10 per cent in cold spots among the farming population that had a probability of lower than 0.05 of occurring by random chance. The hot spot and cold spot figures should have been 22 per cent and 27 per cent respectively. These findings indicate that there are significant local drivers and inhibitors to incentivised land use changes among local communities of farm households. National top down afforestation policies which fail to account for local factors are likely to be sub optimal. This offers useful insights for policy makers in the promotion of other voluntary incentivised land use changes among the Irish farming community such as biomass crops, agri-environmental schemes, etc.

**Keywords:** biomass, farm forestry, land use innovation, policy, communication networks

## **21. Effects of endophytic bacteria isolated from bioenergy crops on the biology and behaviour of entomopathogenic nematodes**

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Entomopathogenic nematodes (EPN) and bacterial endophytes have considerable potential in biological control and plant growth promotion (PGP), respectively. The use of EPN together with various crop protection or improvement agents, as well as their compatibility with conventional agricultural equipment has been well documented. Similarly, the use of bacterial endophytes in the promotion of plant health and soil fertility has also been well documented.

Although EPN and bacterial endophytes naturally function in a common habitat in the soil and have widespread applications as biological control agents, the potential of synergism has yet to be explored. Knowing and understanding how different nematode species and strains interact with naturally occurring soil biota may result in increased plant growth and health, in addition to a reduction in the use of non-specific chemical fertilisers and pesticides. This project will investigate the potential synergism between these two naturally occurring taxa with the aim of producing a more sustainable, cost effective and environmentally friendly biological control product for both food and non-food crops. Investigating the effects of various endophytic bacteria on nematode biology and behaviour is essential when developing such a product to ensure nematode efficiency and predictability within a dynamic environment.

This project explores the potential synergism between an Irish strain of EPN *Steirernema feltiae* (12[1]) and the commercial EPN *S. feltiae*, *S. carpocapsae* and *Heterohabditis bacteriophora* (e-nema), and a number of endophytic bacterial strains isolated from bioenergy crops. The results presented here will be from experiments investigating the effect of endophytic bacteria on nematode infectivity in laboratory and glasshouse tests, virulence, life cycle in *mellonella* hosts and nematode fecundity.

**Keywords:** Biological control, entomopathogenic nematodes, endophytic bacteria

## **22. The dose dependent effect of nano and micron sized silver particles on microbial community structure and function in grassland soil**

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The use of nanomaterials is becoming increasingly more widespread in industry. As a result environmental contamination is likely to increase. Currently little is known about the fate of these particles in natural ecosystems. This experiment was set up to investigate the dose dependent effects of silver particles on soil microbial community structure using a soil based microcosm. The soil used in the experiment was collected from an agricultural pastureland and characterised for physico-chemical properties using CEN protocols. Two powder based silver particles (average particle size 20nm and 0.5-1µm respectively) were added to soil at 1, 5, 10, 20 and 50ppm (per Kg fresh weight soil) as a suspension in a 0.01M NaCl solution and compared against an un-inoculated control (NaCl solution only). The experiment was run for 30 days in dark conditions at 22°C while maintaining constant soil moisture content. Soil was sampled on days 0, 3, 6, 10, 20 and 30 for soil enzyme measurements. Dehydrogenase and urease activities were affected by both particles with the 20nm particle reducing activity to a greater extent than the 0.5-1µm particle. Dehydrogenase activity was affected to a greater extent than urease activity and by lower concentrations of the particles. Soil samples on days 0, 6 and 30 were investigated for microbial community structures at concentrations of silver particles at 10, 25 and 50ppm. The bacterial community was found to be affected by both silver particles. The 20nm particle changed the community structure at 10, 25 and 50ppm on days 6 and 30. The 1 micron sized particle only affected community structure at 25 and 50ppm. Soil microbial communities were not statistically different at similar concentrations on day 6 and only differed at 50ppm on day 30 ( $P=0.0384$ ) suggesting similar effects. The fungal community was found to be strongly affected by the 20nm silver particle compared to the 0.5-1µm particle, with the 20nm silver particle differing from the control and 0.5-1µm particle treated soil at 10, 25 and 50ppm by day 30.

**Keywords:** nanoparticles, silver, environmental microbiology, toxicology

### **23. Controlling the abundance of tall herb *Filipendula ulmaria* on the River Shannon Callows**

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The Shannon Callows is the most extensive area of seasonally flooded lowland wet grassland in Britain and Ireland. These semi-natural grasslands support a wide range of plant and bird species. They also provide a host of essential ecosystem services, including being a valuable agricultural resource. The low-intensity agricultural management which has been practiced for centuries is essential in maintaining this ecosystem. The permanent meadows are of the greatest botanical interest as they are more species-rich than the pastures, but they also have had the greatest management problems in recent years with some of them becoming dominated by the tall competitive herb *Filipendula ulmaria*.

This has coincided with extensive summer flooding which the callows has experienced over recent years, often leading to meadows being left uncut for several years. In the absence of this management, competitive species like *Filipendula* can become dominant and suppress smaller less-competitive species leading to a decline in plant species richness. *Filipendula* present in such large quantities also dramatically reduces the value of the fodder saved by the farmers.

This research addresses the restoration of the meadows to healthy conservation status and good hay quality by comparing the effectiveness of different cutting treatments. Three treatments are being tested; two cuts (July & Sept), two cuts plus strewing of green hay from a neighbouring species rich meadow and a control of one cut (July). These will be repeated for two years. Relevés and biomass samples were taken in summer 2013 as a base-line to monitor changes in plant species richness and evenness as well as biomass changes in *Filipendula* compared to other functional groups and will be repeated in the final year (2015). Initial data demonstrate the base-line differences in site vegetation.

**Key Words:** Species-richness, hay quality, low-intensity farming, meadow restoration

## **24. Identifying the distribution and extent of High Nature Value (HNV) farmland in Ireland**

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IDEAL-HNV is a collaborative project between IT Sligo and Teagasc that aims to map the potential distribution of High Nature Value (HNV) farmland in Ireland. HNV farmland is typically characterised by low intensity farming as well as supporting high biodiversity and a range of wildlife habitats. This type of farmland is important for the conservation of semi-natural habitats and the plants and animals associated with them. Supporting HNV farmland is necessary to ensure vibrant rural communities and deliver environmental public goods such as high quality water, air and soil, resilience to flooding, and farmland biodiversity. It is also an EU policy requirement to identify, assess and support these farming systems through national Rural Development Programmes.

This project will develop and apply geostatistical methods for identifying systems associated with HNV farmland. These will include object-oriented image classification and landscape heterogeneity measures. It will also conduct farm surveys to assess the accuracy of GIS methods for identifying HNV farmland, describe the HNV typologies in Ireland and develop a decision-support tool to identify HNV areas at the farm-scale. Finally the project will analyse the socio-economic and policy implications that may arise from HNV farmland identification.

To date, data and software requirements of the geostatistical analyses have been fulfilled and an initial coarse potential HNV map has been developed. Fieldwork commenced in 2013. Here, we present preliminary results from the project, including the likely distribution of Irish HNV farming systems.

**Keywords:** farmland biodiversity, low intensity farming, semi-natural habitats, potential HNV distribution

## 25. Power to Gas applied to Ireland

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The Sabatier equation describes a chemical reaction, whereby carbon dioxide and hydrogen combine exothermically to give methane and water ( $4\text{H}_2 + \text{CO}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}$ ). Two process routes are possible: chemical and biological. The hydrogen required for this process may be provided by electrolysis of water. Thus, the process may provide a solution to the problem of storage of intermittent electricity sources, such as wind or ocean energy, while recycling  $\text{CO}_2$  and generating renewable natural gas (RNG). Ireland plans to have 40% of its electricity coming from renewable sources, predominantly wind, by 2020. Even with interconnection with Great Britain, wind curtailment levels are expected to be in the range of 6.5 to 14%.

The source of  $\text{CO}_2$  is crucial in the viability of such a process. The higher the concentration of  $\text{CO}_2$  in the source stream, the lower the cost of capture.  $\text{CO}_2$  in ambient air and flue gases is very dilute and, as such, expensive to capture. Anaerobic digestion produces highly concentrated carbon dioxide streams, and is thus highly suited to the Sabatier process. The use of biogas in a Sabatier reactor can eliminate the need for biogas upgrading facilities, while greatly increasing methane production. This work examines the potential resource for the Sabatier process in Ireland, looking at both  $\text{CO}_2$  and renewable electricity resources. The economic case for a combined anaerobic digestion and Sabatier facility in Ireland is also presented. The potential RNG resource is limited by the expected supply of surplus electricity. Biogas upgrading via this method is expected to be more expensive than typical upgrading routes. The viability of a Sabatier plant in Ireland may then depend on the provision of government subsidies. This research lays the foundations for the development of a lab-scale biological system, where raw biogas will be upgraded to a high methane content by hydrogen-consuming microbes.

**Keywords:** Sabatier, biogas upgrading, methanation

**26. Assessing the potential to produce Biomethane, from *Ulva lactuca* and dairy slurry using BMP and semi-continuous systems.**

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*Ulva Lactuca* is a green macro algae which can naturally accumulate on beaches and shallow estuaries which are prone to eutrophic conditions, resulting in beach closure and an environmental hazard known as “green tides”. Currently the *Ulva* is land filled or land spread. This biomass is classified as a third generation biofuel and has the advantage over first or second generation biofuels with not competing directly with land used in the production of food. *Ulva* was collected over 2 years to assess annual variation, from the Argideen estuary, West Cork; up to 10,000 tonnes of this, algae biomass arises each year in this estuary. The biomass was exposed to a combination of 4 pre-treatments in an attempt to increase its specific methane yield. These include washing, wilting, macerating and drying. The treated and untreated *Ulva* was assessed for BMP (Biochemical methane potential). Fresh *Ulva* has a biomethane yield of 183 L CH<sub>4</sub>/kg VS. The best performing pre-treatment (dried, washed and macerated *Ulva*) generated a BMP of 250 L CH<sub>4</sub>/kg VS. The *Ulva* biomass however showed high levels of sulphur and a low carbon to nitrogen (C:N) ratio (7 – 9.5). To avoid any potential inhibitory effects which may occur, *Ulva* was co-digested with dairy slurry. Ratios of 25%, 50% and 75% *Ulva* and slurry were selected to obtain an optimised co-digestion percentage mix for both fresh and dried *Ulva*. Synergistic effects were observed in all 6 assays with an increase of up to 19% in biomethane yields. To more closely replicate an industrial process these 6 mixes were operated in 5L semi-continuous reactors fed daily for 9 months. Trials showed that a mix of 25% fresh *Ulva* and 75% slurry performed best, yielding 193.23 L CH<sub>4</sub>/kg VS; an increase of 22% from expected yields based on pro-rata BMP results of individual substrates.

**Key words:** Biomethane, third generation, *Ulva Lactuca*, BMP, Semi-continuous.

## **27. Enhancing the Consolidated Bioprocessing (CBP) Activity of *Fusarium oxysporum* by manipulating a Hemicellulose Fermentation Enzyme**

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Fungal-mediated consolidated bioprocessing (CBP) of lignocellulosic material has significant potential to bring a breakthrough in commercial bioalcohol production by reducing the overall cost of production. *Fusarium oxysporum* is one of the most promising CBP agents that has been identified thus far. Recent work in UCD found that strains of this fungus differed in their ability to release ethanol from straw, *F. oxysporum* 11C being the most efficient strain and strain 7E being relatively inefficient. Complete utilization of both hexose and pentose sugars is a prerequisite for efficient bioethanol production. UCD researchers identified a hemicellulose fermentation gene (Gene A) encoding an enzyme actively involved in pentose metabolism whose activity was higher in strain 11C as compared to strain 7E (in press). The ability of this gene to influence lignocellulosic bioconversion was assayed. Silencing of this gene in *F. oxysporum* mutants had a negative effect on bioethanol yield from untreated wheat straw/bran. Conversely, overexpression of this gene in *F. oxysporum* mutants showed a rise in bioethanol yield. These results suggest that this gene plays a key role in the fermentation of lignocelluloses to alcohol by *F. oxysporum* 11C.

**Keywords:** *Fusarium oxysporum*, Hemicellulose fermentation, Consolidated Bioprocessing, Lignocelluloses, Bioethanol

## 28. Catalytic Hydrogenation of Furfural to Furfuryl Alcohol

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Due to the growing demand for fossil fuels there is a rising interest in the research and utilisation of alternative energy sources and fuels. Biofuel research and production has increased greatly as a result of this demand in particular the use of biomass as a starting material. Consequently, this has led to a significant number of derived research areas. One such area is the production of fine chemicals; furfural is an example of a functional by-product which is produced naturally from biomass in the biofuel industry and has an extensive number of derivatives.

Furfural may be synthesised to generate a large chemical set, many of which are valuable for use in both industry and the production of additional chemicals. One of the most important of these derivatives is furfuryl alcohol which is used extensively in the polymer and chemical manufacturing industry. Furfuryl alcohol is produced by the catalytic hydrogenation of furfural in the liquid or vapour phase. Traditionally, copper chromite catalysts were used for this process and while still partially active in industry it poses a severe environmental threat particularly to water sources and aquatic life. The challenge induced with the disposal of this catalyst has created a significant research emphasis on attaining a suitable alternative which is inexpensive and effective.

The research presented here is focused on the production of furfuryl alcohol with the objective of producing an economically viable catalyst to replace the traditional copper chromite catalyst. A variety of precious metal catalysts were produced using an array of supports. All catalysts were produced by wet impregnation and were subject to hydrogenation under a range of temperatures and pressures. All catalysts were tested for conversion of furfural and selectivity to furfuryl alcohol. Studies were also carried out comparing the performance of synthesised catalysts to a number of commercial catalysts.

**Keywords:** biomass, catalysis, hydrogenation, furfural, furfuryl alcohol.

## **29. A Comparative Analysis of Pre-treatment Technologies for the Bioconversion of Willow, Miscanthus and Hemp**

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Biofuel produced from lignocellulosic material, so called second generation bioethanol shows energetic, economic and environmental advantages in comparison to bioethanol from starch or sugar, first generation biofuel. However, physical and chemical barriers caused by the complex structural matrix of the main components (cellulose, hemicellulose and lignin) hinder the hydrolysis of the cellulose and hemicellulose to fermentable sugars. Pre-treatment technologies are designed to increase enzyme accessibility thereby improving digestibility of cellulose. Pre-treatments can be divided into three categories: physical, chemical and biological. This paper focuses on chemical pre-treatment, comparing the efficiency and yields of selected pre-treatments on Irish feedstocks: willow, miscanthus and hemp. Pre-treatments include dilute acid, alkaline and ammonia fibre explosion. Enzymatic hydrolysis and a simultaneous saccharification and fermentation process (SSF) are described in the comparative report on bioethanol yields presented in this paper.

Sample analysis was conducted using an ICS 5000 Ion Chromatograph. Ion chromatography is used to deliver a highly sensitive qualitative and quantitative sample analysis. The use of ion chromatography in this type of research is a relatively new idea, with previous research of pre-treatments being performed on HPLC instrumentation.

**Keywords:** Willow, Miscanthus, Hemp, Pre-treatment Enzymatic Hydrolysis

### **30. The potential for biomethane from grass and slurry to satisfy renewable energy targets**

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The Renewable Energy Directive requires that 10% of all energy in transport in Ireland must be renewable by 2020. Second-generation biofuels such as grass biomethane can be used to comply with such targets. Ireland has a temperate climate which can potentially achieve high annual yields of grass in a European context. The introduction of government initiatives to increase beef and dairy exports has put further demand on grassland resource in the country. Implementing the maximum N fertiliser application and a more efficient grass utilisation rate could provide a substantial grass resource in excess of livestock requirements. This surplus grass could serve as an excellent feedstock for biomethane production. A biomethane potential (BMP) assessment was carried out to quantify the specific methane yields for grass silage, dairy slurry and the co-digestion of grass and slurry. On a fresh weight basis, grass silage produced almost 7 times more methane than slurry ( $107 \text{ m}^3 \text{ CH}_4 \text{ t}^{-1}$  compared to  $16 \text{ m}^3 \text{ CH}_4 \text{ t}^{-1}$ ). First and second order kinetics of the different BMP substrates were obtained. A matrix of the potential bioresource of second-generation gaseous biofuel in Ireland based on quantities of potential excess grassland was established. This study illustrates that co-digestion of the majority of slurry produced from dairy cows in Ireland with grass silage quantities equivalent to 1.1% of grassland on a 50:50 volatile solids basis would generate over 10% renewable energy supply in transport (RES-T). The industry proposed would equate to 170 digesters each treating  $10,000 \text{ t a}^{-1}$  of grass silage and  $40,000 \text{ t a}^{-1}$  of slurry from dairy cows.

**Keywords:** Gaseous biofuel, Grass silage, Slurry, Biogas, BMP

### **31. Studying post glacial colonisation routes of Irish soil fauna through the phylogenetic analysis of *Oniscus asellus*.**

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Post glacial colonisation routes and the possibility of an Irish glacial refuge have been explored in relation to several Irish mammal species. However, the status of Ireland's soil fauna during the last ice age has been largely ignored. This study aims to investigate the phylogeography of the isopod *Oniscus asellus* in order to begin to understand the movements of this species during, and after, the last glacial maximum. Molecular analyses of Irish and European samples are being used to study genetic differentiation between *O.asellus* populations and morphological differences are being assessed using geometric morphometric analysis. Some critical aspects of the biology of this widespread species are not well known. In this study the lethal cold temperature of different populations of *O.asellus* were compared to identify how Irish populations might respond during periods of extreme cold.

Microsatellite markers were developed following next generation sequencing. These are being used in conjunction with mitochondrial markers to gain an insight into the relatedness of Irish and European populations of *O.asellus*. The genetic markers developed will be used in addition to morphometric comparisons to identify specimens of *Oniscus asellus occidentalis* collected from its restricted range within Ireland and England. Although hybrids between *O.a asellus* and *O.a.occidentalis* are widespread throughout Western Europe, *O. a. occidentalis* is thought to be our most vulnerable woodlice species.

It is hoped that this multidisciplinary approach will provide new information regarding the factors that restrict the distribution of *O.asellus* and the movements of the species during the LGM. This in turn, will provide an insight into the origins of Irelands' soil fauna.

**Keywords:** *Oniscus asellus*, phylogeography, morphometric, colonisation.

**32. Is the grass ‘greener’? Biodiversity impacts of legume-supported grasslands.**

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Biodiversity is of great importance for the delivery of many key ecosystem services in agriculture (Altieri and Rogé, 2010) such as pollination, weed suppression, soil conditioning and pest control. Legume crops have a long history of use in traditional agricultural systems for the ability to fix atmospheric nitrogen (Graham and Vance, 2000) but have suffered a decline due to the ready supply of cheap inorganic fertilisers over recent decades (Graham and Vance, 2003). The Legume Futures project (EU FP7) aimed to investigate the potential for promotion of wide-spread legume-supported cropping in Europe, and the potential environmental impacts of such systems. We surveyed non-crop vegetation and earthworm (Lumbrucidae) biodiversity in semi-permanent and permanent agricultural grasslands, with and without legumes, at four established field sites belonging to the Legume Futures consortium ([www.legumefutures.de](http://www.legumefutures.de)). We found that responses to legume-supported cropping were different for non-crop vegetation and earthworms, and were dependent on the measure of biodiversity – abundance, species richness, diversity indices etc – considered. Mixed grass-legume swards supported more even and more diverse (Shannon’s H’ Index) non-crop vegetation communities but had less obvious impacts on earthworm communities.

**Key words:** biodiversity, agroecosystems, non-crop vegetation, earthworms

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**33. The effects of non-native *Sarracenia purpurea* L. and *Darlingtonia californica* Torr. on vegetation communities and peat accumulation in Woodfield Bog, a raised bog in Co. Offaly**

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The non-native pitcher plant *Sarracenia purpurea* has been identified as an important invasive plant species on Irish peatlands. Despite being found in increasing amounts within known infected sites, little is known about their impact on peat-forming vegetation communities and peat accumulation processes. The effects of the pitcher plants *Sarracenia purpurea* and *Darlingtonia californica* on vegetation communities within Woodfield Bog, a raised bog in Co. Offaly, were examined. Systematically placed relevés (125 x 1m<sup>2</sup>) were recorded within afflicted areas using the DOMIN scale. The relevé dataset was analysed using non-metric multidimensional scaling ordination and hierarchical, agglomerative, polythetic cluster analysis.

Both pitcher plant species are completely naturalised; however, *S. purpurea* has reached invasive status at Woodfield Bog. Ombrotrophic vegetation groups appear to be defined by the magnitude of *S. purpurea* cover. Shannon-Weiner diversity was highest in relevés containing only native vegetation and lowest when *S. purpurea* cover exceeded 90%. Plant species richness and diversity began to decline once *S. purpurea* cover exceeded 50%. *S. purpurea* and *Sphagnum* bryophytes, a key peat-forming genus, reached their highest magnitude of cover in the wetter portions of Woodfield Bog. The cover of *S. purpurea* increased as *Sphagnum* abundance decreased. *Sphagnum* cover was found to decline considerably and consistently when *S. purpurea* cover exceeded 25%.

The *D. californica* population should be monitored for changes to its current population status. *S. purpurea* alters ecosystem structure and function by displacing native species. Due to the ability to successfully colonize peatland habitat, early detection and eradication of *S. purpurea* introductions to new sites should be a priority. Research pertaining to the population biology and ecology of *S. purpurea* should be undertaken in order to better understand factors controlling their success as invaders, and identify life history stages where management strategies will be most effective.

**Keywords:** Raised bogs, ombrotrophic vegetation communities, peat accumulation, invasive species, *Sarracenia purpurea*, *Darlingtonia californica*

### **34. The impact of the aquatic invasive weed species *Lagarosiphon major* on the seed banks of native Charophytes**

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The invasion of the alien species *Lagarosiphon major* and other aquatic members of the Hydrocharitaceae family have led to substantial changes in the native plant community of aquatic ecosystems. Such infestations have placed increasing pressure on native biodiversity. While ongoing studies have outlined the negative impact of *L. major* on both flora and fauna its impact on the seed banks of native species remains unclear.

We examined the impact of the tall growing invasive *L. major* on seed bank characteristics of native low growing charophyte species. The distribution of charophyte oospores were determined using a modified coring device which allowed the sediment cores taken under *L. major*, *Elodea canadensis*, and charophyte species to be sectioned into 3 depths (0-5cm, 5-10cm, 10-15cm). After sieving, oospores were counted and a subset germinated under controlled laboratory conditions. This determined seed bank characteristics and potential for recovery from oospores.

Oospore densities were generally high at all depths under charophytes. Weed beds of *L. major* and *E. canadensis* significantly reduced the density of oospores in the first 5cm of the sediment. Reductions of up to 99% under *L. major* and 98% under *E. canadensis* were recorded relative to under charophytes. Germination experiments showed oospores at all depths were capable of germination when overlying sediments were removed.

The impact of invasive weeds on native seed banks may be attributed to reduced oospore production coupled with increased sedimentation in invaded areas. Recruitment of charophytes is also hindered by the poor dispersal capacity of oospores. Our results suggest regeneration potential of native seed banks is greatly reduced by the presence of invasive weed species. This could hinder community rehabilitation after control efforts have been made. New methods may be needed to ensure the rapid regeneration of native communities that support a rich diversity of invertebrates.

**Key words:** Alien species, oospore, charophyte, *Lagarosiphon major*, *Elodea canadensis*, hydrocharitaceae, biodiversity.

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### 35. Modelling biological invasion by the Asian kelp *Undaria pinnatifida* in European coastal habitats

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Introductions of species to new continents and oceans cause fundamental and irreversible changes to natural communities and ecosystems worldwide, resulting in systematic homogenization of biota of a region and distinct changes in ecosystem functioning. Alien seaweeds represent one of the largest groups of marine aliens in Europe, and constitute between 20 and 29% of all alien marine species. Seaweeds are major primary producers in coastal areas, and large-scale substitution of dominant native seaweeds with alien species will consequently alter coastal productivity and food web structure, and therefore impact ecosystem services.

In this study, a computational modelling approach is being taken, in association with data already gathered by the host institution from field studies, ecological experiments and molecular work, to study the impact of the Asian kelp seaweed *U. pinnatifida* (an emblematic invader in the English Channel and a threat for Ireland) on native biodiversity under variable climatic conditions. The aim of this project is to develop a generic individual-based model of coastal ecosystems for investigating the underlying mechanistic basis for ecological features and invasive potential of this species.

The spatial pattern of an invasion plays a key role in the rate of spread of the species and understanding this can lead to significant cost savings when designing efficient management strategies. We are developing a model framework that can be used to explicitly represent complex spatial and temporal patterns of invasion in order to be able to predict quantitatively the impact of these factors on invasion dynamics of *U. pinnatifida*. This would be a useful tool for making accurate risk assessments of invasion potential under different environmental conditions and for choosing optimal management strategies in order to minimise future control costs.

**Keywords:** *Undaria pinnatifida*, invasive species, seaweed, individual-based model

### **36. A proposed new classification system for Irish semi-natural grassland communities.**

Dr. Fionnuala O’Neill.

The Irish Semi-natural Grasslands Survey (ISGS) was carried out by BEC Consultants between May 2007 and September 2012 under the auspices of the National Parks and Wildlife Service. The six years of the ISGS resulted in the botanical survey and mapping of 1,192 grassland sites covering 23,188 ha of Ireland. A total of 4,544 grassland relevés were recorded. A new grassland vegetation classification system, based on these relevé data and identified by means of fuzzy analysis in the R statistical environment, is outlined in this presentation. Nineteen separate grassland communities were identified: nine of wet grassland/mire, six of dry calcareous/neutral grassland and four of dry/humid acid grassland. It is recommended that future grassland surveys in Ireland utilise this classification system for vegetation community description and mapping, as it gives greater resolution for distinguishing between different grassland habitats than the current Heritage Council classification system (Fossitt 2000), which describes only four grassland habitats and one marsh habitat.

### 37. Environmental toxicity of ZnO nanoparticles: impacts on Lemna minor

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Nanoparticles are particles that have at least one dimension in the range of 1~100 nm. Nano-ZnO is used in many different applications (transportation, cosmetics, etc.). It is anticipated that as a result of the extensive production and use, nano-ZnO will inevitably end up in the environment.

The aims of this project are to determine the phytotoxicity of ZnO nanoparticles and the potential mechanism thereof.

The short-term and long-term toxicity of nano-ZnO were determined by measuring impacts on Lemna minor organismal endpoints (growth rates of biomass and fronds, root length), pigments (chlorophylls and carotenoids) content and photosynthetic efficiency (Fv/Fm, qN, qP and Y(II)), using one-week (according to OECD guidelines) and 6-week (according to lifespan of Lemna minor fronds) exposure experiments. To analyze the dynamics of nano-ZnO-induced phytotoxicity, effects on chlorophyll a fluorescence were measured daily, for up to 7 days. To establish the role of released Zn ions in nano-ZnO toxicity, a comparison was made between one-week-exposure impacts of “Zn<sup>2+</sup> equivalent of nano-ZnO” and added nano-ZnO on Lemna minor endpoints (organismal endpoints, chlorophyll content and photosynthetic efficiency). The effect of pH on the release of Zn ions in medium and pH dependent effects of nano-ZnO on Lemna minor endpoints (organismal endpoints, pigments content and photosynthetic efficiency) were also studied.

Results showed that all endpoints were negatively affected by added nano-ZnO. The strongest toxicity was found in long exposure experiments. Rapid inhibitory effects (started from day 1) were found in "dynamic toxicity" test. Similar effects were found when plants exposed to “Zn<sup>2+</sup> equivalent of nano-ZnO” and added nano-ZnO, respectively. Furthermore, rapid and total dissolution of nano-ZnO was found at pH 4.5 (pH of the medium), however, almost no released Zn<sup>2+</sup> was found at pH 8.

This study shows that toxicity of nano-ZnO varies with concentration and can be aggravated by exposure time. The release of Zn ions is particularly strong at low pH-values. It is concluded that the main reason for nano-ZnO toxicity on Lemna minor is released Zn ions,

**Keywords:** nano-ZnO, Lemna minor, acute toxicity, chronic toxicity, released Zn ions.

**38. Examining the Occurrence of Antimicrobial Resistance in E. coli Isolated From Veterinary and Environmental Sources and Exploring the Relationship via Spatial Mapping**

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The emergence of resistance genes coupled with the increasing use, and misuse, of existing antibiotics in human and veterinary medicine has led to an antibiotic burden on the environment [1]. The development of generations of antibiotic-resistant microbes throughout the planet is the result of years of selective anthropogenic pressure via overuse, underuse and misuse of antimicrobials.

To explore the geographical patterns of acquired antimicrobial resistance at a local level *Escherichia coli* isolated from animals suffering from a bacterial infection and potable water sources were mapped. All clinical animal samples and bacteria isolated from the potable water with laboratory confirmation of *E. coli* were included and antimicrobial susceptibility testing was performed. Locations of sample sites were geocoded and antimicrobial susceptibility zone diameters were mapped against location using ArcGIS software. Large amount of antibiotics are used in veterinary medicine annually and many of these get excreted into the environment. However little is known about the effects of these chemicals on bacteria found naturally in the environment. Furthermore, water sources, sewage and other wastes have been polluted with sub-lethal concentrations of antibiotics. This sub-lethal application could lead to natural microbial populations developing a new resistance. Our study is the first example of a geographical mapping analysis of antimicrobial resistance in *E. coli* from animals infected with a bacterial infection and the potential impact on groundwater. By geo-mapping antimicrobial resistance patterns of pathogenic bacteria over geographical areas it will provide information on the spread of resistant organisms and may aid in the explanation of patterns in the occurrence and spread of antimicrobial resistance.

Dowling, A, O'Dwyer, J, Adley, C.C, 2013 Alternatives to antibiotics: future trends, Microbial pathogens and strategies for combating them: science, technology and education. Formatex Research Center. pp 216-226. ISBN (13) Volume 1: 978-84-939843-9-7.

**Keywords:** Epidemiology, spatial mapping, antibiotic resistance profiles

### **39. Using Tellus airborne geophysical and geological data to map radon risk potential**

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Radon is a radioactive element which occurs naturally from rocks and soils as a daughter product of Uranium 238 and Radium 226. Exposure to high concentrations is known to increase the risk of lung cancer (UNSCEAR 2009; WHO, 2009). Accurate mapping of its occurrence can help identify households that are at potential risk of radon exposure and highlight areas where buildings require radon mitigation measures. Currently radon risk maps are based on in-house measurements at a 10km grid scale.

Tellus Border is an EU-funded regional mapping project which has collected airborne geophysical data, including variations in natural radiation across the six border counties - Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth. Equivalent uranium data measured from a low-flying aircraft has been used in conjunction with other available geological data (groundwater recharge coefficient, bedrock type and degree of karstification) to help map radon risk potential. Models have been constructed and evaluated using indoor radon measurements made available by the Radiological Protection Institute of Ireland. These models use multivariate linear regression based on 1km grid squares. The airborne and geological data is assigned to grid squares and correlated with existing indoor radon measurements. Good agreement has been found and new detailed maps of radon risk produced. New anomalous zones have been found and are subject to further investigation. By using 1km compared to 10km grid squares the resolution of the mapping has been improved by a factor of 10.

The project is a joint initiative between the Geological Survey of Ireland, the Geological Survey of Northern Ireland, Dundalk Institute of Technology and Queen's University Belfast and follows on from the successful Tellus project completed in Northern Ireland. All survey data is freely available from the project website [www.tellusborder.eu](http://www.tellusborder.eu).

## **40. Development and Application of a Real-time PCR-based Method to Estimate Levels of Infectious Norovirus in Environmental Samples**

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Human norovirus (HuNoV) is a pathogen responsible for over 90% of viral gastroenteritis cases across the world and is frequently linked to the consumption of contaminated produce. Filter-feeding bivalves can be exposed to HuNoV contamination when grown in waters impacted by municipal wastewater. Such shellfish can represent a significant health risk when consumed raw or lightly cooked.

Due to the lack of a reliable host cell-line in addition to other obstacles, current real-time reverse-transcription PCR (RT-qPCR) methods are routinely used for the quantitative estimation of HuNoV concentrations in shellfish. While highly sensitive and accurate, a major disadvantage of PCR is that it can lead to an overestimation of infectious virus concentrations as it cannot distinguish between infectious and non-infectious virus particles. The aim of this project is to identify molecular methods that can provide a clearer understanding of the infectious risk associated with levels of HuNoVs detected in environmental samples.

We identified an approach that uses long-range RT-qPCR (loRT-qPCR) to estimate virus infectivity based on genomic RNA integrity. We developed and optimised this approach for HuNoV genogroups I and II (GI and GII). In addition, as an infectivity assay is not available for HuNoV we applied the same approach to a surrogate virus, namely F-RNA bacteriophage genogroup II (GA). We carried out both PCR methods for HuNoV and GA and compared it against the GA infectivity assay to show that the correlation between PCR signal and infectivity is better represented by the loRT-qPCR method than the current RTqPCR method. We demonstrate that the current RT-qPCR procedures can overestimate the concentrations of infectious HuNoV GI, GII and FRNA bacteriophage GA by at least a log<sub>10</sub> difference of 0.86, 0.89 and 0.73 respectively.

**Keywords:** norovirus, gastroenteritis, shellfish, wastewater, quantitative PCR

## **41. Carbon footprint of travel to the Great Western Greenway:**

### **lessons for the sustainable design of walking and cycling networks**

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Current transport patterns for both commuting and recreation in Ireland are significantly damaging the environment. 75% of all journeys are undertaken in a car or a van, representing 90% of all distance travelled. Active travel (walking and cycling) accounts for less than 3% distance travelled as Irish people, on average, walk and cycle less than 1 kilometre per day. Carbon emissions due to passenger transport continue to increase and driving a car to work is responsible for the release of approximately 6 million tonnes of CO<sub>2</sub>e per year. To encourage increased walking and cycling for commuting, recreation and tourism, a National Cycle Network (NCN) is under construction. The NCN will be formed by a range of cycle route types, prioritising greenways (traffic-free cycle trails).

The routes which form the NCN, after a rigorous design process, should provide a significant resource for walking and cycling and reduce the carbon emissions associated with driving a car; however the carbon footprint of such routes must be considered. Previous research has quantified the embodied carbon of greenways (such as the Great Western Greenway in Co. Mayo) as 68 tCO<sub>2</sub>e/km (tonnes carbon dioxide equivalents per kilometre of greenway). As the Great Western Greenway and other planned greenways are located in rural areas and have become tourism and recreation attractions in their own right, carbon emissions associated with travel to these facilities must also be considered.

Based on a survey of users on the Great Western Greenway, the carbon footprint of travel to greenways in Ireland has been estimated. This figure is normalised against the carbon footprint of other typical recreational activities in Ireland. Recommendations for the reduction of this environmental impact are presented, including the completion of an extensive network of routes nationwide (particularly near cities and large towns), connections to public transport, bicycle facilities on public transport etc.

### **Acknowledgement**

This research is funded by the College of Engineering and Informatics at the National University of Ireland, Galway and by the National Sustainable Transport Office at the Department of Transport, Tourism and Sport.

**Keywords:** walking; cycling; greenway; transport; travel; recreation; carbon emissions; sustainability

## **42. Determination of Iodine in Fucus Serratus Seaweed Bathwater**

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Seaweeds have been extensively used by our ancestors for nutritional and therapeutic value. By strengthening our understanding of the levels of potentially therapeutic constituents in our indigenous seaweeds, we increase the perceived value of our natural environment as a resource that must be protected and sustainably managed for future generations.

Iodine is a vital micronutrient for normal thyroid function, growth and development. The classical spectrophotometric Sandell-Kolthoff method is a widely used technique in the determination of total iodine. The levels of iodine in seaweeds vary depending on species, locality and season and can account for up to 1.2% of the dry weight of some seaweeds. Simulated seaweed bathwater samples were prepared weekly using *Fucus Serratus* and seawater. The collected samples were initially digested using ammonium persulphate. The catalytic activity of iodide in the reduction of ceric ammonium sulphate is directly proportional to its concentration in the sample. The method was validated and samples collected over 12 weeks were analysed. Linearity was demonstrated between 20ppb and 600ppb iodine with a minimum correlation coefficient of 0.991. The LOD and LOQ were determined to be 18ppb and 60ppb respectively. Precision was measured by replicate analysis of a 150ppb iodine standard, a seaweed bathwater sample and a urine sample. The repeatability indicates a CV no greater than 1.9%. Intermediate precision was determined by replicate analyses over 3 days with a CV of 2.95%. The average iodine concentration of the seaweed bathwater samples was 8652ppb with sample concentrations ranging from 2386ppb-11615ppb. Iodine levels in seawater samples collected for the same period were generally below the LOQ.

**Keywords:** Seaweed, *Fucus Serratus*, Iodine, Seasonal variation, Sandell-Kolthoff

### **43. The impact of acute and chronic hydrochemical disturbances on stream ecology; implications for agricultural policy.**

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The two main threats to water quality in Ireland are municipal (point source) and agriculture (diffuse sources). For the agriculture sector in Ireland, the Teagasc Agricultural Catchments Programme is identifying links between land managed according to Good Agricultural Practice (GAP) measures and water chemical and ecological quality. However, the degree to which stream ecological status will improve in response to implementation of the GAP measures requires further investigation. Hypotheses emerging from the ACP are that a high frequency of storm events that cause overland flow (acute disturbance) increases the likelihood of poor in-stream ecological status, and that stream hydromorphology (and not stream chemistry) can limit WFD ecological status.

This study will test these hypotheses using a combination of a microcosm and catchment scale assessment. The impact of nutrient and sediment dynamics in headwater streams on biological water quality indicators across a range of land use and stream habitat types will be studied. In particular, the impact of acute (e.g. storm runoff from agriculture) and chronic (e.g. nutrient inputs from septic discharge during low flow) disturbance will be compared. The study will utilise existing high temporal resolution hydrochemical monitoring infrastructure and seasonal stream biology and habitat data of the ACP and generate a new ‘event response’ stream ecological dataset. A conceptual model of when ecological quality is limited by habitat, rather than stream chemistry, will be developed.

By identifying the impact of stressors on biological water quality indicators, the study will help inform how agriculture in Ireland can be intensified sustainably with respect to implications for water quality in headwater agricultural catchments. Outcomes from the research will inform policy makers of which Good Agricultural Practice and other measures will be most effective in helping stream waters in Ireland reach Good Ecological Status as per Water Framework Directive requirements.

**Keywords:** sediment, stream ecology, agriculture

#### **44. Farmers' attitudes towards climate change: identifying typologies**

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Ambitious targets to reduce greenhouse gas (GHG) emissions from agriculture have been formed internationally, by both national governments and indigenous livestock sectors, to meet global commitments on climate change. At the individual level, support for government initiatives and voluntary action regarding climate change has been linked to acceptance and awareness of the issue. Therefore, attitudes are important as they can help explain farmer decision-making. The aim of this study was to examine livestock farmers' attitude towards, and perceptions of, climate change. Responses from 286 farmers in Wales indicated that those questioned were predominantly aware of climate change, with 63% considering it as anthropogenic in origin. There was less consensus on livestock's contribution towards climate change and the impact of on-farm practices to the emission of GHGs. Attitudes towards climate change were evaluated using Principal Component Analysis (PCA), and subsequent Cluster Analyses revealed four farmer typologies based on PCA scores. 'The Productivist' and 'The Countryside Steward' depicted low levels of acceptance and awareness of climate change, but differed in their respective attitudes towards environmental responsibility, productivism, and empowerment. In contrast, both 'The Environmentalist' and 'The Dejected' scored higher in their levels of acceptance and awareness. Conversely, 'The Dejected' exhibited a high sense of disempowerment in terms of both their ability to mitigate GHGs and their capacity to adapt. For new climate change and adoption policies to be effective, policy-makers need to recognise the complexity of farmers' attitudes and the multiple factors that influence decision-making. The typology approach allows for the development of targeted knowledge transfer of initiatives to better inform farmers of impacts, opportunities and mitigation options brought by climate change. The typologies identified in this study could also aid the design of future environmental policy instruments through knowledge dissemination.

**Keywords** Beef, environmental impact, farmer engagement, lamb, red meat, sustainability

#### **45. Ecotoxicological case study of matrix conditioned ash from Ireland's first industrial scale wooden biomass CHP boiler**

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Ashes generated by burning of renewable biomass contain less fuel born substances of concern (e.g. heavy metals) than ashes from solid fossil fuels or municipal waste incineration. Organic contaminants in biomass ash though, are strongly linked to the combustion process. Although the physico-chemical evaluation of biomass ashes such as from untreated wood suggests a comparably low waste hazard level, environmental innocuousness may not be assumed. Variation in the matrix constitution of the ash (as in particle size or degree of combustion) strongly influences the bioavailability of contained toxicants and in turn affects the hazard characterization of the material.

Three ISO/OECD standard aquatic test systems (Microtox® inhibition of bioluminescence, Lemna minor growth inhibition and Daphnia magna immobilization) were applied in toxicity assessments of BS EN 12457-2 waste leachates of wood ash. Native ash leachates as well as neutralized leachates of ash were tested. Mobile contaminant fractions from native, pulverized and re-ignited samples of an Irish wood bottom and fly ash batch were assessed to compare environmental hazard levels of ash that is (i) un-altered and straight from the furnace, (ii) ground to a uniform, very fine particle size or (iii) re-combusted to minimize organic matter residuals respectively.

Results generally confirm (1) bottom ash to be consistently less toxic than fly ash and (2) ash mediated alkaline pH of leachates having a major impact on the test system response. Matrix conditioning of the native ash samples to pulverized ash leads to little difference in physico-chemical properties and biological effect concentrations measured in the leachates. In contrast, re-ignition of the ash increases toxicity of leachates, their pH and conductivity.

#### **46. Evaluation of zeolite and chemical amendments to control phosphorus and nitrogen losses in runoff from agricultural wastewaters.**

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Surface runoff of phosphorus (P) and nitrogen (N), following land application of agricultural wastewaters, may trigger eutrophication of receiving waters. Chemical amendments have proven successful in reducing the amount of P lost in surface runoff, but were relatively ineffective in reducing the amount of N lost. This study examines the use of zeolite to reduce N in surface runoff from three types of agricultural wastewaters (dairy soiled water (DSW), pig and dairy cattle slurry) and to see if it can be used in combination with chemical amendments to also reduce P. Four treatments were investigated: (1) control (grassed soil only) (2) unamended DSW, dairy and pig slurry spread on grassland; and DSW, dairy and pig slurry amended with either (3) a combination of zeolite and chemical amendment or (4) chemical amendment only (without zeolite). Laboratory runoff boxes, packed with intact grassed soil cores, were placed in a rainfall simulator at a slope of 10% and subjected to three consecutive daily simulated rainfall events, of 30 min duration, at an intensity of approximately 10 mm h<sup>-1</sup>. Surface runoff, collected at 5-min intervals, was analysed for a range of water quality parameters. Zeolite, combined with either alum or poly-aluminium chloride (PAC), reduced total phosphorus by 50% (for DSW), 35% (for dairy slurry) and 81% (for pig slurry) compared to unamended slurries and reduced total nitrogen by 45% (for both pig slurry and DSW) and 57% (for dairy slurry). In all cases, the average P and N removals in runoff using the combined amendments were greater than those using chemical amendment only. These results may assist with establishing methods to reduce pollutant nutrients in runoff from land spreading of agricultural wastewaters, and may ultimately facilitate increased volumetric slurry application rates to lands.

**Keywords:** zeolite, agricultural wastewaters, phosphorus, nitrogen

#### **47. Comparing LiDAR and conventional resolution digital elevation models for spatial modelling of nutrient loss pathways and critical source areas**

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Diffuse phosphorus (P) losses from agricultural land to surface waters can cause eutrophication and negative impacts on water quality. Defining hydrological pathways of such losses using digital elevation models (DEMs) is important for identifying high-risk areas, termed critical source areas (CSAs), in order to optimise mitigation measures. Topographic features, often at sub-metre scales, could play a significant role in re-routing surface runoff pathways. Such features are typically not captured in lower resolution conventional DEMs, but are captured in new high resolution Light Detection and Ranging (LiDAR) DEMs. This could considerably improve CSA delineations. A very high resolution (0.25 m) LiDAR DEM and a conventional 5 m resolution INTERMAP DEM were used to model surface runoff pathways and hydrological connectivity of those pathways using the Topographic Wetness Index (TWI) and the Network Index (NI) respectively, in two agricultural catchments in south-east Ireland. Results were compared at the catchment scale and for targeted upland and lowland sites. DEM resolution was found to have a critical effect on the predictions of surface runoff pathways. LiDAR-derived pathways were diverted by the presence of roads, hedgerows and tramlines, and often routed to either different agricultural drainage networks or different locations along the network. This could have significant implications for where CSAs are identified and where mitigation measures should be located. Furthermore, diversions from hedgerows also caused flow to be funnelled and accumulate at downslope field margins, and ‘breakthrough’ to areas downslope where gaps in hedgerows exist. This suggests locations where P is potentially immobilised where flow accumulates and sediment is deposited, and conversely mobilised where flow ‘breakthrough’ occurs. If field-verified, these results indicate the potential for targeted (sub-field scale) CSA mitigation advice to intercept and trap P in overland flow close to the source.

**Keywords:** phosphorus, critical source areas, eutrophication, LiDAR, digital elevation model

## 48. Scaling soil process modelling to the national level

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Agricultural soils represent a significant source of greenhouse gases (GHGs); in Ireland agriculture represents the largest source of GHG emissions to the atmosphere, representing 30.5 per cent of total national emissions in 2010. Recent GHG emission projections from the EPA highlight the need for a reconsideration of national mitigation strategies: Ireland's agricultural GHG emissions may increase by 12 per cent over 2012 levels, exceeding 2020 GHG targets in order to meet Food Harvest 2020 production targets (Ireland's Greenhouse Gas Emission Projections 2012-2030, EPA April 2013).

There are significant challenges ahead for Ireland to progress to a low carbon economy. Central to this transition is the requirement for data on national GHG sources and sinks. The aim of this project is to use established process-based models to upscale soil processes to the national level, in order to produce a map of agricultural GHG emissions that may be used to test mitigation strategies inherent in approaching a low carbon economy.

We are using the DailyDayCent, DNDC and ECOSSE models to simulate GHG emissions from a diverse range of agricultural systems, including pasture, arable crops, energy crops, and forestry, comparing model predictive capacity using a validation dataset consisting of over 10,000 data points. We will also carry out uncertainty analysis using factorial model runs, in order to determine the spatial and temporal drivers that are most suitable for calculation of emission factors. Ultimately, the best model for simulating each agricultural system will be used to scale GHG emissions to the national level, according to the IPCC's Tier 3 methodology. Here we describe our approach and initial findings.

**Keywords:** greenhouse gas emissions; process-based model; upscaling; model comparison;

## 49. Benchmarking and Mitigation of Resource Consumption in Irish Wastewater Treatment Plants

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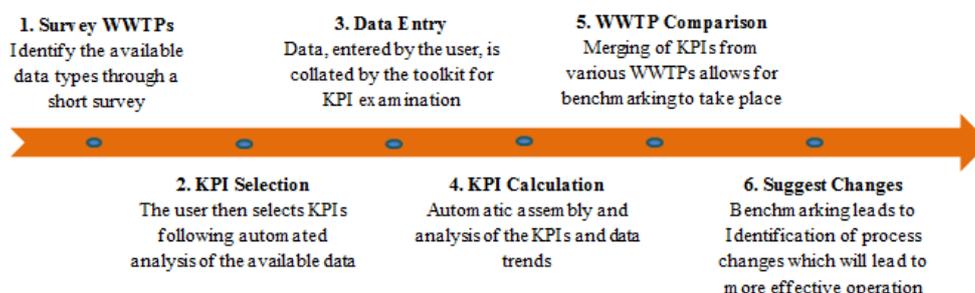
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Energy and water are key resources to sustain a growing population and ensure continued economic growth. In effect, the two are inextricably linked; energy is required to purify water (the transport and treatment of water and wastewater accounts for 7–8% of the world’s energy produced) and water is required to generate electricity (Hoffman 2004).

Water services in Ireland cost over €1.2 billion in 2010, with operational costs amounting to €715 million (DECLG 2012) A public water utility company, Irish Water, has recently been established to take over the operation of water and wastewater utilities, previously run by local authorities. Irish Wastewater Treatment Plants (WWTPs) currently account for approximately 50% of local authorities’ energy costs (SEAI 2012); thus significant efficiencies, including reducing energy consumption must be sought.

Given that WWTPs operate on a continuous basis, are subject to highly variable influent wastewaters, may not always be manned and must meet the strict discharge requirements stipulated by the EPA and Water Framework Directive (WFD), it can be difficult to reduce resource consumption while ensuring compliance with discharge requirements. This research is currently developing and testing a unique benchmarking system to reduce resource consumption in Irish WWTPs which will isolate where and how resources are used and identify potential resource consumption mitigation measures (an outline of the benchmarking stages are shown in Figure 2).



**Figure 2.** Flow chart representation of the stages of benchmarking

This project combines both on-site measurement of resource intervention and software modelling of centralised and decentralised WWTPs to increase resource efficiency while maintaining or improving plant performance and will lead to the creation of best practices for resource benchmarking in WWTPs.

## 50. Occurrence of Priority Pollutant Heavy Metals in wastewater treatment plant effluent in Ireland

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A list of 15 priority heavy metals have been chosen as priority substances and listed in the EU Water Framework Directive. The levels of heavy metals in the environment are affected by a number of emission factors (natural, municipal-, residential- and traffic- related) which must be taken into account when monitoring levels of heavy metals being released into the environment via waste water treatment plant effluent. Effluent samples have been collected from nine different wastewater treatment plants in 2 areas of Ireland (Dublin and Cork) over a period of 24 months (2009-2011), including several weeks of high intensity sampling. Samples were subject to microwave assisted acid digestion before analysis by inductively coupled plasma mass spectrometry (ICP-MS). All samples analysed were found to contain priority metals, sometimes exceeding environmental quality standards (EQSs).

A major driver of this research is the identification of current gaps in knowledge in the area of water monitoring as well as directing the establishment and implantation of more comprehensive water monitoring programs in the future and as such it is important to closely evaluate the emission factors which directly contribute to the occurrence of priority heavy metals in Irish wastewater effluent. The relationship between occurrence of heavy metals in water and emission factors such as industrial inputs, levels of treatment at wastewater treatment plants, and percentage urban area in an agglomeration have been evaluated. The lack of historic data for heavy metals in water is a limiting factor when it comes to the development of monitoring programs. Datasets of the occurrence of heavy metals and priority substances will allow policy makers and monitoring authorities to target their future monitoring initiatives thus reducing cost and time investments.

**Keywords:** wastewater, priority pollutants, emission factors, polycyclic aromatic hydrocarbons, solid-phase extraction, liquid chromatography, gas chromatography, monitoring.

## **51. The Application of a Commercial Mycorrhizal Inoculum in a Willow Wastewater Treatment System**

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Ireland is one of the most ruralised countries in the EU. Due to the dispersed settlement pattern, there are almost 500,000 onsite wastewater treatment systems in operation. The use of short rotation willow coppice in a zero-discharge onsite wastewater system has shown promise. This is due to the high evapotranspiration rate of willow trees; up to 1700 mm during the growing season in fertilised conditions. The advantage of this system is that there is complete isolation and removal of the wastewater. Mycorrhizal fungi are known to benefit the growth of many tree species. The aim of this study was to examine the effect of mycorrhizal fungi on willow trees receiving different wastewater strengths and irrigation rates.

Rooted *Salix viminalis* L. cuttings (n = 120) were planted in a high clay subsoil. During planting, cuttings were either inoculated with DIEHARD™ Transplant (a commercial ectomycorrhizal-endomycorrhizal inoculum) or left uninoculated. Cuttings were irrigated three times per week with synthetic primary wastewater, synthetic tertiary wastewater or rainwater. There were two irrigation rates of 3 L or 9 L per tree per week.

Inoculated trees performed better than non-inoculated controls across all six wastewater strengths and irrigation rates. Trees receiving primary wastewater showed the largest height increase during the trial (> 0.8 m), while trees receiving rainwater showed the lowest increase (< 0.40 m). Inoculated trees receiving rainwater were 64% taller than the control. Inoculated trees receiving tertiary and primary wastewater were 23% and 12% taller respectively. Dark-adapted chlorophyll fluorescence tests showed no significant difference between irrigation rates indicating that the plants were not water stressed.

Results so far indicate that the use of commercial inoculum can facilitate the establishment and growth of *Salix viminalis* cuttings in a low nutrient pre-wastewater application stage.

## **52. Improvement of Resource Efficiency within Municipal Wastewater Treatment Plants in Ireland through Process Control Optimisation**

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As societies' ever-increasing reliance on electrical energy continues, the role of process optimisation becomes more and more prevalent. The increasing price of electricity generation has caused energy conservation to become a top priority for industry worldwide. One area where this priority has become apparent is municipal wastewater treatment. Budget restrictions and cutbacks have caused treatment plants to re-think the methods of water treatment and look at how energy savings can be made using process control optimisation.

International studies on municipal wastewater treatment plants have shown that for an activated sludge wastewater treatment plant, up to 68% of total plant energy use is dedicated to water pumping and aeration<sup>1</sup>. If energy can be conserved in these areas, there is huge potential for large cost savings within wastewater treatment plants. Such savings can be made through various strategies. The implementation of variable frequency drives onto pumps allows flexibility with the pumping speed. By reducing this speed, the motors can run more efficiently and pump wear is significantly reduced.

The aeration basin blowers are generally the largest energy drain on wastewater plant. By introducing inter basin dissolved oxygen control systems, the blowers can be controlled, based on the varying oxygen requirements within each basin rather than oversupplying the aeration basin and thus wasting energy.

This research aims to investigate the energy usage of various types of municipal waste water treatment plants within Ireland and identify areas where energy savings can be made. The main focus of this work is based on energy conservation using process control optimisation. By working closely with the Environmental Protection Agency (EPA) and local County Councils to put in place a water treatment energy benchmark protocol, it is hoped that municipal treatment plants across the country will benefit from significant monetary savings.

**REFERENCE:** Zahreddine, P., Doerr, D. (2012, May 17th). Innovative Energy Conservation Measures at Wastewater Treatment Facilities [PowerPoint slide presentation]. US EPA

### **53. Study of the fine-scale spatial distribution of surface moisture content in Canadian and Irish peatlands**

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The moisture content of the shallow layers of a peatland fluctuates depending on the water-table position and the vegetation cover. When these superficial layers of peat dry to below a moisture content of 125% (in a dry weight basis) they become more vulnerable to burning in a smouldering fire. While the moisture distribution through the vertical peat profile has been well studied, there is little research looking at how the horizontal spatial distribution of moisture content. Even fewer studies analyse the variability of physical properties of the peat at a fine scale.

We took peat samples within 150x150cm square to examine the fine scale spatial distribution of vegetation and peat physical properties (i.e. moisture content and bulk density). Samples were taken from a Canadian old undisturbed peatland during the summer 2013 (Burned Crow Century, AB, Canada) and from a drained Irish peatland (Wicklow Mountains National Park, Ireland) during the autumn 2013.

In the Canadian samples we found a significant association between vegetation types and moisture content and bulk density of the peat. While for the Irish peatland there was only an association between vegetation and bulk density of the peat (the moisture content is more homogeneous through all the vegetation types). For both datasets, the scale of spatial autocorrelation in peat physical properties is up, which is consistent with the spatial scale of the hummock-hollow microtopography. The variables in our analysis have a direct effect on the propagation of the smouldering fire in peatlands. For that reason a better knowledge of the scale and spatial variability of the peat properties can help regulating water-table levels in certain local areas of a peatland to prevent unwanted fires.

**Keywords:** ecohydrology, peat, soil physical properties, bulk density, spatial variability, microtopography

#### **54. Attack of the clones. Are all Asian clams in Ireland related?**

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The highly invasive Asian clam, *Corbicula fluminea* (Müller, 1774) was first discovered on the island of Ireland in 2010, in the River Barrow. *C. fluminea* was subsequently discovered in the Rivers Nore and Shannon. Within Europe, a number of morphotypes of *Corbicula* clams exist. The specific morphotype present at each site in Ireland was examined using an analysis of the mt COI haplotype.

The pathway by which *Corbicula* clams were introduced to Ireland has not been identified. It is not currently known how *Corbicula* clams reached Ireland or have spread within its surface waters. In order to investigate the hypothesis of multiple discrete introductions, a genetic investigation of Irish *Corbicula* clams was undertaken to determine the presence of any variations in haplotype from within Irish populations.

Samples of *Corbicula* clams were collected from each site on the island of Ireland. Genetic analysis was carried out in conjunction with the University of Namur, Belgium, at its Laboratory of Evolutionary Genetics and Ecology. The mt COI haplotype of each sample was assessed and 10 *Corbicula* specific, microsatellite markers were examined for a subset of samples.

The *Corbicula* clams present at each site in Ireland were confirmed to be of the same COI haplotype as the European form R and American form A, corresponding with the species *Corbicula fluminea*. A morphological analysis of the Irish samples also confirmed the sole presence of form R, *Corbicula fluminea* at each site.

The scope of this research addresses a significant contemporary environmental challenge, which is the ever increasing economic and biological impact of invasive species. This genetic study utilises a recognised scientific tool to determine invader pathways and in this case informs the management of the Asian clam in Ireland.

**Keywords:** *Corbicula fluminea*, invasive species, Asian clam, microsatellite

## **55. The impacts of *Rhododendron* nectar toxins on Ireland's bee population: deadly meal or valuable forage?**

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Bees provide the valuable ecosystem service of pollination while visiting flowers and collecting nectar. We are currently experiencing a “pollinator crisis,” as bees and other pollinating species decline in response to anthropogenic pressures such as habitat loss, pesticides and disease. Additional drivers of bee decline could therefore have far reaching consequences, and bees may exhibit species-specific responses to pressures.

*Rhododendron ponticum* is a severely invasive flowering shrub that causes ecological and economic damage in Ireland. Its tissues contain grayanotoxins (GTXs), neurotoxins thought to act as a defense against herbivores. *R. ponticum* produces floral nectar in order to attract pollinators, but paradoxically this nectar contains high concentrations of GTXs. Our study investigated the impact of GTXs on the health of three native Irish bee species; *Apis mellifera* (honeybees), *Bombus terrestris audax* (a bumblebee species), and a solitary *Andrena* species. For each species we tested whether consumption of nectar GTXs had an impact on (1) survival, (2) foraging behaviour, and (3) activity levels.

Our results clearly demonstrate that bees have critically different responses to GTXs in *R. ponticum* nectar. GTXs are fatal for honeybees; individuals showed neurological symptoms within two hours of consumption and died within six hours. Bumblebees, however, showed no lethal or sublethal responses to grayanotoxins. The chemicals did not impact their survival, foraging behaviour, activity levels, parasite loads, or survival under stress during a 30 day assay. Solitary bee survival was not affected by consumption of GTXs, however average food consumed and activity levels were decreased in bees fed GTXs, and they were also temporarily incapacitated by neurological symptoms. Our results demonstrate that *Rhododendron* reduces available forage for honeybees and some solitary bee species but alternatively could provide an important spring food resource for *Bombus* species. Management decisions regarding *Rhododendron* should therefore consider bee species requiring conservation.

**Keywords:** invasive species, bees, *Rhododendron*, pollinator decline, food security, nectar toxins

## **56. Rare plant records highlight the added value of conservation outside of designated areas**

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Records of vascular plants from the island of Ireland have been collated into a single plant distribution database. Rare and threatened plant species records were identified and subsequently mapped at the tetrad (2km by 2km) scale using a geographical information system. The plant species identified as rare and threatened are those named in the Irish Red Data Book, the Flora Protection Order (FPO), the Northern Ireland Wildlife Order (WO) and the Northern Ireland Priority Species list. We examined the overlap in spatial coverage between areas designated for the protection of biodiversity in Ireland and tetrads containing rare and threatened plant species.

The designated areas encompassed a large proportion of the locations of rare and threatened plant species within their boundaries. The remaining locations of these species in the wider countryside represent a significant proportion that will not benefit from the protection provided by designated areas. For example, 22% of tetrads with records of FPO species occurred outside of designated areas in the Republic of Ireland. In Northern Ireland, 31% of tetrads with records of WO species occurred outside of designated areas. The locations of non-designated sites that contained records of rare and threatened plant species were not equally distributed throughout the landscape, but often occurred closer to designated areas. The combination of designated areas and landscape within 4km of the designated areas contained over 90% of the locations where records of rare and threatened plant species occurred. These results indicate the importance of both designated areas and the wider countryside for biodiversity conservation, and offer an opportunity for the spatial targeting of conservation actions.

**Keywords:** Vascular plant diversity, designated areas, spatial targeting, conservation in the wider countryside.

## 57. Molecular Microbial Ecology of Ammonia Oxidation in Coastal Bay Sediments

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The nitrogen cycle is critical to understand as it requires a fine balance between nitrogen loss and conservation. This can be unbalanced due to human impact (nitrates entering the water from fertilisers etc.). Microorganisms within marine sediments play an important role in the global nitrogen cycle mediating the fate of nitrogen entering coastal waters. For example, microorganisms such as ammonia oxidising bacteria (AOB) and ammonia oxidising archaea (AOA) drive ammonia oxidation (AO). The *amoA* gene is the functional gene for AO; it is found in both AOA and AOB and is used as a genetic marker for potential activity. The overall aim of this research is to understand AOA and AOB activity and dynamics in marine sediments and furthermore evaluate their contribution to global nitrogen and carbon cycles.

Temporal and spatial dynamics in AO were determined in two coastal bay ecosystems (Rusheen Bay & Clew Bay) starting in April 2013. Potential Nitrification Rate (PNR) assays and corresponding AOA/AOB community were measured over an annual period. PNR results show spatial sites within the bays show variation in AO rates but rates are stable over time. AO rates ranged from 0.024-9.716 NO<sub>2</sub><sup>-</sup> µg/g/d. Simultaneous *In situ* temporal and spatial distribution of AOA/AOB has shown for the first time that AOB dominate in coastal sediment using quantitative PCR.

**Keywords:** nitrogen cycle, ammonia oxidising bacteria and archaea, *amoA* gene, primers, potential nitrification rate assay, qPCR.

## **58. Assessment of the Physicochemical Properties of Karst-Channelled Submarine Groundwater Discharge and their Individual and Synergetic Impact on the Structuring the Microalgal Community**

Laura Foley

Anthropogenic nutrient loading prompts environmental change in coastal ecosystems, upon which humans rely for goods and services. Effective management to ensure future environmental health of these systems requires characterisation of the dynamics and mode of action of these loads and their effect on ecosystem functioning in receiving environments.

Where permeable sediments and a positive hydraulic head exist, fresh groundwater can enter the marine environment, mostly at the intertidal. Such submarine groundwater discharge (SGD) is a potential pathway for anthropogenic nutrients to the marine environment. Due to coastal pollution concerns, SGD nutrient fluxes (mainly nitrogen) have received significant scientific attention. However, physicochemical characteristics of SGD vary relative to that of the receiving water body and surface drainage so that assessing nutrient loading is challenging and may not be sufficient to predict the local level ecological impacts.

These variables, which include temperature, pH, salinity, and concentrations of dissolved gases such as carbon dioxide, may operate individually as well as synergistically with nutrient fluxes to modify predicted ecosystem responses to nutrient loading, complicating both the assessment of nutrient pollution and where necessary, mitigation measures.

The form and magnitude of physicochemical variability in SGD seepage is largely a function of the characteristics of the aquifer which conveys the groundwater to the coastline. SGD is frequently associated with Karst aquifers. A number of characteristics generally common to karst aquifers, including rapid conduit flow and decreased capacity for attenuation of contaminant loads render these significant in terms of SGD and potentially associated pollution. Here we present the first results characterising a number of the physicochemical properties (pH, salinity, temperature and nitrogen concentrations) and the form of the macroalgal primary producers associated with karst-channelled intertidal SGD on the Irish west coast. We subsequently discuss the individual and synergetic effects of the former in structuring the latter.

**59. Analysing Submarine Groundwater Discharge (SGD)-borne Dissolved Organic Matter (DOM) in a karstic aquifer, Kinvara, Co. Galway.**

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Groundwater in transit from land to sea is frequently contaminated, often containing higher concentrations of nutrients, metals and organic matter than surface waters. Seepage of SGD at the littoral fringe may be more important than surface flow in the oceanic budget of these materials. DOM, ubiquitous in aquatic ecosystems, is a complex, heterogeneous mixture of organic molecules and represents one of the largest pools of organic carbon on earth and consequently, is of great importance to the carbon cycle. Presently, little is known about the effects of SGD-borne DOM on coastal carbon cycling.

Kinvara (Galway, western Ireland) is the focal point for waters discharging from the Gort-Kinvara karstic aquifer. This aquifer represents the ideal study location to evaluate the contribution of SGD to the coastal DOM pool, as SGD is focused in the bay, surface drainage is very limited, and groundwater travels across a large catchment area with a short transit time, minimising DOM modification through the subterranean pathway.

Because refractory carbon will not be mineralised, thus contributing to oceanic carbon storage, whereas labile DOM will contribute to eutrophication; determining the types of organic matter present in seepage water is crucial to forecast effective environmental management. This study aims to determine the types and concentrations of DOM present using excitation-emission matrix fluorescence, and high temperature catalytic oxidation, and to use this information to determine the global and local impact of DOM.

**Keywords:** Submarine Groundwater Discharge, Dissolved Organic Matter, Karst aquifer

## 60. Nitrate reduction in coastal sediments

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It is generally accepted that nitrogen availability is one of the major factors regulating primary production in coastal marine environments. Coastal regions often receive large anthropogenic inputs of nitrogen and together with cumulative effects of climate change, increasing population and industrialization will likely continue the course of intensified eutrophication in coastal and estuarine waters. Microorganisms within coastal sediments mediate the nitrogen load entering coastal waters. Furthermore N<sub>2</sub>O, greenhouse gas can be produced via microbial nitrogen reduction. The microbial transformations of nitrate within estuarine sediments occur via three processes namely, denitrification, dissimilatory nitrate reduction to ammonia (DNRA) and anaerobic ammonia oxidation (ANAMMOX). The aim of this project is to determine the fate of nitrates in Irish estuaries of contrasting nutrient status.

This will be achieved using a two pronged approach – directly measuring the nitrate reduction potential of estuarine sediments while simultaneously targeting the microorganisms responsible for the process via molecular detection of key functional genes.

To-date, assays to determine the rate of nitrate reduction and molecular techniques to recover DNA from marine sediments have been established. Furthermore bacterial 16S rRNA genes in addition to marker genes for nitrate reduction, *narG* and *napA* have been recovered from coastal sediments.

**Keywords:** nitrogen cycle, nitrate reduction, *narG*, *napA*

## **61. Assessment of a Best-Practice Framework to Facilitate the Development of a Sustainable Energy Community in an Off-shore Island in Ireland**

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The purpose of this research is to investigate existing international frameworks for the implementation of Sustainable Energy Communities (SECs) in order to determine the enablers and barriers to the successful implementation of an SEC on an island in Ireland. Inis Oírr is a small island off the west coast of Ireland with less than three hundred inhabitants and is a tourism hub for Irish culture and heritage receiving approximately 100,000 visitors per year. Inis Oírr is currently completely dependent upon energy imported from mainland Ireland and is dealing with higher energy costs as a result. The Sustainable Energy Communities (SECs) Programme is an initiative of Ireland's national energy authority, the Sustainable Energy Authority of Ireland (SEAI). The SECs programme policy instrument suggests that achieving SEC status must be dealt with in societal as well as technological terms. The aim of the research is to gather information on successful methodologies for the implementation of SECs internationally and to assess whether these are appropriate for implementation in Inis Oírr. This research investigates existing organisational structures in Inis Oírr and assesses methodologies to facilitate change while engaging with the community at a local level. The research examines the following research questions: How can best practice international implementations of SECs inform the development of a framework suitable for Inis Oírr? What are the enablers and barriers to the implementation of an SEC in Inis Oírr? The research approach consists of a literature review in order to undertake a concept centric analysis of SEC frameworks on islands internationally. The research will also include detailed discussion of key enablers and barriers influencing the effectiveness of existing SEC frameworks in the context of Inis Oírr. This paper will make a contribution by informing both Irish and European policymakers on a suitable SEC framework for small island communities.

**Keywords:** Sustainable Energy Communities, Energy, Inis Oírr, Ireland, Island Communities

## **62. Energy Efficiency of Water: Analysis of Pumps-as-turbines Replacing Pressure Reducing Valves in Distribution Networks**

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Water and energy are interconnected. Energy consumption in the water distribution network (WDN) is a well-established problem (McNabola et al., 2011; Corcoran et al., 2011). In Ireland, 41% of treated water is lost via leaks in the network (Environ, 2012). Leaks in the WDN are largely attributed to excessive pressure build up, highlighting a need for improved pressure management.

Pressure Reducing Valves (PRVs) are widely used to regulate pressure in WDNs (Williams, 1998) by mechanically dissipating hydraulic energy. Potential exists to capture 85% of energy dissipated at PRV sites (Wallace, 1996) by retrofitting with an energy recovery system.

Pumps operating as turbines (PATs) are increasingly being examined for use as energy recovery systems (Simao & Ramos, 2010; Choulot et al., 2012), due to their cost effectiveness in relation to their more conventional counterparts (Fecarotta et al., 2011).

Experimental analysis was conducted on a scale model PAT which examined the viability of PATs as a micro-hydro energy recovery device, for application in the WDN, either as a retrofit option for PRVs or as new pressure management systems. The experiment, focused on control of flow variability, energy output, regulation of downstream pressure and optimal system arrangement.

The bounds to the operating envelope for a PAT are identified by verifying PATs efficiency for typical diurnal flow patterns representative of the WDN and related optimal arrangements and adjustments of PAT arrangements which are conducive to optimal operation. The results outline design requirements for PAT to operate as a micro-hydro energy recovery system in the WDN.

**Keywords:** Pressure Control; Energy Recovery; Pump as Turbine

**63. “How To” support deep-retrofitting? Lessons from the SERVE Project, Tipperary, Ireland.**

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The 2012 National Economic and Social Council (NESC) Secretariat report to the Department of the Environment, Community and Local Government addresses the climate change challenges facing Ireland. It sets out a vision for a carbon-neutral society by 2050, addressing the questions of “How Much” needs to be done in tandem with “How To” best achieve decarbonisation. The transition to a carbon-neutral society will require the creation of five strategic building blocks. One aspect of this foundation is the development of an energy efficient society using renewable forms of energy and heating. Realising this goal will require a process of “deep-retrofit” in our existing building stock, requiring higher standards of insulation, enhanced utilisation of smart-energy systems and greater uptake of biomass. Achieving deep-retrofitting, defined as the installation of residential energy efficiency measures which result in energy savings of 40%, or more, will require overcoming several obstacles, such as an upfront payment barrier and underlying perceptions, etc. In 2012, Limerick Institute of Technology-Tipperary completed the SERVE Project (Sustainable Energy for the Rural Village Environment). Funded under the EU CONCERTO Programme this project aimed to develop a more sustainable region in North Tipperary, through the implementation of sustainable energy actions. One such action was that of deep-retrofitting and over 350 buildings were upgraded; 346 residential and 11 non-residential properties. Data relating to energy savings and performance suggest energy-efficiency improvements of 44%. However, this paper reports on the socio-economic analysis undertaken by the project team. These findings can be used to assist policymakers in meeting the challenge of “how to” affect the transition to a carbon-neutral society. Insights from economic analysis and social surveys have indicated a number of interesting leverage points to assist in overcoming the aforementioned deep-retrofit barriers. These include enhanced payback periods; potential for local economic stimulus; and quality of living improvements.

**64. Direct catalytic low temperature conversion of bio-methane to methanol via  
Cu-ZSM-5  
- Presentation -**

**Barbara Schaller<sup>1</sup>, Teresa Curtin<sup>1</sup> and J.J. Leahy<sup>1</sup>**

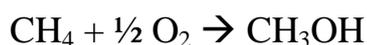
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The Biofuel directive of the European Commission requires that a minimum of 10 % of the transport sector should be covered by alternative fuels by 2020. Methanol is a flexible key component for several alternative fuels and is also used in other industries such as in plastic production.

In literature it is recognised that a “dream” reaction of modern heterogeneous catalysis is the quantitative direct partial oxidation of methane to methanol



Since methane is very symmetric, it has an extreme high C-H bond stability, which requires high activation energies. Stopping the oxidation and releasing the formed methanol from the catalyst are still challenging problems. Currently, methanol is synthesized via an indirect selective two-step process using syngas, which is costly and energy consuming.

The objective of this project is to develop a new catalytic method for the direct catalytic conversion of bio-methane to methanol. In nature, the C–H bond in methane can be oxidized in mild conditions using methane mono-oxygenase enzymes (MMO). There are two main enzyme families, one which contain copper (particular MMO) and the other iron (soluble MMO) complexes. Indeed from current reported literature, copper and iron catalysts supported by zeolites seem to be relatively promising for this partial catalytic oxidation reaction.

For this project different copper catalysts supported by zeolites, such as ZSM-5 and Mordenite were prepared through an aqueous ion exchange procedure using copper acetate as the metal precursor salt. Atomic absorption was used to measure the exchanged metal content of the prepared catalysts. The experiments were performed on a catalysis gas rig using an on-line mass spectrometer device for monitoring the desorbing gases. To desorb methanol from the catalyst surface a wet helium stream was introduced via a saturator. Low temperature and pressure conditions were used for the process.

**Keywords:** methane, catalyst, oxidation, methanol, zeolite, copper

## 65. Development of low cost autonomous chemical sensing platforms for the direct determination of ammonia and nitrate in water

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Our ability to effectively monitor the aquatic environment at remote locations is essential as pressure on available water resources continues to grow. There is therefore a growing need for low cost, remote sensing systems which can be deployed in sufficiently large numbers to ensure that data on key water quality parameters is readily available. The challenges facing this ideal of monitoring include the cost of these platforms and the inability to “deploy and forget” due to limited long term stability and maintenance requirements.

Microfluidic technology has great potential as a solution to the demand for low cost environmental monitoring, by combining colorimetric chemical assays; low cost LED/photodiode-based detection systems; and wireless communications. In order to drive down the cost of these devices, it is vital to keep the fluidic handling requirement as simple as possible, as multistage methods are expensive to implement as well as being less reliable in long-term deployments.

An analysis system for the determination of nitrate in water using chromotropic acid has been developed.<sup>1</sup> The chromotropic acid method has been modified to facilitate its implementation into an autonomous platform, resulting in a quick, inexpensive and simple procedure to measure nitrate up to 80 mg/L nitrate with a limit of detection of 0.73 µg/L nitrate, showing excellent correlation with ion chromatography.

A variation of the Berthelot method (eliminating several steps previously associated with the method for a nontoxic and simple assay) for the determination of ammonia has been integrated into an autonomous field deployable platform. The method allows for the determination of ammonia up to 12 mg/L ammonia with a limit of detection of 1.5 µg /L ammonia.

The development of these platforms could provide the basis of a widely dispersed sensor network, providing frequent water quality updates at several locations in a rapid, simple and inexpensive manner.

**Keywords:** Environmental monitoring, water quality, microfluidics, nutrients, chemical analysers.

\*We acknowledge support for this research from The Questor Centre (grant code DCU9/11/14) and Enterprise Ireland (grant code IP/2011/0103).

## **66. Autonomous remote gas sensing: Web-based monitoring of greenhouse gases in the waste sector**

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Quantifying greenhouse gas (GHG) emissions is becoming increasingly important in today's society from the perspectives of regulation (compliance with international directives), industrial efficiency (handling and potential utilisation of GHGs arising from their activities) and social health (mitigation of harmful effects to people and ecology). Intrinsic to this is the capacity to adequately monitor GHGs, where a number of challenges are posed: sensor performance, long-term reliability and, perhaps most significantly, cost viability.

In this work, autonomous gas sensing platforms with remote data accessibility have been developed. The focus has been on achieving long-term reliable performance at a price-point that enables the deployment of multiple distributed systems. Such a wireless sensor network exhibits extensive temporal and spatial resolution, thus defining GHG emissions over the course of time and area for the deployment location in question. The waste sector (e.g. landfills and wastewater treatment plants) was targeted given its status as a substantial contributor to worldwide GHG generation. Decomposition of biodegradable waste generates methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>). In landfills, these gases must be thermally oxidised by flaring or preferably running an engine if sufficient methane quality. The benefits of autonomous remote gas sensing are twofold: firstly, it will serve to protect local environment by detecting and preventing gas migration beyond the landfill facility perimeter; secondly, it can be used to determine the gas generation potential at various points within the landfill, thus ensuring that the engine or flare receive an adequate supply to maintain optimum operation.

The remote monitoring achieved by these bespoke platforms provides insight into the characteristics of gas emission sources which, in turn, can contribute significantly towards the optimised management of GHG emissions. Case studies are presented on monitoring gas behaviour at distributed locations on landfill sites and on measuring surface emissions from wastewater lagoons and treatment plants.

**Keywords:** Environmental monitoring, remote sensing, landfill gas

**67. A low-cost autonomous phosphate sensor for quantifying the influence of agriculture on river water.**

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Phosphorus (P) is a growth limiting nutrient. When P levels increase, excessive growth of algae occurs, leading to hypoxic waters and subsequent death of aquatic animals. The EU Water Framework Directive states that rivers should not exceed phosphate levels of 0.1 mg L<sup>-1</sup>. An affordable network of phosphate sensors for continuous, real-time monitoring, providing temporal and spatial variations in phosphate levels, is essential for the management of water quality.

An automated phosphate sensor has been developed in DCU, capable of continuous, real-time monitoring. This sensor utilises the molybdenum yellow method for colourimetric detection of phosphate. The limit of detection of 0.2 mg L<sup>-1</sup> limits the applicability of this sensor to waters with higher levels of phosphate such as waste water treatment plant effluent or known polluted waters.

To improve the detection limit this sensor will be adapted to use the molybdenum blue method for phosphate determination, allowing the sensor to be used in waters with lower concentrations of phosphate such as rivers and lakes. The blue method is more complicated to automate as it requires the separate addition of two reagents, compared to one reagent for the yellow method.

A microfluidic chip is used with pumps for addition and mixing of reagents with sample. It incorporates a cylindrical optical cuvette for absorbance measurements using an LED and photodiode. These measurements can be sent remotely to a laptop via a GSM modem or WiFi, showing real-time variations in phosphate levels.

Legislation such as the EU Water Framework Directive is driving this research as there is a need for low cost, sensitive, reliable phosphate sensors. Low-cost monitoring systems are an essential component for effective river water management.

**Key words:** Phosphate, water, monitoring system, sensor.

## **68. Challenges of Monitoring of Suspended Sediment Fluxes: Turbidity Surrogate Method.**

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Excessive levels of suspended sediments impair ecology of fluvial systems and contribute to pollutants and nutrients transport. When deposited, fine sediments affect sensitive ecosystems such as fish spawning grounds or freshwater pearl mussel beds. Monitoring of suspended sediment levels is therefore crucial for the protection of sensitive environments. High temporal variations of suspended sediment fluxes require long-term, high-frequency sampling which is now commonly supported by continuous monitoring using surrogate methods such as turbidity. In-situ sensing devices provide a detailed record of sediment dynamics and can provide good estimates of sediment fluxes. Continuous in-situ monitoring can be challenging, however, because system mounting, fouling, bio-fouling, and instrument type settings can affect the accuracy of results. Although turbidity meters are calibrated to a Formazin standard, they can produce different results depending both on measured sediment properties, and the technical specifications of the instrument. This may not be hugely significant in suspended sediment studies in which turbidity is rated against sediment concentration, but where turbidity is the parameter of primary interest, such discrepancies will produce uncertainties in results. An improved understanding of these effects is necessary for developing reliable and widely applicable monitoring systems for suspended sediment fluxes to help develop standards for the protection of river ecology. This paper will present the results of an investigation of six different turbidity sensors operating under controlled laboratory and field conditions. The study aims to test the effects of variable parameters, including sediment concentration, grain size and fouling, on sensor performance, to provide a better understanding of turbidity instrument performance and applications in the field.

**Keywords:** turbidity, sensors, suspended sediment, sediment concentration and flux

## **69. Mineral weathering rates for Irish forest soils using the models PROFILE and A2M**

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Mineral weathering rates determine inherent soil fertility and resistance to pH change. However weathering rates are difficult to quantify, and there is currently little knowledge of weathering rates for Irish soils. This project will map weathering rates of acid mineral forest soils in Ireland.

Soil samples representing about 240 acid mineral soils from fully-described profile-pits of the ISIS (Irish Soil Information System) survey will be analysed for mineral particle-size distribution, surface area, bulk density and major oxide content based on fusion X-ray fluorescence (XRF). In addition, a sub-set of samples (n = 30) will have detailed mineralogy assessed by X-ray diffraction (XRD). The results of these analyses will be further processed using the A2M and PROFILE models. A2M estimates mineralogies from oxide analysis by solving the extreme mineral modes from a given oxide composition. The "average" of these extreme mineral modes can be used as the most-probable mineralogy. The PROFILE model estimates weathering rates from soil mineralogical data, particle size analysis, and other physico-chemical analyses. The PROFILE model accounts for the effect of the soil solution composition on the mineral weathering rate of the soil.

Using PROFILE-model outputs, point estimates of weathering rates can be mapped. Interpolation of these points will be carried out using kriging to create a continuous coverage. The map will show variation in the mineral weathering rates for acid mineral forest soil types nationally. This will be used as an input to forest nutrient mass-balance calculations, as a means to assess the nutrient impacts of increased biomass harvested for fuel ([www.ucd.ie/forsite](http://www.ucd.ie/forsite)).

**Keywords:** Mineral weathering, GIS, mapping, modelling

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## **70. Journalysis: increasing accountability in academic publishing**

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Today some 8,300 scientific journals are listed in the research database, Web of Knowledge. This figure includes only journals with Impact Factors, and the actual number of scientific journals is almost an order of magnitude greater. The distribution of the ‘impact’ of these publications is broadly Poisson-shaped, with the vast majority of journals existing in the lower range of impact. These journals are often the target of early career researchers and those publishing research on applied topics that are not of sufficient interest to the highly editorially selective journals of ‘high impact’. Impact Factors (IF) published by Thompson Reuters are typically been used to judge the impact and quality of journals and their published research, however, evidence shows that a small fraction of the research they contain contributes to their IF, which, in turn, is highly variable from year to year. Presented with multiple possible platforms for publishing, researchers often need more information when choosing a suitable journal. As publishing shifts from a user-funded model to an author-funded model, assessments of publishing standards will likely also shift from an output quality basis to that of service quality. To date there has been no way for authors to share their experiences of publishing in order to provide comment and data to help other researchers more appropriately choose a journal to suit their needs. Journalysis, a HEFCW-funded project, aims to provide academic authors with a platform for reviewing their experiences with publishers, both good and bad, and to share metrics, such as time-in-review, time-to-publishing, and overall ratings. This academic ‘Trip Advisor’ will increase accountability and hopes to raise standards in the publishing industry.

**Keywords:** publishing, review, journals, accountability, impact factor, library, open access

## **71. Key Performance Indicators for the Effectiveness of Strategic Environmental Assessment in Ireland**

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A draft framework of Key Performance Indicators (KPIs) has been developed for use by Statutory Environmental Authorities and Local Authorities, on evaluating the influence of Strategic Environmental Assessment (SEA) on development Plans and Programmes, and in environmental protection. Interviews were conducted with 20 SEA practitioners selected from Irish Statutory, Local and Regional Authorities and consultants clarified what is generally considered crucial to SEA effectiveness. Data collected supported the development of a framework of KPIs for SEA effectiveness, following the strategy mapping approach, i.e. identifying the goal of SEA and the critical success factors that need to be achieved to meet this goal, as perceived by SEA practitioners. A candidate set of KPIs reflecting these critical success factors were then selected and associated targets for future progress were identified. Through a further consultation workshop with practitioners a final set of KPIs was selected. These included indicators for a) the quality of SEA reports; b) the effectiveness of SEA implementation, i.e. how well the recommendations of SEA are integrated into Plans/Programmes; and c) the effectiveness of SEA for environmental protection i.e. the extent to which these Plans/Programmes which have been evaluated through the SEA process are contributing to environmental protection. Further work will involve applying the KPIs to completed SEA environmental reports and associated adopted plans and to on-going SEA, to further refine the KPI set, indicate the effectiveness of SEA in Ireland, and highlight actions to enhance the SEA process in Ireland.

**Keywords:** Strategic Environmental Assessment, key performance indicators, policy effectiveness

## 72. A model of knowledge transfer and integration at the science-policy interface

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Adaptive policy making will require more integration of knowledge from different sources (i.e. transdisciplinarity) as well as long-term communication between scientists and policy makers. Many policy measures have been taken and new ones are being implemented to facilitate transdisciplinary approaches to knowledge creation, which is a relatively new, but increasingly widespread, practice in the scientific community. The objective of this work is to explore how some simple changes in the parameters given to scientists working on policy-related research can change the quality and relevance of the outcome of the project. An agent-based model was created in the open-source software NetLogo using some modeling ideas from SKIN (Simulating Knowledge Dynamics in Innovation Networks). The baseline assumption was that scientists deliver random quality and relevance of answers in their respective discipline and that the overall quality and relevance of the knowledge created was reflected in the sum of what scientists delivered. According to probabilistic principles the emergent distribution of quality and relevance of answers is centered on, and peaks at mediocre quality and relevance of answers in this baseline scenario. Scenarios of increasing facilitation of communication among experts and stakeholders were run to show the effects of increased dialogue, expert selection, networking as well as additional data collection on the outcome. While this model is highly artificial and a great simplification of joined knowledge creation at the science- policy interface, some interesting insights as how the parameters given to scientists for the delivery of their advice can influence outcomes for policy makers emerged.

**Keywords:** adaptive policy making, knowledge communities, scientific advisory, sustainability science

### **73. Assessing the Environmental Impacts of Micro-hydropower in the Water Industry**

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Micro-hydropower (MHP) is a promising, economically-viable process which can be used for energy recovery in the water industry. The industry consumes between 2-3% of global energy resources in water treatment, supply and disposal processes and this demand is set to increase with global population growth. In addition, water suppliers in the UK have set targets to reduce the greenhouse-gas (GHG) emissions of the industry. The introduction of renewable energy sources is one method of meeting these targets. However, the carbon emission associated these systems are not reported and thus it can misrepresent the green credentials of the water industry. Implementing MHP at some of the 200 sites identified in Wales and Ireland outlines the potential for substantial energy recovery in the water infrastructure. This paper focuses on quantifying the environmental impacts of MHP at locations in the water industry by calculating the embodied carbon using a life cycle assessment (LCA) approach. The results from this study show the duration for carbon of hydro installations ranges from 0.9-3.2 months, which was significantly lower than the financial payback (3.5-8.3 years) of the same projects. The embodied carbon for a MHP installation varied for each case study, with the most substantial differences due to the associated civil works. Due to these variations, a comparison of the turbine and generator as a fixed element of each project was carried out. This showed that the carbon payback were quite similar and ranged from 0.4-0.9 months for the different projects. The recovered energy from installing MHP turbines in the water infrastructure reduces electricity demands and provides income through Feed-in-Tariffs (FiTs). This study shows the additional value of MHP installations as a renewable energy source that has a low environmental impact with a short carbon payback period that notably outweighs the economic payback of these installations.

**Keywords:** Environmental Impacts; Life Cycle Assessment; Micro-hydropower; Energy Recovery; Water Industry.

## **74. Evidence Synthesis in the Environmental Sciences: A systematic review**

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Evidence synthesis, in the form of systematic reviews and systematic maps, is rapidly becoming a standard means of summarising the evidence in answer to an environmental concern. Where there is too much information for policy-makers and practitioners to review, where the evidence conflicts, or where a comprehensive assessment of study quality is needed, evidence synthesis can be a vital means of providing a summary of the available information. Traditional reviews and meta-analyses are rarely transparent about their choice of studies, or how the reviews were undertaken. Furthermore, they often focus purely on published evidence, allowing for publication bias to potentially reduce their reliability. Systematic reviews follow a set transparent, objective and repeatable methodology, and involve stakeholder engagement and peer-review both at the planning and full review report stages. These strict standards ensure that the answers provided in the review are as reliable as possible. Systematic reviews have progressed a long way since their inception in the medical sciences and translation for application in other sectors, including environmental sciences. Major environmental bodies now employ evidence synthesis as an industry standard. Three examples of evidence synthesis have been funded by the UN (STAP), Defra, and EMAS (FP7) and focus on quite different themes. The first relates to the human wellbeing impacts of terrestrial protected areas. The second relates to the greenhouse gas and carbon flux impacts of lowland peatland management. The third relates to the environmental and human wellbeing impacts of high altitude agricultural land abandonment. The evolution of these evidence syntheses from broad concerns to finalized and disseminated reviews will be introduced in this presentation as an example of the diversity and suitability of evidence synthesis techniques for environmental sciences as a whole, and specifically for Ireland.

**Keywords:** evidence, systematic review, systematic map, policy, practice, agriculture, environment, wellbeing

**75. The occurrence of PAH's and Faecal Sterols in Dublin Bay and their influence on sedimentary microbial communities.**

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Sediment samples were collected from 30 stations in Dublin Bay aboard the R.V Celtic Voyager (CV10\_28). Faecal sterols, polyaromatic hydrocarbons (PAH's) and microbial lipids were extracted from sediments using a classic lipid extraction method and analysed by GC-MS. The procedure allowed for the simultaneous evaluation of faecal sterols, PAH's and their influence on microbial communities. Faecal sterols are used as indicators for sewage contamination in the Bay. PAH's are classified as priority pollutants by the EPA, their distribution, concentrations and possible sources are studied here. Microbial lipids, specifically phospholipid fatty acids (PLFA's), were used as taxonomic indicators for the division and structure of microbial populations in Dublin Bay. The impact of particle size, %TOC, %H and %N were also assessed. Faecal sterols are found to be highest around Howth Head, this is consistent with a history of sewage discharge here. PAH's range from 12 to 3072 ng/g, but are not strongly correlated to faecal matter, suggesting other diffuse sources. PLFA's positively correlate with PAH's and faecal sterols. PLFA's do not appear to be impacted by %clay, %silt or %mud. While PAH's are found mostly in sediment with a high %clay. The results suggest microbial community is impacted by the type of organic matter input.

**Keywords:** Polyaromatic hydrocarbons, faecal sterols, phospholipid fatty acid biomarkers, microbial populations, sewage contamination, pollution, marine sediment, Dublin Bay.

## 76. ‘SmartBay – Ireland’s test, demonstration and validation facility’

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SmartBay - Irelands national test facility for marine technology is facilitating the development of innovative approaches to sensing, communication and data management/visualisation technologies through sensor deployments in a real world marine environment. SmartBay comprises a suite of commercially available technology platforms including a network of buoys, sensor hardware and communication systems against which new technologies can be validated. This presentation elaborates on current SmartBay projects including acoustic monitoring in Galway Bay, the Galway Port Buoy and the Cork Buoy status. Details on how sensor data acquisition and data visualisation tools can be integrated to develop an innovative, robust, flexible cyber-infrastructure which provides numerous benefits to a diverse user community will be reviewed. This presentation will also discuss the status of the cable observatory installation which SmartBay Ireland will manage and operate . The power and data cable will terminate at a subsea monitoring station which will host a suite of commercially available sensors and will also have additional ports to trail innovative and novel sensors in a sub-sea environment. The presentation will provide an overview of the ‘Oceans of Tomorrow’ **MARINE** environmental in situ Assessment and monitoring tool **BOX** (MARIABOX). The project will develop a wireless marine environment analysis device for monitoring chemical and biological pollutants while installed into a buoy, a maritime means of transport or a mooring. The device, based on novel biosensors, will be of high-sensitivity, portable and capable of repeating measurements over a long time, allowing permanent deployment at sea.

## **77. Assessing the Hydro-Environmental Impacts of Tidal Turbines**

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Tidal current turbines have the potential to provide a considerable proportion of global energy requirements. At present the commercial viability of marine current devices is being tested using single devices; however investigation into large scale tidal turbine arrays has yet to be significantly explored. The feasibility of such technology will depend on the expected power output, as well as the consequential hydro-environmental impacts.

To date there has been little research undertaken to assess and quantify the hydro-environmental effects, however studies incorporating numerical models suggests these impacts could be substantial. A full literature review into tidal current turbines, focusing on previous physical and numerical investigations into assessing the hydrodynamic and environmental impacts of tidal turbine arrays has been carried out. Concluding from this work the major hydro-environmental impacts associated with the deployment of tidal turbine arrays have been identified as changes in water elevations and current velocities, changes to sedimentation and other coastal processes such as pollutant transport and the implications of these changes for marine life.

The long term goal of this research is the development of a methodology to quantify the significance of these impacts. It is proposed to develop an impact index, using flushing time as the environmental indicator, which would indicate the significance of hydro- environmental impacts for different turbine arrays. Such a tool would be of enormous benefit in the planning and siting of tidal turbine arrays.

**Keywords:** Tidal current turbines, hydro-environmental impacts, impact index

## 78. The Role of Passive Sampling in the Screening and Monitoring of New and Emerging Chemicals

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In recent decades, scientific and legislative communities have become increasingly aware of the presence and potential effects of pharmaceuticals, personal care products and other “emerging compounds” in the environment. These compounds may reach the aquatic environment via a number of sources, including wastewater effluent, agricultural and terrestrial run off and accidental release. They are often potent at trace levels and despite recent advances in detection methodologies there is still a limited understanding of their occurrence, fate and environment effects. Under the Water Framework Directive (WFD, 2000/60/EC) there is a requirement for substantial monitoring of priority and relevant pollutants in all waters to achieve “good ecological and chemical status” by 2015. It can be challenging to achieve sufficiently low detection limits to measure some priority substances at environmentally relevant concentrations.

Passive sampling (PS) technologies are fast being recognised as a cost-effective, state of the art, pragmatic tools to identify and measure ultra-trace micro-pollutants in water. PS generally enables greater sensitivity than that achieved by “traditional” spot-sampling, potentially improving detection capabilities by orders of magnitude. PS may also have a role in replacing elements of biota monitoring. Like organisms, PS devices accumulate contaminants over time, to similar concentrations, with similar drivers for uptake but are not complicated by the physiological variability in response to environmental variables encountered with traditional biota monitoring. The role of PS in the screening and monitoring of emerging chemicals and priority pollutants is currently being investigated in this EPA funded project. Preliminary results from samplers deployed in the Lee catchment Co. Cork and water and biota samples will be discussed along with previous WFD monitoring results. Further sampling will be conducted in 2014. Results from this project will inform whether PS, in combination with a range of other supporting tools, can be utilised to support WFD pollution monitoring.

**Keywords:** Passive sampling, Water Framework Directive, biota, water quality, emerging compounds.

## **79. Impacts of multiple stressors on marine ecosystems during the establishment of assemblages.**

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Coastal ecosystems are among those most threatened by the action of multiple stressors and are more likely to suffer a higher rate of local extinction in the coming years. Reduction in biodiversity might impair the functioning of coastal ecosystems with severe repercussions for services provided to society. The limited knowledge of the mechanisms through which multiple stressors operate limits researchers' capacity to predict their effects on biodiversity and ecosystem functioning. Furthermore, there has been a tendency to focus on how stressors disrupt adult stages in mature assemblages, rather than early colonisation of newly available habitats. Understanding which life stage is more vulnerable to environmental variability would help inform management of human activities to reduce effects on biota. The present study experimentally tested whether copper and freshwater input affect colonisation of hard substrata independently or interactively and assessed differences in community respiration and total biomass among early stage assemblages, which develop under different regimes of copper and freshwater. Copper had a significant influence on the colonisation of experimental tiles. The effects of freshwater inputs were limited and were usually influenced by the presence of copper. However, this interacting effect was very weak and when present was due to antagonistic interactions between copper and water flow, rather than changes in salinity. The stressors manipulated here did not have any effect on the total biomass or respiration of the community studied. These effects contrast with those on establishing assemblages reported by Kinsella and Crowe in a linked study also reported at this conference, confirming the complexity of stressor interactions in natural environments and the variability and context dependency of their impact.

**Keywords:** multiple stressors, biodiversity, ecosystem functioning, recruitment, larvae, copper, salinity

**80. Uncertainty Analysis for the Irish NMVOC emission inventory Solvent and other Product Use sector.**

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Emission inventories are considered a primary tool for modelling atmospheric pollutants. NMVOC emission inventories are inherently uncertain for numerous reasons ranging from the aggregation of solvents under the NMVOC classification to lack of detailed data on emissions. This project attempts to quantify that uncertainty using the EMEP (2013) Tier 1 method. Rather than assume data distributions, where available data permits, the distribution is assessed using frequency tables and chi square analysis. In situations where either a small sample size or non-normal distribution is found, a bootstrap analysis is employed to re-sample the emissions data and by doing so, creating a sample size large enough for analysis or transforming data in a more normal distribution. In addition to this, a sensitivity analysis was also employed to further refine the output from the uncertainty analysis. This was accomplished using the ANOVA model. Input data (sectorial emissions data) was analysed against output data (Total emissions) for each NFR sector to establish which category created the most variance within the emissions system. This was first uncertainty analysis of its kind in the Irish inventory system and results show that it is broadly in line with European counterparts. However, correlations between variables have not been accounted for in this methodology and therefore further work using Monte Carlo Simulations are necessary

## **81. Reducing the NO<sub>x</sub> gas emissions of a liquid fuel burning boiler through the prehumidification of the combustion air**

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NO<sub>x</sub> (mono nitrogen oxides) gases are pollutants, reacting in the atmosphere to form smog, acid rain and ground level ozone. They are formed by combustion at very high temperatures in the presence of nitrogen and oxygen and are therefore present in the flue gases of industrial boilers. Previous studies carried out on gas burning boilers have shown that the introduction of water vapour into the combustion air significantly reduces the NO<sub>x</sub> emissions (up to 3.8 times) [1]. This is due to the cooling affect of the vapour in the radiation zone of the boiler. There are no negative impacts on efficiency observed as the radiation of the triatomic water molecules compensates for the decrease in temperature. Additionally, there is a substantial improvement in energy efficiency when the air prehumidification is achieved through flue gas waste heat recovery, which lies in the basis of the method proposed [1].

A new study has been carried out, as part of a project funded by Enterprise Ireland, to investigate the impact of combustion air prehumidification on the NO<sub>x</sub> emissions of a medium sized, liquid fuel burning industrial boiler. For this purpose, an experimental stand was constructed to introduce low pressure steam into the combustion air. Experiments were carried out under varying boiler loads (50 – 100%) and at varying levels of prehumidification (up to 10.2% v/v). Reductions in the NO<sub>x</sub> gas emissions (up to 2.5 times) were observed for all boiler loads.

**Keywords:** NO<sub>x</sub> emissions reduction, GHG emissions reduction, energy efficiency improvement

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## 82. The spatial distribution of ambient atmospheric ammonia concentrations in Ireland

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Ambient atmospheric ammonia (NH<sub>3</sub>) concentrations are currently being monitored in a network of 25 volunteer-operated monitoring stations established across Ireland. The monitoring campaign started in June 2013 and is planned to run for one calendar year. Atmospheric ammonia concentrations are determined using Willems-badge passive samplers, exposed in triplicate at each monitoring site. Ammonia is collected on an absorbent acid layer within the sampler. The passive samplers are exposed continuously, at a sampling height of 1.2 m, and replaced on a two-week cycle. Ammonia amounts, determined from each passive sampler by spectrophotometric analysis, are converted to an air concentration value ( $\mu\text{g m}^{-3}$ ). Concentration measurements from each station are only accepted where all three triplicate values are available and the coefficient of variation (CV) is below 25 percent. Laboratory blanks and travel blanks are used as controls. The data presented here comprise two consecutive fortnightly exposures and represent the first month of the monitoring programme, from the beginning to the end of June 2013. The results show variation across the country, with a distinct trend of increasing ammonia concentration towards the northeast midlands. The lowest concentration for the period, with an average of  $0.51 \mu\text{g m}^{-3}$  was recorded at Mace Head station, Co. Galway while the highest average concentration of  $6.09 \mu\text{g m}^{-3}$  occurred at Carrickmacross, Co Monaghan. The average level of  $1.85 \mu\text{g m}^{-3}$  from all 25 sites for this period is well below the  $8 \mu\text{g NH}_3 \text{ m}^{-3}$  critical level recommended by the Convention on Long Range Trans-boundary Air Pollution (CLRTAP). Recent studies suggest however that the current critical level in Europe has been set too high and should be dramatically reduced to avoid impacts to sensitive receptor ecosystems. High atmospheric ammonia levels resulting in subsequent ammonium deposition may cause soil acidification and leaching of soil nutrients, and also contribute to eutrophication and groundwater pollution. This project faces the challenge of explaining the distribution of ambient atmospheric ammonia, and provides a means to monitor its spatial distribution in real time.

**Keywords:** ambient atmospheric ammonia, spatial distribution, eutrophication, critical level

### **83. Urban biodiversity management in Ireland - capturing the experience of practitioners**

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Apart from the scientific challenge of monitoring and understanding urban biodiversity, urban biodiversity management presents many practical challenges. In particular, urban biodiversity is essential to the experience of nature for the urban population as well as for delivering ecosystem services such as flood control. The management of urban biodiversity therefore needs to cater to many needs and stakeholders. Furthermore, management of urban biodiversity is often resource intensive such that trade-offs between management actions have to be carefully weighted. The aim of our project is to develop a conceptual framework within which these management trade-offs can clearly be depicted and priorities can be determined. In a first step to develop this framework we carried out a survey of several relevant professional groups (engineers, ecologists, landscape architects, and horticulturists ) in order to identify 1. relevant stakeholders (their role, priorities, and education in relation to biodiversity; 2. the resources they manage, trade-offs in allocation and prioritisation of resources and 3. the actions they implement currently or plan to implement. We examine trends among professions. The results from this survey suggest low awareness of some environmental designations and of stakeholders' budgets for biodiversity. When asked to identify threats to urban biodiversity, the loss of habitats is identified by many more than fragmentation. Based on these surveys, which were only distributed to those attending seminars on biodiversity-related themes, we intend to extend this survey to a wider group of professionals, with a view of assessing the requirements for mainstreaming biodiversity concerns in Irish local authorities. Ultimately, this consultative process will allow us to determine the needs in terms of guidance on urban biodiversity management for these professional groups and deliver such guidance for more effective biodiversity management to these groups.

**Keywords:** urban biodiversity, biodiversity management, trade-offs, ecosystem services

## **84. Spatial planning in Ireland: Can a transitions approach empower the NSS mark 2?**

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Ireland's polarised urban hierarchy is characterised by limited integration of transport and land-use planning, dispersed urban forms and considerable fossil fuel dependency. The National Spatial Strategy (NSS), published in 2002, is a Government framework which seeks to address these issues, aiming for a better balance of social, economic and physical development across Ireland. The NSS advocates integrated planning and joined-up approaches between Government departments. However, although updated in 2010, and remaining as Ireland's spatial planning framework, the NSS has had very limited success. The housing bubble over 2003-2007 had substantial adverse impacts for spatial planning and for long-term policy agenda setting. During this time, the Government generally overlooked the NSS and the planning system facilitated development which exacerbated historical trends, such as extensive commuter settlement in proximity to Dublin and developer driven planning elsewhere. As the Irish Government prepares an NSS mark 2, this paper asks, how can a new strategy can be better formulated to more effectively achieve spatial planning goals? The potential of transitions approaches is forwarded as a means of setting and achieving sustainability goals, while taking due consideration of current socio-political inertia and path-dependency. According to the transitions literature, addressing socio-ecological problems and underlying complexes of technologies and institutions requires governance approaches with a long-term orientation, as well as policy design which is reflexive and adaptive. The potential of transitions approaches as a framework for systematically analysing the prospects for low-carbon development at urban and regional scales is assessed and the implications for NSS architects are highlighted. Due to the gap between present conditions and those conditions required to realize sustainable urban centres and regions, this paper emphasises the need to foster innovation at the urban scale, together with the requirement for a systematic consideration of strategic policy approaches to address future economy-wide challenges.

**Keywords:** National Spatial Strategy, Spatial Planning, Sustainability, Transitions, Reflexive Governance

## **85. $\mu$ AQUA – a universal microarray for the detection of waterborne pathogens**

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The threat of waterborne diseases is predicted to increase in the future. To avoid outbreaks and ensure safety, water quality needs to be continuously monitored. A universal method for rapid and cost-effective detection of waterborne pathogenic microbes has been sought after for many decades. Traditional methods can be laborious, require high levels of expertise and typically focus on only one or a few organisms. As part of the interdisciplinary and international project  $\mu$ AQUA, a universal microarray chip was developed, equipped with species-specific oligonucleotide probes targeting protozoa, bacteria, viruses and cyanobacteria. The array is designed to include a hierarchical approach, with probes targeting higher clades to increase specific detection of pathogens. We designed and tested probes that target human pathogenic members of the protozoa *Cryptosporidium*, *Giardia*, *Naegleria* and *Entamoeba* in environmental water samples. Critical focus points included obtaining and processing samples for the extraction of high quality nucleic acids and the validation of the array signals with field samples using current best-available techniques. The project also involved monitoring of different types of waters in Europe, including distinct Irish rivers that drain agriculturally intense and urbanised catchment areas, providing water from different environmental conditions. The abundances of *Cryptosporidium* oocysts and *Giardia* cysts in the Irish rivers have been assessed monthly using EPA method 1623 to use as validation for the microarray signals. The greatest numbers of *Cryptosporidium* oocysts were found early in spring and autumn, mainly in the agriculturally intense catchment, but none of these were characterised as human pathogens.

## **86. A Continuous Fluorescence Assay based Sensor for the Monitoring of Faecal Indicator Bacteria in Marine Environments**

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The EU Bathing Water Directive (BWD) sets the microbiological water quality standards for European waters. *E.coli* and Enterococci are specified as Faecal Indicators (FI) and their acceptable levels in fresh and transitional (coastal) waters are dictated by the BWD. Culture-based tests for FI enumeration are widely used and accepted (e.g. Microfiltration, Colilert 18, Enterolert). These are reliable and proven but they are slow, taking 18 hours or more to produce a result and they detect only Viable Culturable (VC) cells, but not ‘Viable But Not Culturable’ (VBNC) cells. Epidemiological studies have shown VBNC cells to have significant correlation to human illnesses.

More rapid tests would allow for timelier decision-making and control measures and detection of VBNC cells which can make up a significant portion of the cells present depending on conditions, would allow for more sensitive detection of faecal pollution events.

In this work a continuous fluorometric assay based on *E.coli* metabolism was used to overcome the drawbacks of culture based methods. A fluorogenic substrate based on a glucuronide of a fluorescent molecule (7-hydroxycoumarin) was added to the sample without a growth medium. Substrate was taken up by target cells and hydrolysed by  $\beta$ -D-Glucuronidase (GUD) enzyme. Resultant fluorescence was measured and used to indicate the number of cells present. The hydrolysed molecule fluoresced strongly at near neutral pH, thus allowing for a continuous assay. Such a continuous assay approach allowed for a minimum of sample handling.

This assay was integrated into a new low-cost field portable detection system (ColiSense) which provided in-situ analysis. Using this presented system and assay it was possible to differentiate within 10 hours between concentrations of target cells.

**Keywords:** Continuous Assay, Fluorescence, Faecal Indicator, Sensor

## **87. An Optical Colour Sensor for Monitoring Marine and Aquatic Environments**

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A multi-wavelength optical sensor for monitoring aquatic environments is presented. The sensor is capable of measuring the attenuation of light emitted by LEDs along two paths, at right angles to each other, through water. The sensor is low-cost, robust, re-deployable and flexible giving qualitative data on water property changes; enabling high spatial and temporal data resolution. Potential applications could include the detection of major turbidity and chlorophyll events.

The increased stress on aquatic environments due to anthropogenesis is recognised and its alleviation forms part of policy [1, 2]. The need to real-time monitor, understand and mitigate the causes of the pressures is urgent. Optical sensors for environmental monitoring are commonly utilised for their accuracy, repeatability and sensitivity; however many commercial sensors are complex, intricate and expensive.

The sensor head has five LEDs: IR, red, amber, green and blue. The LEDs chosen give coverage across the visible spectrum allowing the possibility of chlorophyll determination using spectral-banding [3, 4]. Two photodiodes (PDs) are positioned at 90° and 180° to the LEDs. The transmission of light through the water and scattering of light from the water (including particulate matter) are measured simultaneously. The LEDs and PDs are covered by T-shaped tubing to prevent light directly entering the 90° PD. The body is made from PVC-U tubing, which holds flotation material, electronics and communications and the detection head. To minimise bio-fouling the sensor head is constructed of copper which has antifouling properties.

The sensor underwent deployment in Dublin bay, results illustrate the ability to detect changes in turbidity and chlorophyll-related turbidity and they are supported by data collected from a commercial sonde.

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## **88. Autonomous Environmental Sensors As Tools In Marine Resource Management.**

Authors: Sullivan, T., Zhang, D., Briciu-Burghina, C., Heery, B., O' Connor, N. E., Smeaton, A. F., and Regan, F.

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Our coastal seas are a vital and increasingly exploited resource. A key future challenge lies in ensuring sustainable use of this resource, where traditional uses of transport and fishing now compete alongside more recent activities such as mineral extraction and ocean energy devices. To protect our marine resources, it is necessary to monitor and understand the impact of exploitation on marine processes. Key management decisions must be made based on collected data to reduce negative impacts while supporting environmentally sustainable uses. However, widespread deployment of automated sensors to collect the required data on large spatial scales in a cost-effective manner remains a challenge. Further challenges are presented by data handling capabilities and lack of instrument reliability under field conditions. Combining multiple technologies and sensing modalities in environmental monitoring programmes may provide some solutions to the lack of robustness for sensing systems and perhaps even enhance understanding of environmental events.

Considerable advances can be made if robust sensing technology is combined with sophisticated methods of data analysis, modelling and prediction, ultimately leading to improved network reliability and greater understanding of environmental change.

Here we report the results of a series of autonomous environmental sensor deployments that demonstrate the power of these tools for understanding environmental change. We demonstrate how advances in modelling, data handling and data mining techniques allow use of fewer sensors in the field, with greater network robustness. We present results utilising these advances to understand fate of near-shore microbial contaminants, predict estuarine flooding events and impacts of climate change.

**Keywords:** multimodal data, marine resource management, decision support, visual sensing

## **89. Smart Sensing for Marine Monitoring and Decision Making**

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According to the Integrated Marine Plan for Ireland 2012, the Irish ocean economy will generate €6.4 billion a year in turnover by 2020, contribute 2.4% of GDP (direct and indirect Gross Value Added) by 2030, and support approximately 1% of the total workforce. These increasingly exploited resources need to be monitored, managed and protected efficiently and effectively. This provides a need for long-term, large-scale marine monitoring systems, and decisions must be made based on analysis of collected data to avoid or limit negative impacts.

Following development of modern wireless communication and marine sensing technologies, numerous remote monitoring systems have been deployed to collect continuous real-time or near real-time marine water quality measurements. Much research has been carried out to deal with sensor reliability issues such as biofouling, sensor drift and sensor failure in order to enhance reliability of the wireless sensor network (WSN). However, there is very little research focus on automatically monitoring our marine environment at higher spatial and temporal scales. At such scale, large volumes of data will be generated by sensors, which cannot be observed by operators manually. In this work, we propose a novel marine event-monitoring framework using state of the art machine learning techniques from computer science domain. Marine environmental events will be automatically detected, grouped and logged based on their similarities. The system can send early warning messages to system administrators when anomalies are detected, thus operators can respond in real-time to avoid or limit negative impacts. The system can also create an event catalogue according to event signatures, allowing the end user to browse and query. For example, searching the time of a particular event and the number of similar events that have occurred in the past. Environmental scientists can then further investigate the cause of each event subclass to better understand the marine ecosystem and future policies can be designed and implemented to protect these environments.

**Keywords:** marine monitoring, smart sensing, decision making

## **90. The Impact of Traditional Septic Tank Soakaway Systems and the Effects of Remediation on Water Quality in Ireland**

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Two experimental sites of low permeability subsoil have been routinely sampled for effluent, soil moisture, groundwater and soil samples at specific intervals; pre-remediation and post-remediation. The study aims to confirm by microbial source tracking (MST), the source (human and/or animal) of faecal microorganisms detected in groundwater, surface water and effluent samples, and to monitor the transport of pathogens specific to on-site wastewater outflows. In combination with MST, the evaluation of nitrification and denitrification in surrounding soil and effluent samples aims to assess the effectiveness of remediation at reducing the risk of nitrate loading to local ground and surface waters.

A robust and reproducible DNA extraction method was developed, applicable to both sites. MST markers based on host-specific Bacteroidales bacteria for universal, human and cow-derived faecal matter are being employed to determine quantitative target occurrence using real-time Polymerase Chain Reaction (qPCR) assays (Kildare et al., 2007). The abundance of both archaeal and bacterial 16S rRNA and of several functional nitrification and denitrification genes (i.e., amoA, nirS, nirK, and nosZ) is also being determined and compared in both sites.

Results from both sites suggest low permeability subsoil prevents the even distribution of effluent through the receiving subsoil, forcing it instead to flow laterally via distinct pathways such as sand lenses and nearby drainage routes. This affects the ability of the subsoil to sufficiently treat the percolating effluent. Initial results from the remediation of the existing systems to alternative low pressure systems indicate a decrease in effluent loading to groundwater at both sites. This step towards a better understanding of the factors influencing microbial denitrification and the behaviour of pathogens in sensitive environments aids in identifying management options for reducing nitrous oxide (N<sub>2</sub>O) emissions and nitrate (NO<sub>3</sub><sup>-</sup>) leaching; and for enhanced protection of public health.

**Keywords:** Microbial Source Tracking, N-cycle functional genes, qPCR.

**91. Evaluating the effect of natural and human processes on groundwater pollution using a GIS based modelling approach.**

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Determining the likelihood that groundwater contains faecal coliforms can aid water resource management in facilitating the protection of drinking water supplies. This study assesses the microbiological quality of 132 Private Water Supplies (PWS's) serving individual houses in the Midwestern region of Ireland. Utilising the IDEXX Colilert-24 method for the quantification of thermotolerant coliforms, the incidence of contamination of private water supplies with the faecal indicator organism *Escherichia coli* was analysed. The microbiological results demonstrated that 57.6% of the supplies tested were found positive for the presence of *E.coli* at least once during the testing regime. Using a Geographical Information System (GIS) the relative hydrogeological and climatological features unique to each sampling location was derived. Utilising this information, a Logistic Regression (LR) model was used to predict the probability of contamination of private water supplies with *E.coli*. The model contained two independent variables: Rainfall (mm) ( $p < .001$ ) and Aquifer Characteristics ( $p < .001$ ). The full model, containing both predictors was statistically significant  $P < .001$ , indicating that the model was able to distinguish between the independent variables relationship to the incidence of contamination. The likelihood of *E. coli* contamination is greater with increased rainfall and in areas where a bedrock aquifer is dominant. The LR model explained between 27.4% (Cox and Snell R squared) and 36.8% (Nagelkerke R squared) of the variance in contamination and correctly classified 75.2% of cases [1] The significance of the findings demonstrate the need for increased awareness for the consumer; through appropriate risk management and the incorporation of treatment systems in vulnerable areas the potential human health impacts attributable to private wells in Ireland could be reduced.

**Key words:** GIS, Groundwater, Modelling, *E. coli*

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## **92. The hydrological impact from proposed road widening scheme on a blanket bog in Connemara**

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The proposed widening of the N59 road through Connemara must have a minimal effect on the adjacent active blanket bog system, which is defined as a priority habitat. The functioning of the bog ecosystem is intrinsically related to a specific hydrological regime. The main objective of this study is to characterize the baseline hydrological conditions in order to determine the potential long term impacts to blanket bog from the road widening. Three transects containing standpipes (measuring the phreatic water table at the surface) and piezometers (measuring hydraulic heads at depth in the peat) were installed running c.15 m perpendicular from the road. Weekly water levels have been recorded at these locations since July 2012. The hydraulic conductivity of the peat was estimated as  $10^{-8}$  m/s, from rising head and falling head tests conducted on the site. A hydrological model using Hydrus 2D has been built using this field data which indicates that there is a significant subsurface flow at an acute angle to the line of the road only slightly influenced by the presence of the 0.5m deep shallow drain. The drain however, is influencing the subsurface flow regime in the adjacent bog itself. The field data and modeling suggest upwards flow into the drain where an artesian head occurs with more conventional downward gradients in the peat, thus indicating a convective subsurface flow within the peat into the drain – in addition to overland flow when the peat is fully saturated. Nevertheless, as the drain is relatively shallow, its influence on the bog is also limited – the drying effect on the bog is still partly manifest in the adjacent belt of vegetation. Therefore, there is need for mitigation measures (for example, the use of linear wetlands) to decrease any excess potential drainage from the bog as well as to treat the runoff from the roads, which are currently being modelled.

### **93. A QMRA approach to estimate Public Health Risks caused by Microbes Associated with Beach Sands**

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In Ireland beaches are a great leisure and amenity facility with direct implications on the local economy if a beach failure occurs through excess pollutants in the associated water. In light of the EU revised Bathing Water Directive (rBWD), more stringent classification measures have to be implemented by 2015 with bathing waters being categorised as “excellent” “good” “sufficient” or “poor”. These classification standards are based on different levels of Faecal Indicator Bacteria present (FIB - E.coli and intestinal enterococci). However the rBWD does not include microbiological standards for beach sand, which is where people spend most of their time when using recreational waters. Previous studies have shown that sand acts as a reservoir of non-pathogenic and pathogenic microorganisms, causing public health risks. This study aims to identify pathogenic microbes present in beach sand, the risks to public health they may cause and what management measures can be used to reduce these risks. The project employs culture dependent and independent techniques in addition to Quantitative Microbial Risk Assessment (QMRA). In conjunction with the EPA’s collated data on water quality, a number of different recreational areas around Dublin Bay have been chosen for optimisation of FIB and pathogen detection within beach sand for this study.

**Keywords:** Beach sand, FIB, pathogens, public health, QMRA

#### **94. A combined remote sensing and geochemical tracing approach for localising and assessing groundwater discharge to lakes**

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The combination of thermal satellite remote sensing and geochemical tracing has been demonstrated as a robust, affordable and effective technique to identify potential groundwater discharge sites in coastal areas on a regional scale. In this paper, the approach is evaluated in its applicability to lakes and is substantiated with statistical analyses that both verify and further qualify the method as a means to localise groundwater discharge sites in lacustrine environments.

Despite the difficulties in acquiring appropriate cost- and cloud free satellite imagery and the subsequent and inevitable mismatch between satellite image acquisition and in-situ lake survey dates, the results are extremely promising. For our study area (Lough Mask Co. Mayo, Republic of Ireland), surface temperature patterns generated from four Landsat 7 ETM+ Thermal Infrared (TIR) images acquired during summer months clearly reveal large cold water plumes emanating from northern and eastern lake margins. Moreover, normalised temperature values generated from the thermal images are highly correlated with standardised excess radon activities measured across the lake during a survey in July 2012.

A simple linear regression shows that lake temperature values can explain up to 60% of the observed variability in surface radon activity while the spatial distribution of mapped studentized residual values clearly highlights the models under-prediction at groundwater discharge hotspots for each of the regression analyses. This we suggest is attributable to the more intense degassing of radon due to its dependence on the water-air concentration gradient, higher at groundwater discharge entry points which are located in shallow lake margins.

The study demonstrates the suitability of the approach as a comprehensive and cost-effective preliminary assessment tool for the identification and localisation of groundwater discharge entry points into lakes for use in any region where discernible temperature differences exist.

**95. Appraisal of an Irish rural community to determine its resilience against the effects of a waste management facility**

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The Ballynagran Project area aims to reduce its reliance on energy produced outside of its geographical boundary. Ultimately, the community strives to achieve Zero CO<sub>2</sub> emissions. The Ballynagran Committee has identified a number of approaches that can be considered when planning for the reduction of fossil fuel consumption. The aim is to demonstrate that the Sustainability Evaluation Metric for Policy Recommendation (SEMPRe) can be adapted to the requirements of the Ballynagran Energy Plus<sup>+</sup> Community (BEP<sup>+</sup>C). A suite of policies will be identified and evaluated to measure the level of sustainability of the community. This will provide a baseline Sustainability Development Index (SDI). The target of Zero CO<sub>2</sub> encompasses two main components; transport and energy. In order to reach this target a number of relevant policies and initiatives must not only be implemented but also accepted by the community. The chosen policies and initiatives must be both practical and applicable in real world settings. Data on reduced energy and transport emissions that may result from these implementations can then be calculated. Two evaluations will be conducted; the first will consider the Ballynagran community without the influence of the landfill facility and the second will take into consideration the effect of the landfill on the SDI. A change to the SDI will determine whether the landfill facility can be apportioned some responsibility for the positive or negative change and also whether NIMBYism (in this case study) is justified. The addition to the SEMPRE interface of policies that promote improvements and alternatives to current waste management options will allow for the recalculation of Ballynagrans SDI. This information can be used to address the current requirements of the Landfill Directive. With the addition of on-site anaerobic digestion, the community's future reliance on fossil fuel derived energy can be estimated.

**96. Amendment of peat-based and peat-reduced growing media with vermicompost: Effects on plant growth, development, and fruit yields of tomato (*Solanum lycopersicum* cv. Grande)**

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Waste management policy supports the conversion of biodegradable wastes into value-added products. Spent mushroom compost (SMC) is a widely-available, low-value, by-product of the mushroom industry, with approximately 200,000 tonnes produced in Ireland in 2012. Currently, SMC has little or no value as a soil enhancer, due to expensive transport and land-spreading costs. The main objectives of this study was to identify if spent mushroom compost could be used as a component of peat-reduced horticultural growing media, and to investigate if it could be vermicomposted, and used as a growing media additive. Tomato seedlings were transplanted into peat-based and peat-reduced (50:40:10 v/v vermiculite, SMC, and peat) growing media, with and without amendment of 10% vermicomposted spent mushroom compost. Plants received a standard watering and fertiliser regime throughout the experiment. After seven weeks, plants in the peat-based growing medium had significantly higher plant and root fresh weight, and higher plant dry weight, than those in the peat-reduced growing medium. Plants flowered significantly earlier in the peat-based growing medium, while addition of vermicompost had no effect on flowering date in both growing media. Plants were harvested 170 days after sowing, when the majority of tomatoes were ripe. The peat-based growing medium resulted in significantly higher plant and fruit fresh weight in these plants, as well as number of fruits, compared to the peat-reduced growing medium. There were no differences in plant and fruit dry weight in the peat-based and peat-reduced growing media. The addition of vermicompost to both growing media, significantly increased plant and fruit dry weight, fruit quality, and reduced the number of fruits with blossom end rot. The addition of 40% SMC to the growing media negatively affected plant growth, however, the addition of 10% vermicomposted SMC was shown to be a suitable amendment for peat reduction in growing media.

**Keywords:** growing media, spent mushroom compost, vermicompost, blossom end rot

**97. Process improvement through cleaner production in a material recovery operation: a case study**

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A material recovery facility in the north-east of Ireland operated by Crumb Rubber Ireland Ltd. produces crumb rubber and associated products from end-of-life tyres. This paper documents a cleaner production (CP) initiative recently undertaken to improve the eco-efficiency of their activities. The production process was characterised qualitatively and quantitatively and a CP assessment conducted on the activities involved. Two areas of significant potential were identified viz., steel cleaning and ‘fines’ recovery and a series of trials comprising process changes were conducted. Both sets of trials proved very successful with a doubling of steel recovery, 20% increase in throughput and the development of a recovery system for a valuable material.

**Keywords:** cleaner production; life cycle; material recovery; waste tyres

## **98. A Critical Review of Construction Waste Management Practices on a Selected Case Study.**

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Construction and demolition waste production (C&D W) in Ireland has seen remarkable fluctuations over the past ten years, hitting a peak of 17.8 million tonnes (Mt) in 2007 followed by a dramatic decline to the most recent estimate of just over 3 Mt in 2011. This trend has reflected the unsustainable economic growth and decline over this period and has clearly highlighted the direct correlation between construction output and increased environmental impacts. Despite these recent lower estimates, C&D W continues to be one of the largest waste streams in Ireland. The aim of this study was to investigate the waste management practices of a small-to-medium-sized main contractor on a selected case study in the Galway region. Site practices were observed over a 20-week period to determine areas of improvement through the lens of site waste management plan best practice guidelines. A series of ‘quick wins’ were identified to improve the management of direct and indirect construction waste production on site. In addition, a retrospective desktop review was carried out to highlight opportunities for waste reduction during the design phases. Strategies such as source segregation, supplier take-back schemes, benchmarking indicators and materials logistics planning were identified as key elements of effective site waste management. A more even distribution of waste management responsibility should be recognised, which will engage all the relevant supply chain stakeholders involved in the design and construction process.

**Key words:** Case study, construction and demolition waste, construction-SME, site waste management plans, waste reduction.

## 99. Production of biogas from slaughterhouse wastes in Ireland

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Slaughterhouse organic waste streams represent a significant potential energy resource within Ireland. Regulations regarding the disposal or uses of animal by-products (EC 92/2005) constitutes biogas transformation as a suitable treatment method for Category 2 and Category 3 wastes. The purpose of this work is to determine the potential energy that could be generated through the anaerobic digestion (AD) of slaughterhouse wastes.

Worldwide interest in utilising organic materials for the production of biogas through AD is growing due to decreasing energy supplies and the environmental challenges associated with the use of fossil fuels. However there is a lack of clear references and comparability, notably in Ireland, of organic materials that could be used as potential substrates increasing the relevance of this research.

The approach comprises of the determination of the methane potential of the waste streams through batch assays under mesophilic conditions. Research into the AD of individual slaughterhouse wastes is extensive however the direct comparison of the different waste streams has not been undertaken to the same extent. The innovation of this research is to test waste streams from cattle, poultry and swine slaughterhouses under the same process conditions to allow accurate and reliable comparability.

The preliminary results from cattle slaughterhouse waste shows that the methane potential of offal (Category 3), paunch and wash water sludge (Category 2) were: 49.2, 35.1, 4.9 m<sup>3</sup>CH<sub>4</sub>/tonne respectively. In terms of a transport fuel 130.4t of Category 3 offal is capable of fuelling a freight truck for one year. Therefore a facility slaughtering 57,671 heads of cattle each year is capable of fuelling 37 trucks per year.

**Keywords:** anaerobic digestion, biogas, organic waste streams



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(Listed by Theme)

- Agriculture & Environment (AE)
- Air Quality (AQ)
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- Climate Change (CC)
- Energy (EN)
- Environment & Human Health (EHH)
- Environmental Policy & Communication (EPC)
- Marine & Coastal (MC)
- Monitoring & Instrumentation (MI)
- Urban Development (UD)
- Waste Management (WM)
- Wastewater (WW)
- Water Quality & Resources (WQR)

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## **Pathogens and faecal indicator bacteria in streams and sediments in a rural agricultural catchment**

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Faecal coliforms including *Escherichia coli* are commonly used as faecal indicator bacteria (FIB) of recent contamination of water bodies with human or animal waste. Studies have shown that aquatic sediments can also contain elevated levels of FIB, that these can persist in sediments for months and can re-contaminate the water column during high flows. There is little work, however, on contamination of sediments in agricultural catchments and none relating to the impact of streamside fencing on levels. Sediment samples were collected from three headwater tributaries within the Milltown Lake catchment, an agricultural catchment in County Monaghan, in April, July, and October 2013. Samples were also collected from a catchment in a site which has no intensive cattle production. Preliminary data showed that all sites in the Milltown Lake catchment were heavily contaminated with faecal coliforms (both total faecal coliforms and with *E. coli*) and that values were highly variable both between tributaries and from site to site. Concentrations of *E. coli* in the Milltown Lake sediments ranged from  $4.0 \times 10^1$  to  $1.3 \times 10^6$  CFU g<sup>-1</sup> d. w. Values were highest where cattle had access to the stream. More importantly concentrations were significantly lower in a fenced stream than in two unfenced streams. A significant positive correlation was also found between *E. coli* concentrations in sediment and *E. coli* in the overlaying water ( $r = 0.69$ ,  $p = 0.00$ ). Future work will include investigations of the conditions under which FIB are resuspended, and persistence of pathogenic bacteria in sediments.

**Keywords:** *E. coli*, faecal indicator bacteria, sediment, freshwater

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**A risk ranking approach to evaluate the human health risk of metals and emerging contaminants in biosolid-amended agricultural land.**

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The application of biosolids to agricultural land can benefit soil quality due to the increased supply of major plant nutrients (N and P), provision of some essential micro-nutrients (Cu, Cd, Zn and Ni), and overall improvement in soil physical properties. However, the presence of potentially toxic contaminants (metals, pharmaceuticals and personal care products) present potential environmental and human health risks, negatively affecting groundwater/surface water and, consequently drinking water quality. A quantitative Monte Carlo risk ranking approach was developed to prioritise contaminants and evaluate the human health risk from metals and emerging contaminants (EC) detected in Irish biosolids which are applied to agricultural land. This assessment used monitoring and literature data to characterise variability and uncertainty in model inputs including: contaminants detection levels, solid water distribution coefficient ( $K_d$ ), solubility, bioavailability fractions, recovery (%) and LD50 as a toxicity ranking endpoint. The metals investigated were cadmium, copper, lead, nickel, chromium and zinc. The selected EC's (carbamazepine, triclosan and triclocarban) were chosen based on their detection in Irish biosolid samples. Preliminary results indicate that the metals Zinc and Nickel and the EC's triclocarban and carbamazepine attained the highest rank. Sensitivity analysis revealed that bioavailability fractions and the solid water distribution coefficient ( $K_d$ ) (correlation coefficient of 0.72 and 0.69, respectively) were the most important parameters that affected the fate of metals in soil. Contaminant detection levels and solid water distribution coefficient ( $K_d$ ) were the most important parameters for the fate of EC's in soil (correlation coefficient 0.91 and 0.83, respectively). The model developed in this study facilitates the identification of contaminants requiring priority attention and monitoring.

**Keywords:** Contaminants, biosolids, risk ranking, metals

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## **Developing indicators of farmland wildlife habitats on intensive grasslands**

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The international challenges of the assessment of sustainability in agricultural systems have become increasingly relevant for Irish food production. This is driven by the pressing requirement for sustainable intensification while also marketing Ireland's 'green' reputation. Protecting biodiversity is an integral part of the environmental sustainability of agricultural landscapes along with energy, water, nutrient use efficiency and GHG emissions. The inherent complexity of biodiversity presents challenges for both its measurement and inclusion in environmental sustainability assessments. This study aims to address some of these challenges by developing a wildlife habitat index based on existing biodiversity knowledge and benchmark data provided by surveys of wildlife habitat quantity and quality on 80 grassland farms (24 farms surveyed in 2013).

For each farm, the following survey work will be undertaken: all habitats mapped, all field boundaries categorised by dominant species, structure and features, together with a further, more detailed, structural and floristic survey of hedgerows. Grassland plants will be surveyed at a selection of 'intensive' and 'improved' grassland fields (Sheridan et al. 2011). Percentage cover of semi-natural habitat and the additional measures of habitat will enable comparison across more intensively-managed grassland farms. In combination with farm management data, this information on wildlife habitats can help develop practical indicators of farmland habitats to underpin food quality assurance schemes.

This work forms part of the E-Ruminant project (funded by Research Stimulus Fund of DAFM).

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## Smart Grassland Systems – Innovative Management Systems to Maximise Resource Use Efficiency in Grasslands

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The greatest challenge facing Irish farmers is maximisation of production outputs in a manner which is environmentally and economically viable and sustainable. Singular reliance on high input grass monocultures is becoming less economically viable and socially acceptable. The ability to produce high yields of good quality forage, at minimal cost to farmers and with minimal impact on natural resources, is fundamental to the sustainability of future growth in Irish grass-based farming systems. Research indicates that the production potential of multi-species grasslands, which may require comparatively lower levels of nutrient inputs, has been greatly underestimated. This project aims to investigate the production potential of a multi-species sward mixtures consisting of three plant functional groups (grasses, legumes and forage herbs) when compared with perennial ryegrass monocultures and perennial ryegrass – white clover swards. Experimental plots have been established at two sites in 2013, UCD’s Lyons Farm, Co. Kildare and Teagasc Grange, Co. Meath. Sward types will be compared in terms of their production potential, such as dry matter yields, nutritive quality, in vitro digestibility and methane production, quality of silage, and biodiversity support value under a range of nutrient input levels and grazing/cutting regimes. Measurements will be taken from 2014 to 2016. A comprehensive cost-benefit analysis will be undertaken to identify the optimum combination of sward mixture and management treatment which maximises resource use efficiency and thus output, while minimising costs incurred by farmers, coupled with protection of public goods such as biodiversity.

**Keywords:** Grass-clover-herb mixtures, forage yield and quality, biodiversity, ecosystem services

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## **The cost effectiveness of grassland conservation options within national agri-environment schemes**

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From 1994 to date in excess of €4.2 billion has been spent on Agri-Environment schemes (AE). Under Article 16, EC Regulation No 746/96 all EU Member States are required to monitor and evaluate the environmental, agricultural and socio-economic impacts of their AE programmes. The aim of this research is to aid in the identification of the range and type of grasslands funded by AE schemes.

Three grassland options in receipt of Agri-Environment Options Scheme (AEOS) payments were identified; Species Rich Grassland; Traditional Hay Meadow, Species Rich Grassland which formerly received a Natura 2000 payment. Pastoral, drystock farms were selected from counties Laois, Offaly, Westmeath, Longford, Kildare and Roscommon. Botanical diversity of the grasslands was surveyed using twenty randomly located quadrats within each selected field. Plant abundance values were assigned according to the Braun-Blanquet Scale.

Preliminary results of the 22 sites sampled revealed a total of 112 higher plant species across all grassland types. While the difference in species richness between grassland types was not significant ( $p>0.05$ ) greatest species richness was associated with Natura 2000 Species Rich Grassland ( $n=4$ ) with 93 species, 21 grasses and 72 herbs. Lowest species richness was associated with Traditional Hay Meadow ( $n=9$ ) with a total of 73 species, 21 grasses and 52 herb species. Species Rich Grassland ( $n=9$ ) comprised of 83 species, 20 grasses and 63 herb species.

This research will help to address the issue of whether current AE measures are cost effective or whether there are alternative methods of achieving biodiversity goals by targeting the expenditure of limited funds to areas of highest conservation value. It will also contribute to the knowledge gap in the identification of High Nature Value farmland which are important areas for biodiversity but fall outside of protected sites.

**Keywords:** grassland conservation, agri-environment schemes, biodiversity goals

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## **Environmental risk assessment of intensive pig production applied to a river in North Cork**

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In an attempt to protect European waterways, the EU developed the Water Framework Directive (WFD) in 2000. The aim of the directive is to ensure all aquatic resources in the EU reach good or high ecological status by 2015. For rivers and streams, this means achieving a Q-Value of 4 or greater. Many of Ireland's waterways, however, are at risk of not achieving WFD targets. The Environmental Protection Agency (EPA) recognises that agriculture accounts for the majority of slight and moderate river pollution in Ireland. Nevertheless, gaps in knowledge exist with regards to pollution generated by individual agricultural activities. The majority of Irish pig production occurs on commercial units. Pig units with more than 1,000 pigs, or 100 sows, on gley soils, and units with 3,000 pigs, or 300 sows, on all other soils require an Integrated Pollution Prevention Control (IPPC) licence. On these farms, it is estimated that 3.1 million m<sup>3</sup> of manure are produced each year. Although IPPC licenced pig farms are highly regulated by the EPA, accidental release of manure could lead to human health concerns in drinking water and a loss of biodiversity through eutrophication.

Analysis of information available from the EPA has identified a river in North Cork which is at risk of not reaching WFD goals. Two IPPC licenced intensive piggeries discharge treated wastewater into the river, and previous research carried out by South Western River Basin District consultants suggests these units may be contributors to observed pollution. An environmental risk assessment is being carried out to determine the relative contribution of the farms to pollution levels in the river and to assist future management of the river water quality.

**Keywords:** Water Framework Directive; water quality; pig farming; environmental risk assessment.

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## **Rapid transfer of nitrogen excreted by earthworms to cereal seedlings and aphids**

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To test the novel hypothesis that there is direct, rapid transfer of organically bound N compounds from soil decomposer animals (earthworms) to plants (wheat) and above-ground herbivores (aphids), we traced the fate of <sup>15</sup>N-<sup>13</sup>C double-labelled earthworm excretions in a factorial, controlled experiment. Wheat seedlings were grown for 21 days in a sand-clay growing medium or natural, non-sterile soil. Earthworms (*Allolobophora chlorotica*) double-labelled with <sup>15</sup>N and <sup>13</sup>C tracers were allowed to burrow into the substrate and adult cereal aphids (*Metopolophium dirhodum*) were introduced onto seedlings. Aphids were sampled in rapid sequence (0, 4, 8, 14, 24, 48, 72 hours), while labelled earthworms, wheat and soil were sampled after 72 h. All samples were analyzed for bulk N, <sup>15</sup>N and C, <sup>13</sup>C concentrations by Elemental Analysis–Isotope Ratio Mass Spectrometry (EA-C-CF-IRMS).

The <sup>15</sup>N signatures were transferred to soil and wheat within 72 hours and were detectable in aphids after only 4 hours. The dynamic of <sup>15</sup>N increase in aphids over time was similar in the artificial and natural soil treatments, providing strong experimental evidence for a direct nitrogen transfer from earthworms and aphids. Slight <sup>13</sup>C enrichments detected in aphids suggest that some organically bound nitrogen compounds were transferred. To aid interpretations, earthworm mucus was analysed by high-resolution solution state 1D and 2D Nuclear Magnetic Resonance spectroscopy.

**Keywords:** Labelling earthworms, stable isotope tracers, nutrient cycling, decomposers, herbivores

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**Re-establishing native aquatic charophytes – an evaluation of two mechanical methods used to control the alien invasive plant *Lagarosiphon major***

Maguire, C., Keenan, E. and Baars, J-R.

School of Biology and Environmental Science, Science Centre (West), University  
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The aquatic invasive plant *Lagarosiphon major* causes significant changes to the flora and fauna of lake ecosystems, in its introduced range. In Lough Corrib, one of Ireland's largest lakes, this weed has out-competed native charophytes, which are important in the ecological functioning of littoral habitats. Mechanical weed control techniques currently being used are V-blade (towed by a boat) and light exclusion using biodegradable geotextile jute matting. Little is known about their effectiveness in rehabilitating weed infested areas. The primary method of rehabilitation involves the redistribution of charophyte oospores. This study assessed the effect of the two control methods on the distribution of oospores in lake sediments. The density of oospores was assessed before and after treatments and compared to adjacent untreated sediment.

Sediment core samples were collected, using a modified core extractor, allowing separation into three 5cm depths (0-15cm). This study focused on the density of oospores present to a depth of 10cm. Samples were wet sieved to remove four fractions (425µm, 355µm, 250µm and 125µm). Only sediment  $\geq 355\mu\text{m}$  was analysed, as it contained in excess of 90% of the total oospores. Samples were then split into quarters, using a folsom splitter. The number of viable oospores was then counted using light microscopy.

The results show that oospore density in the top sediments under *L. major* was much lower than in the deeper sediments. Following jute treatment, oospore density in the top sediments remained low, indicating that this had no effect on redistributing oospores. Following V-blade treatment, oospore density was higher but highly variable between samples.

This study indicates that the two treatment methods do not reliably redistribute charophyte oospores in sediment, to facilitate rehabilitation. Sediment under established charophyte beds could be used to re-seed treated sites. Alternatively, mechanically agitating the sediment would complement the use of the V-blade.

**Keywords:** Alien invasive species, Chara species, *Lagarosiphon major*, management, mechanical control, oospores.

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**Competition between *Lemna minuta* and *Lemna minor* under different stress conditions.**

Authors: Simona Paolacci, Simon Harrison, Marcel A.K. Jansen

The growth rate of the invasive alien species *Lemna minuta* Kunth, a floating freshwater plant, was measured under different abiotic stresses and compared with the growth rate of the native congeneric *Lemna minor* in order to assess the competition between the two species. It was hypothesised that fast growing, competitive *L. minuta* would exhibit relatively low stress tolerance. To test this hypothesis, both species were stressed by growth in the presence of heavy metals (Cu and Al) or at extreme pH values. Desiccation tolerance was also tested, and the effect of the wind on the mat formed by these plants on the water surface was assessed. *L. minuta* shows a better tolerance to high concentrations of heavy metals and to extreme pH values than *L. minor*. However *L. minor* shows a higher resistance to desiccation and a lesser tendency of the mat to be disrupted by the wind. It is speculated that the better performance of *L. minor* under drying and wind stress is due to its bigger size and to the longer roots. It is concluded that *L. minuta* has a faster intrinsic growth rate than *L. minor*, but is also a good tolerator of some stress conditions.

**Key words:** *Lemna*, alien species, competition, heavy metals, desiccation, pH, stress

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This study indicates that the two treatment methods do not reliably redistribute charophyte oospores in sediment, to facilitate rehabilitation. Sediment under established charophyte beds could be used to re-seed treated sites. Alternatively, mechanically agitating the sediment would complement the use of the V-blade.

**Keywords:** Alien invasive species, Chara species, *Lagarosiphon major*, management, mechanical control, oospores.

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**Use of catchment scale-modelling to assess the impact of climate change and land use variation on microbial transport.**

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Uncertainty surrounding microbial fate and transport renders the assessment of climate change effects on waterborne pathogens complex and difficult to forecast. The objective of this study was to use catchment modelling to examine the impacts of future climate change and land management scenarios on microbial water quality. Pigg river catchment, located in southwest Virginia, USA was chosen as the study location for model development using the Hydrologic Simulation Program in Fortran (HSPF). The model was initially calibrated and validated to simulate hydrology and bacteria transport using existing catchment data. Subsequently, climate change impacts were assessed using data from 7 Global Circulation Models (GCMs), downscaled for the study location. Concurrent variations in land management were also considered in future predictions and based upon data projections from available sources. Results indicate that future climate change and land management will cause higher microbial loads in the catchment. High flow and low flow periods exhibited the biggest increase in bacteria levels. Seasonally, Winter and Spring showed the greatest increase in microbial loading. Results were reflective of forecasted precipitation trends and variations in land management. Outcomes of the work suggest that current water quality standards are sufficient to preserve the quality of water. However, renewed focus on developing adaptation measures and improving watershed management will be required to counteract predicted problems associated with both climate and land use change. Otherwise, previous remediation efforts to reduce microbiological contamination of water bodies could prove inadequate and the potential risk posed to humans from exposure to pathogenic microorganisms may be amplified.

**Keywords:** microbial transport, climatic change, catchments, water quality.

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## Stability of amine-modified CO<sub>2</sub> adsorbents for fossil fuel fired power plants can be highly influenced by preparation of adsorbents

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CO<sub>2</sub> is considered a greenhouse gas which is contributing to climate change. Fossil-fuel fired power generating plants account for 40% of the world's carbon-derived emissions. The removal of CO<sub>2</sub> from flue gas streams of power plants is possible by the use of liquid amines such as monoethanolamine (MEA). MEA reacts with CO<sub>2</sub> to form ammonium carbamate. The MEA solvent is regenerated by heating, releasing CO<sub>2</sub> which is pressurised for use as a feedstock or for storage as part of carbon capture and storage projects. However the regeneration of the liquid solvent can reduce a power plant's efficiency by up to 30% and lead to corrosion of plant infrastructure. This project has focused on the amine modification of mesoporous solid supports such as SBA-15 and AISBA-15 as potential solid sorbents for CO<sub>2</sub> capture from power plants. These would reduce the energy requirements required for regeneration. These amine-modified solids have shown good potential in terms of CO<sub>2</sub> adsorption ability and stability. Two different amines have been used (1) 3-aminopropyltriethoxy silane (APTES) and (2) tetraethylenepentamine (TEPA). A number of adsorbent preparation methods have been utilised; grafting, wet impregnation, dry impregnation and multiple dry impregnations. Both dry impregnation and multiple dry impregnations show high CO<sub>2</sub> adsorption ability, however after repeated CO<sub>2</sub> adsorption/desorption cycles they show poor stability and both APTES and TEPA degenerate. Grafting of APTES has produced good CO<sub>2</sub> adsorption ability and good stability, which may be due to the chemical fixation of APTES onto the solid support through its silanol group. TEPA shows good CO<sub>2</sub> adsorption ability however it lacks a silanol anchoring group and thus is easily removed from the porous support during regeneration.

**Keywords:** CO<sub>2</sub> capture, impregnation, amine modification of mesoporous solids

## The Challenges in Predicting future Rainfall for Ireland

Emily Gleeson<sup>1</sup>, Paul Nolan<sup>2</sup>, John O'Sullivan<sup>3</sup>, Conor Sweeney<sup>3</sup>, Ray McGrath<sup>1</sup>

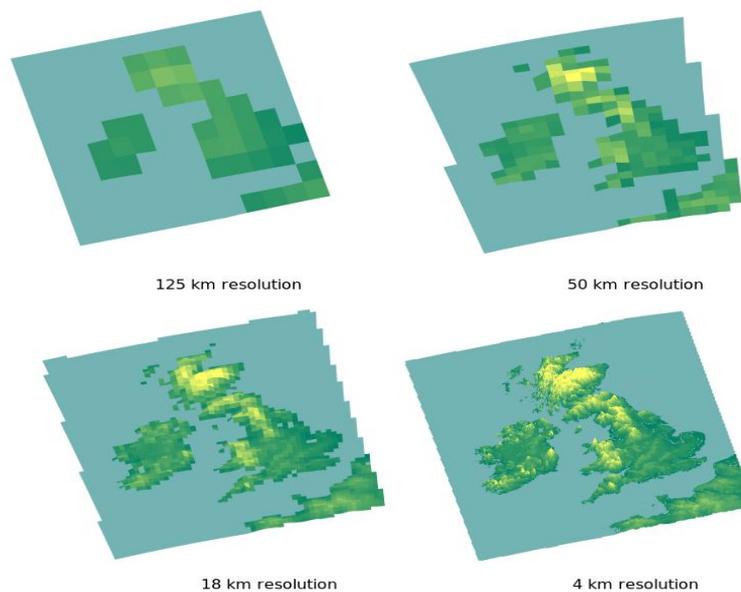
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To capture details about local climate, data from global climate models (run on a coarse scale) must be downscaled over the region of interest. In this poster we present downscaled precipitation projections for Ireland using a 22 member ensemble on a 4-7km grid. This is the largest high resolution ensemble available for Ireland. We show how the models compare to observed precipitation data, in terms of averages and extremes, and discuss the uncertainties in future rainfall changes and the associated challenges.

Ireland and UK as seen by climate models with different horizontal resolutions.



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**Impacts of Environmental Factors on Soil Carbon  
in Afforested Organomineral Soils**

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Plantation forests occupy >10% of the Irish landscape and are a significant sink for carbon. While considerable progress has been made over the last decade in our understanding of carbon cycling in Irish forests, research has not addressed soil carbon stocks and fluxes in organomineral soils. While carbon stock changes in peat soils are assessed using emission factors and mineral soils using carbon stock changes it is unclear which method should be applied to organo mineral soils.

To answer this question this study partitions soil respiration into heterotrophic and rhizospheric respiration, an important step for understanding and modelling carbon cycling in organomineral soils with the following objectives:

1. Measure soil respiration at all sites and partition it into its autotrophic and heterotrophic components to determine the factors causing temporal and spatial variation in soil respiration,
2. Study whether the partitioned components have different sensitivities to environmental variables in afforested organomineral soil.

Soil respiration is measured using a portable soil respiration chamber and is partitioned between autotrophic and heterotrophic respiration using root exclusion collars. Environmental variables - temperature and moisture content are measured simultaneously. An annual and seasonal budget for autotrophic and heterotrophic soil respiration is determined using statistical modelling.

**Keywords:** Heterotrophic respiration, rhizospheric respiration, organomineral soil

## Applying Statistical Theory to improve our understanding of Temperature Extremes in Ireland

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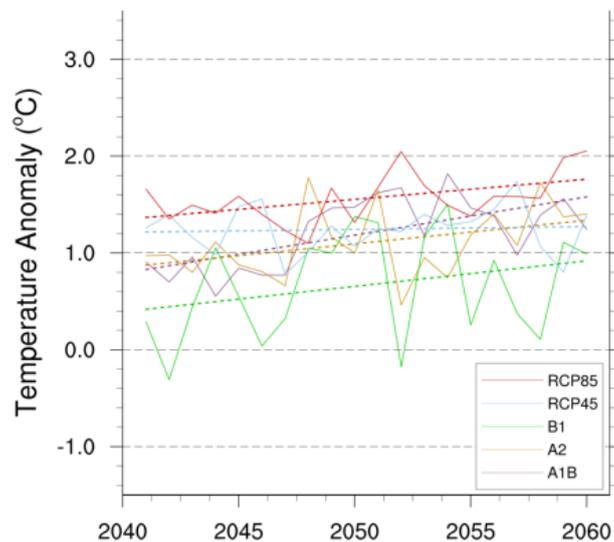
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To learn about projected changes in temperature at a local scale, data from Global Climate Models is downscaled over the regions of interest.



This poster will present some results from a study on downscaled high-resolution (4-7km) temperature data over Ireland, driven by five different future scenarios. There is a paucity of such research to date, with previous studies using much coarser datasets.

Changes in the extremes of temperature will affect people on a day-to-day basis more than changes in mean values. This poster will present some current research into how extremes of temperature over Ireland may change in the future.

In addition, plans for future work in the area (including a comprehensive application of Extreme Value Theory to CMIP5 projections) will be detailed.

The time series of the annual mean temperature anomalies for each group is shown, with lines of regression superimposed. Each group is run using a different future scenario.

**Keywords:** Climate change, extremes, temperature, downscaling, heat waves

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**Production and characterisation of a thermoacidophilic endo-1,4- $\beta$ -glucanase of potential use in the production of cellulosic bioethanol.**

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Initiatives taken by the EU to combat climate change include mandating increased use of renewable transport fuels. Cellulosic bioethanol is a renewable transport fuel produced from lignocellulosic material, for example, agricultural residues. The cellulosic bioethanol production process involves an initial pretreatment step to disrupt the lignocellulose structure followed by enzymatic hydrolysis of the cellulose and hemicellulose components to their constituent monomeric sugars, which can then be fermented to produce bioethanol. Commercial enzyme cocktails derived from mesophilic microorganisms are currently used in the enzymatic hydrolysis step which is undertaken under the optimum conditions of these enzymes of circa 50°C and pH 5. The production of bioethanol from lignocellulose is technically challenging and improving this process is essential to achieve widespread deployment of cellulosic bioethanol with associated benefits in terms of climate change mitigation, energy security and economic growth. The potential of thermo(acido)philic lignocellulolytic enzymes to contribute towards such improvement is gaining increasing interest. Thermo(acido)philic enzymes display enhanced stability potentially resulting in improved enzyme performance. Increasing the hydrolysis temperature to >50°C by using thermo(acido)philic enzymes is also likely to increase product solubility and reduce viscosity which potentially facilitates higher biomass solids loadings resulting in higher sugar and ethanol concentrations and improved process economics. The development of commercial thermo(acido)philic enzyme cocktails containing optimal combinations of the key enzymatic activities required for efficient and economical lignocellulose hydrolysis is therefore highly desirable. Microbial screening studies undertaken in our research group resulted in the identification of a thermoacidophilic endo-1,4- $\beta$ -glucanase of potential use in such an enzyme cocktail. The enzyme has been cloned and expressed in *E. coli*. The purified recombinant enzyme exhibits maximum activity at 80°C and pH 3.1-4.5. The enzyme is therefore potentially suitable for high temperature enzymatic hydrolysis in the production of bioethanol with associated benefits as outlined above.

**Key-words:** endo-1,4- $\beta$ -glucanase, cellulosic bioethanol, lignocellulose, thermoacidophilic enzyme

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**Potential for disconnect between energy efficiency and carbon emissions in building retrofit projects**

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Buildings are responsible for the generation of greenhouse gas (‘carbon’) emissions over their life cycle from the extraction of raw materials right through to its end-of-life phase. The built environment accounts for the largest proportion of energy demand and associated emissions across all sectors. Buildings typically have long lives e.g. four out of five buildings in use today will still be in use in 2030; consequently energy retrofitting of buildings is seen as offering significant opportunities for reducing carbon emissions. However, building energy efficiency measures do not necessarily lead to lower carbon emissions, this poster explores some of the reasons why building energy conservation and efficiency projects may be over-estimating projections for avoided carbon emissions.

**Keywords:** building energy efficiency, whole life carbon, embodied carbon

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## Identifying best practice sustainability measures in the craft beer brewing process

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Donegal Brewery Ltd produces a speciality craft beer called the “Donegal Blonde” and is sold nationwide in off-licenses, and retail outlets. Craft breweries are uniquely sized to produce a wide array of beers with an emphasis on taste, quality and balance. They continuously seek to adopt an environmentally sustainable and energy conscious “closed loop” approach to producing a sustainable product. Due to the high specific heat of water, considerable energy is expended in heating water during the various stages of the brewing process with the boiling of the wort being the single most energy-intensive step in brewing. This is carried out to ensure the wort is sterile as well as concentrating the wort and intensifying the colour of the brew. Significant energy is used in the preparation and use of brew equipment including refrigeration, compressed air, HVAC systems and bottling / packaging processes. The CREST research focused on the development of specific best practice sustainable measures to offset the high energy use and water consumption associated with the brewing process. Each step of the brewing process was examined and potential energy reduction opportunities were identified. A methodology for implementing these measures included a review of key brewing processes such as mashing, lautering and fermenting. Water consumption levels associated with brewing were assessed and measures including use of cross-flow filtration for microfiltration of yeast, bacteria and solids retention as well introducing modified water metering measures at various stages of the brew process were highlighted. Alternative clean energy technology opportunities for inclusion in the brewing process were outlined including rain water harvesting to minimise water use, solar heat integration to heat water and more efficient packaging and bottling measures to be adopted.

**Keywords:** Craft beer brewing, water consumption, energy consumption, clean energy technologies.

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### Small scale willow harvester

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Ardtarmon House B&B and self-catering cottages, owned and managed by Charles Henry, uses a woodchip boiler to provide full Domestic Hot Water and heating to the accommodation. The woodchip is sourced entirely on-site from a 3 hectare willow plantation, with some additional timber wastes. Willow harvesting on larger plantations is generally carried out by cutting, chipping and collecting all on one operation. This requires large and multiple plant and machinery, and is not practical on smaller sites with no other significant plant and machinery demands. A number of sources recognise the preference and advantages for whole stem harvesting in smaller plantations. Although various whole stem harvesters are in existence, none of these appear to be supported by major manufacturers, but rather have been developed as bespoke designs. The Agronomy Institute in Orkney, Scotland, considered four solutions to the problem: i) manual harvesting, ii) purchase of a standard mechanical harvester, iii) hire of a mechanical harvester, iv) development of a low-cost mechanical harvester. Due to the high labour and time for manual handling, and high costs for purchase or hire of a standard harvester, option (iv) was favoured. CREST have now engaged an IT Sligo Mechanical Engineering Level 7 student group to take up the challenge to design and fabricate a small scale harvester suitable for use at Ardtarmon House. The design is now underway, and includes conveyor guides to gather stems, double head disc cutters and delivery of the stems to a collection trailer which incorporates a U-frame to facilitate tying of the collected bundles for easier handling after unloading. The prototype will be ready for testing in the next harvesting season.

**Keywords:** Short Rotation Forestry, Willow, whole stem harvesting,

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## **Energy Efficiency Improvement in Complex Industrial Systems Using Combined Temperature and Pressure Management & Low Grade Heat Recovery**

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Alumina refining via the Bayer method is a very energy intensive process, whereby high pressure, high temperature steam is needed for digestion of alumina from bauxite ore. In recent years, the growing culture of recycling aluminium combined with a construction industry in decline, has led to a decrease in global demand for fresh aluminium and therefore newly refined alumina. These factors are increasing the pressure on refineries to produce alumina more economically. The refinery examined in this research is one of the most energy efficient alumina refineries in Europe. This research investigates problem areas in the process, specifically opportunities for improving energy efficiency.

The digested alumina liquor contains a large quantity of silica and other components which scale on the wall inside traditional heat exchangers, impeding heat transfer and greatly reducing the efficiency. In such cases the preferable way of heat recovery is through flash-tank heat exchanger cascades where the pregnant (high alumina content) liquor is cooling consequently preheating the spent (low alumina content) liquor. In the digestion area, which is the most energy intensive in the process, the flash tank cascade's pressure is dropped sequentially to atmospheric. The steam generated condenses and exchanges its latent heat with the cold spent liquor stream. For efficiency improvement this process continues downstream of the digester area also using flash tank cascades operating under partial vacuum. This section of the process has never performed as designed since commissioning of the refinery.

The underperformance of the sequenced flash tanks is investigated and potential solutions are presented. The main parameters under consideration are generation of superheated steam due to boiling point rise from salt concentration in digested alumina, and inefficient removal of non-condensable gases from the condensers. As a result a technical solution for performance improvement is developed and preliminarily tested.

**Keywords:** Energy efficiency, Process improvement, Heat recovery

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**Implications of wind farm and infrastructural developments on blanket peat and the impact on a sites carbon reservoir.**

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With their ability to convert wind energy to electrical energy, wind turbines and subsequent wind farms are promoted as technological advancement capable of providing energy in a more sustainable and environmentally friendly manner in comparison with traditional fossil fuel methods. This study makes observations of such developments on blanket peat sites and attempts to update and calibrates the Scottish carbon savings calculator for use in the development and planning stages in Ireland. The study pays particular attention to water table level variations along the necessary infrastructural constructions along with water quality and greenhouse gas emissions.

Preliminary findings for water table levels along road networks suggest that it takes the shape of a parabolic arc along the cut face of a road network whereby the observed water table levels increase rapidly with distance from drainage feature. The carbon savings calculator equation in its current form overestimates the volume of peat that may be lost in gaseous emissions to the atmosphere with the value varying depending on the permeability of the peat at the varying layers, increasing the calculated carbon payback time for a wind farm development. The impact of a wind farm construction on water quality for pH, NH<sub>4</sub>-N, TON, TOC and suspended sediment concentrations was not detected, however this could be due to the fact that the chosen wind farms were well established and that a noticeable impact for the measured parameters has ceased.

**Keywords:** Peatland developments, wind farms, carbon reservoir, water table.

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## **Sizing Solar Thermal Systems for an Irish Environment**

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Buildings account for approximately 40% of all energy consumed. Domestic hot water (DHW) is the second largest contributor to building energy consumption in Ireland, second only to space conditioning. Solar thermal technology can be used to reduce both space conditioning and DHW energy consumption portions. The majority of solar thermal installations are set up for DHW usage.

This research is focused on solar thermal systems for water heating in domestic buildings. In order to size a solar thermal system, knowledge of the hot water demand of that building is required, in addition to information on the climatic conditions and the efficiency of the system used. Sizing a system correctly is important as oversized systems are unnecessarily expensive, have poor annual efficiencies and have greater periods of stagnation resulting in the possible reduction in service life.

Of the factors that determine the dimensions of a solar thermal system, the hot water demand data is the most significant and is also the most difficult to obtain. The main obstacles in obtaining this information arise due to the fact that standard dwellings are not equipped with meters to provide flow and temperature. Furthermore for new buildings, which have never been occupied, sizing the solar tank and collector area becomes even more difficult. A guideline used by the SEAI on DHW consumption of residential areas is given as approximately 40 Litres per capita per day (Lcd). National guidelines propose average values for DHW consumption per capita. However, studies in other countries have shown the actual consumption to be greater than the values outlined in guidelines.

To develop a more detailed understanding of building HW demand this study investigates the impact of building typology, occupancy patterns and behaviour on the HW demand. Both domestic and commercial buildings are investigated via a simulation study.

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## **Molecular Tools to Assess Bathing Water Quality**

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Bartholomew Masterson, Wim G. Meijer

UCD School of Biomolecular and Biomedical Science and UCD Earth Institute

Smart Coasts=Sustainable Communities is a large scale, multi-disciplinary research project, funded by the European Union under the Interreg IVA Ireland Wales programme. It is addressing the urgent need for tools to predict faecal pollution of bathing waters in real-time, to identify the origin of pollution and to inform the general public in a timely manner. In light of the EU Revised Bathing Water Directive (rBWD), European bathing waters must comply with a stricter set of measurements based on Faecal Indicator Bacteria (FIB) levels (E.coli and intestinal enterococci) by 2015. If bathing waters fail, this will have serious implications for tourism and the economy of the local area.

Within this project both culture based and molecular methods are used to detect and identify the cause of faecal pollution within water. Microbial Source Tracking (MST) is a molecular technique used to investigate the presence of faecal pollution and to discern its type of origin (human, animal etc.). DNA based methods employed are end point Polymerase Chain Reaction (PCR) (used for detection) and quantitative PCR (qPCR) (used for quantification). The presence of faecal matter in The Dargle River, Co. Wicklow, Ireland and at Bray Beach, Co. Wicklow, Ireland, was analysed using these methods.

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## Geogenic arsenic concentrations in Irish drinking water

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Worldwide the presence of metals such as arsenic in groundwater has affected the safe supply of drinking water in many countries. In Ireland, 25% of drinking water originates from groundwater sources. Recently within Ireland, elevated arsenic concentrations have been reported as a result of routine testing of drinking water supplies by local authorities and government agencies. In order to access the spatial distribution of arsenic at a national scale, a collaboration was established between NUI, Galway, the 29 County Councils (CC), the Environmental Protection Agency (EPA), the Health Service Executive (HSE) and the Geological Survey of Ireland (GSI) in order to collate all existing data pertaining to groundwater (1993-2010). Data was split into two datasets to evaluate this distribution. Subsequent mapping of data (EPA and HSE/CC) was accomplished using geographic information systems (GIS) software (ArcGIS 10) and presented in Irish National Grid (all value plotted are  $\geq 7.5 \mu\text{g L}^{-1}$ ; the groundwater threshold value [GTV] for arsenic). Following this, a national map, which shows arsenic concentrations on a county-by-county basis, is illustrated. This map highlights counties where potential arsenic problems may be occurring and where future research is required to address any issues. National arsenic values range from  $7.5 - 21,020 \mu\text{g L}^{-1}$  with 4.79% of all groundwater analyses monitored in this period (10,581) greater-to-or-equal the GTV of arsenic. With specific reference to lithology, most arsenic occurrences are within a metasedimentary lithology (e.g. County Louth). This study highlights that, while arsenic is not greatly elevated, it is persistently elevated in certain localities around Ireland (e.g. County Louth). Current groundwater monitoring studies in combination with hydrogeochemical analysis will be used in order to determine the mobilisation and speciation of arsenic and other geochemical parameters within the groundwater system.

**Keywords:** arsenic, groundwater, Ireland, GIS, water quality

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## **Cap Reform, Biomass Policy and Landscape Design in Ireland: A Means to Revitalize Rural Economies and Achieve Greater Environmental Sustainability**

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Current data published by both the European Union and Irish Government demonstrate that Irish farmers face economic challenges of rising input costs and decreasing profits. Of additional political concern are the socio-economic disparities between the Border, Midlands and West region and the South and East region in Ireland including, but not limited to, industrial output, workforce education and farming profitability. Studies highlight the benefits of bioenergy crops (Miscanthus, Willow and grass) including potential higher earnings for farmers and suitability for growth on marginal lands. Two major policies have the potential to incentivize the Irish biomass sector; these are the Common Agricultural Policy (CAP) and the Renewable Energy Directive (Directive 2009/28/EC) (RED). Firstly, the CAP provides funds through its second pillar for innovation, training, and modernization of farms across Europe, funds that the Irish government could access and utilize to grow the sector at field level. Secondly, the RED requires EU Member State to have a proportion of their energy generated from sustainable renewable sources and decrease greenhouse gas emissions by 2020. Across-the-board, Ireland currently is experiencing high emigration levels resulting in a brain-drain, highlighted by a recent study concluding that two-thirds of those emigrating possess 3<sup>rd</sup> level degrees. Manufacturing plants for processing bioenergy crops could provide jobs through construction and material processing for degree holders in rural areas. At the same time, integration of bioenergy crops into the landscape can provide enhanced environmental benefits (e.g. carbon sequestration and lower chemical inputs) even while land uses are intensified. I conclude with an institutional analysis of why a new branch within the Department of Agriculture, Food & the Marine is necessary, with the mission to distribute funds (e.g. from CAP) in a way that optimizes economic, social and environmental values, and to work alongside the Office of Climate Change and Renewable Energy.

**Keywords:** bioenergy crops, Common Agricultural Policy, Renewable Energy Directive, rural rejuvenation

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## **Microplastics: a macro-problem for marine ecosystems?**

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Microscopic plastic litter (<5mm in diameter; ‘microplastic’), originating from the fragmentation of larger plastic items, from industrial practices and from personal-care products, is increasing in abundance in the marine environment. In 1988, an international law banning the disposal of plastic waste at sea was signed into effect, but the problem posed by plastic litter is worsening. This suggests that most marine microplastics originate on land, and are transferred to the marine environment via sewage outfalls or submarine groundwater discharge, but the importance of these sources is poorly understood. Since synthetic material typically takes a long time to decompose, microplastics can accumulate in marine environments, floating in the water column and eventually settling onto sediments. Quantifying the types of plastic and the amounts present in marine habitats are, however, difficult because current methodologies are costly, time consuming and are not yet standardised. When present in the water column or in sediments, microplastics can be ingested by a wide range of organisms and can even be transferred through the food web, but their wider effects on ecosystem processes are yet unknown. It has recently been suggested that plastics need to be classified as hazardous to prevent further contamination of marine habitats. In order to justify this action we need (1) to develop more cost and time effective methods to identify and quantify microplastics from environmental samples in order to (2) identify the key pathways by which microplastics are entering marine environments and (3) determine what ecosystem-level impacts they have when they accumulate.

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**The individual and combined effects of copper and freshwater on assemblage structure and ecosystem functioning.**

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Increased levels of anthropogenic stressors in the marine environment are leading to complex changes in its diversity and functioning. Many marine ecosystems are exposed simultaneously to multiple stressors, and their effects are difficult to predict. Stormwater is an uncontrolled and unregulated source of pollution. As well as reducing salinity, it degrades water quality by introducing contaminants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, pesticides, sediment, nutrients, bacteria and sewerage. Climate change will intensify stormwater inputs to coastal systems through increased precipitation. Using a novel programmable stressor delivery system, mature subtidal assemblages in Malahide Marina, Dublin, were subjected to factorial combinations of copper and freshwater pulses for four months to test effects on their structure and on ecosystem processes. Copper significantly reduced the rate of respiration and gross primary production, along with taxon richness and percentage cover, particularly of filter feeders. Freshwater reduced total percentage cover of all taxa, and of ascidians. These effects contrast with those on establishing assemblages reported by Saloni and Crowe in a linked study also reported at this conference. The findings of this research may be used to improve the effectiveness of stormwater management and remediation approaches to benefit ecosystem functioning and provision of ecosystem services.

**Keywords:** Multiple stressors, copper, salinity, marine assemblage, biodiversity, ecosystem functioning

## **Beneficial Reuse of Marine Sediments**

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Dredging is essential to maintain navigational access to ports and harbours. 99% of Ireland's imports and exports by volume and 95% by value are completed via maritime transport. Sustainable management of the fine and coarse material generated from dredging is required. In Ireland approximately 1.2 million wet tonnes of dredge material (DM) is generated each year. The most common management approach taken in Ireland for DM is disposal at sea with currently 51 licenced disposal sites off the coast of Ireland. The beneficial reuse of DM in Ireland has been limited to date. Sheehan et al.(2011) established that approximately 20% of Ireland's DM is reused with the reuse of maintenance DM being insignificant and 44% of capital DM reused. The purpose of this research is to investigate the feasibility of a range of specific beneficial reuses of marine sediments/dredge material.

This research project is funded under the EU Interreg Civil Engineering Applications for Marine Sediments (CEAMaS) Project. A literature review is being undertaken identifying current state of the art approaches and techniques for the treatment and beneficial reuse of marine sediments for both contaminated and uncontaminated material. The regulations and legislative framework both nationally and internationally will be reviewed.

Current volumes of DM generated from capital and maintenance dredging projects in Ireland will be estimated and quantified. Four local sites have been selected (Port of Cork, Port of Waterford, Bantry Harbour and Dunmore East Harbour) for sediment sampling and testing to examine the feasibility of implementing specific treatment and reuse technologies. Finally a life cycle analysis of the beneficial reuse technologies will be undertaken to determine optimum management practice for the reuse of DM.

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**Application of Near Infrared Spectroscopy to predict water quality parameters.**

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In this study the potential of Near Infrared Spectroscopy (NIR) spectroscopy to predict concentrations of nutrients [total nitrogen (TN), total phosphorus (TP)] and indicator microorganisms (E. coli) in surface water was assessed. Using a partial least square (PLS) regression, the relationship between these pollutants and NIR spectra of aqueous river water and river water filtrate, captured on glass fiber filters, was determined. From the filtrate, the predictive model for TN had a coefficient of determination ( $R^2$ ) of 0.77 (root mean squared error of prediction (RMSEP) = 0.4; ratio of percentage deviation (RPD) = 2.08). Calibrations for TP were less accurate with an  $R^2$  of 0.49 (RMSEP = 0.026; RPD = 1.4). For E. coli the  $R^2$  value was 0.37 (RMSEP = 378; RPD = 1.52). Calibration models developed from the aqueous samples perform less favorably with TN performing best ( $R^2$  = 0.61; RMSEP = 0.4 and RPD = 1.6). TP had an  $R^2$  of 0.309 (RMSEP = 0.03; RPD = 1.26) and E. coli had an  $R^2$  of 0.225 (RMSEP = 503; RPD = 1.13). The performance of the calibrations achieved for TN was good (RPD > 2); however, performance for TP and E. coli was poor (RPD 1.4-1.8). Several pre-treatments were applied to the spectral data in an attempt to enhance the modeling performance. Best performing models were achieved using Savitzky-Golay 1<sup>st</sup> and 2<sup>nd</sup> order smoothing. The performance of the calibrations achieved for TN was good (RPD > 2); however, performance for TP and E. coli was poor (RPD 1.4-1.8). Results suggest that NIR spectroscopy currently has limited ability to predict contaminants below 2 mg L<sup>-1</sup> (2ppm).

**Keywords:** NIR, Spectroscopy, Water Quality, Partial Least Square Regression.

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**The use of an optical fiber sensing structure based of a palladium alloy for the design of a robust Hydrogen sensor**

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Hydrogen gas has become an increasingly important source of clean and renewable energy. However, it is extremely flammable when mixed with air and can ignite at concentrations of only 4.6%. Due to the small size of Hydrogen molecules, containers or vessels used to hold Hydrogen are very susceptible to leakage. It is therefore clear that the increased future focus on Hydrogen as an energy source will bring a need for robust, fast, and safe hydrogen sensors for deployment in leakage detection systems.

The project involves the investigation of an SPR optical fibre sensor for Hydrogen sensing applications. The proposed sensor will operate on the principle that certain metals (e.g. Palladium) spontaneously absorb Hydrogen with a resulting change in their optical properties. These changes can be detected by surface plasmon resonance if such a metal is coated in a carefully controlled way on an optical fibre, for example.

The objective of the project will be to develop and use a mathematical model to design an optimum hydrogen sensor based on an optical fibre coated with a Palladium Alloy. The project goal is to identify a sensing material which gives superior performance than that of a recently reported sensor which employed pure Palladium.

**Keywords:** hydrogen sensing, SPR sensors, optical fibre sensors, surface plasmon resonance

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## Using new technologies to detect aquatic invasive species

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The Curly leaved waterweed *Lagarosiphon major* (Ridley) had completely covered a significant portion of Lough Corrib, a designated (Special Area of Conservation) SAC, one of Ireland's keystone lakes and one of the most important brown trout fisheries in North West Europe. The Curly-leaved waterweed is a tall, canopy-forming submerged plant that is native to southern Africa. It is an aggressive and invasive species in lentic freshwater habitats. Key invasive attributes of the Curly-leaved waterweed include its ability to quickly colonise suitable habitats.

The main objectives of this study are to improve upon the monitoring of aquatic invasive species through the use of sonar imagery. Studies will be carried out at infested Curly-leaved waterweed sites. The tall structure of the plant makes it a suitable candidate for sonar detection. Ideally, sonar imagery paired with geographic information system (GIS) mapping will enhance current management operations.

This study will also aim to monitor the re-establishment of native floral communities post management operations within Lough Corrib. Sonar will be trialled for the detection of other aquatic invasive species, such as *Corbicula fluminea*, Asian clam. Improved monitoring and reporting of aquatic invasive species is vital to the success of invasive species management programmes

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## Efficiency at the City Scale: Transport in Auckland NZ, Socio-spatial Indicators of Affordability

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Urban sprawl has typified the contemporary development of many cities in advanced and emerging economies. Proponents of low density urban fringe development assert that urban sprawl is merely consumer preference writ large, and that such development promotes affordable housing. A strong ideological tension between environmental ideals and housing affordability is frequently evident in public debate. However, the definitions and methodologies of housing affordability have rarely been examined within the context of this debate. Traditional measures of housing affordability are expressed solely as a function of housing cost and income, providing a one-dimensional view of affordability which ignores other significant costs. Chief amongst these is transportation, which consumes a substantial fraction of household expenditure in low density cities. This is problematic due to the extent to which housing location influences transportation costs. Lower housing prices in outlying urban areas are often offset by high transportation costs, resulting in the prevailing housing affordability measures underestimating the financial burden of peripheral housing and of low density sprawling urban development. Narrowly construed definitions of housing affordability are therefore misleading indicators of housing stress. This research utilises disaggregate zonal data to develop comprehensive indicators of commuting costs, providing an integrated housing and transport affordability index at the suburban level for Auckland City, New Zealand (NZ). Mapped outcomes of indicators suggest that once commuting costs are incorporated into developed measures, a very different pattern of affordability emerges across the city scale. Outcomes from the research provide a more comprehensive understanding of housing affordability across Auckland and provide a robust evidence base to inform contested debates such as those on urban growth strategies.

**Keywords:** Housing Affordability; Commuting, Combined costs, Indicators; Socio-spatial differentiation

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**Appraisal of an Irish rural community to determine its resilience against the effects of a waste management facility**

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The Ballynagran Project area aims to reduce its reliance on energy produced outside of its geographical boundary. Ultimately, the community strives to achieve Zero CO<sub>2</sub> emissions. The Ballynagran Committee has identified a number of approaches that can be considered when planning for the reduction of fossil fuel consumption. The aim is to demonstrate that the Sustainability Evaluation Metric for Policy Recommendation (SEMPRe) can be adapted to the requirements of the Ballynagran Energy Plus<sup>+</sup> Community (BEP<sup>+</sup>C). A suite of policies will be identified and evaluated to measure the level of sustainability of the community. This will provide a baseline Sustainability Development Index (SDI). The target of Zero CO<sub>2</sub> encompasses two main components; transport and energy. In order to reach this target a number of relevant policies and initiatives must not only be implemented but also accepted by the community. The chosen policies and initiatives must be both practical and applicable in real world settings. Data on reduced energy and transport emissions that may result from these implementations can then be calculated. Two evaluations will be conducted; the first will consider the Ballynagran community without the influence of the landfill facility and the second will take into consideration the effect of the landfill on the SDI. A change to the SDI will determine whether the landfill facility can be apportioned some responsibility for the positive or negative change and also whether NIMBYism (in this case study) is justified. The addition to the SEMPRe interface of policies that promote improvements and alternatives to current waste management options will allow for the recalculation of Ballynagrans SDI. This information can be used to address the current requirements of the Landfill Directive. With the addition of on-site anaerobic digestion, the community's future reliance on fossil fuel derived energy can be estimated.

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**Weathering of silicon rich amendments and concentration of silicic acid in soil solution**

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Silicon (Si) is not considered an essential nutrient element for plants, but plant growth, development and defence can be improved considerably in many plant species when additional plant available Si is supplied. The release of silicic acid from various Si rich amendments and its concentration in the soil solution was measured in a pot experiment under outdoor conditions. There were 7 treatments: - five waste materials (rice husks, rice husk ash, peat ash, coal ash and ground granulated blast furnace slag [GGBS]) mixed into the soil at the start of the experiment) and two soluble Si treatments (sodium metasilicate and Pro-TeKt, a commercially available Si fertiliser) watered onto the soil weekly. Soil solution samples were collected using Rhizon soil solution samplers every week for the first month and every two weeks thereafter over a period of four months. The concentration of silicic acid in the soil solution was measured colourmetrically using the Heteropoly Blue method. Of the waste materials, rice husks showed the greatest release of Si, followed by rice husk ash; coal ash, peat ash and GGBS showed low release of Si. Both of the watered on amendments provided similar moderate levels of silicic acid even though, the Pro-TeKt was added at a higher concentration. These results suggest that by recycling agricultural waste materials, in particular rice husks, the concentration of plant available Si in the soil can be increased.

**Key words:** Silicon, silicic acid, waste reuse, agricultural residues, rice husks

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**Anaerobic digestion of lipids: the main limitations and bottlenecks for treating industrial waste-streams.**

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Anaerobic digestion (AD) has become an increasingly attractive and economically feasible treatment method for a range of industrial wastes, such as those from the food industry. In 2013 Ireland’s food exports reached 9 billion euro and this is projected to increase further in the years to come. Increased production, coupled with ever increasing energy costs will put a significant strain on waste treatment facilities within the industry. To ensure sustainability of production, the option to recover valuable products from the waste while decreasing energy costs must be investigated. The emergence of AD as a low-cost technology for waste treatment and bioresource recovery is outlined in this study, with a focus on the lipid fraction of food waste. Lipids can be difficult to breakdown as they are a complex substrate and can have an inhibitory effect on the treatment process. The current industrial practices of lipid treatment include: (i) treating the lipid-rich waste aerobically, which is energy expensive and can be impeded by the lipids; (ii) separating the lipid fraction for landfill or incineration. However since lipids are high in calorific value they have the potential to be harnessed simply and efficiently for the recovery of energy and conceivably bioresources. The investigation reports the feasibility of applicable industrial lipid-rich waste-streams and feedstocks. The study aims to focus on the hydrolysis and fermentation stages of AD, examining hypotheses centrally through reactor trials coupled with molecular characterisation of microbes involved. From which, AD will ideally be developed as a sustainable industrial solution supporting the possibility of recovering ‘high-value products’ for biorefining.

**Keywords:** anaerobic digestion, lipids, biorefining, bioresource recovery.

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## Effects of wood ash solids and leachate on mobility of *Daphnia magna*

Orla C. Myers<sup>1</sup>, Lucas S. Jagodzinski<sup>1,2</sup>, Aimee Mariga<sup>1</sup>, Marcel A.K. Jansen<sup>1,2</sup>, John O'Halloran<sup>1,2</sup>

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Scientifically, ash is defined as the non-combustible residue from a fuel material. In industrial practice, however, ash is a by-product of the incineration of materials for energy and this residue may still contain amounts of combustible organic matter. With renewable energy generation becoming more common in Europe and Ireland the amounts of accruing biomass ash are increasing. The European Waste Catalogue and Hazardous Waste List generalize all ash (irrespective of origin and chemical composition) as waste. Biofuel ash generally contains small amounts of contaminants. Various after-uses have been proposed, with the idea that recycling biofuel ash helps to achieve the goal of increased resource efficiency and sustainability. Prior to recycling, the environmental implications of ash introduction must be investigated.

The acute effect of wood bottom and fly ash (from burned un-treated Sitka spruce biofuel) on the mobility of *Daphnia magna*, a common freshwater organism has been studied in static tests according to OECD Guideline 202. The two ash types, bottom ash and fly ash, were tested as particulate solids and corresponding leachates (BS EN 12457-2). In addition, the ash samples were re-ignited (LOI test) and tested accordingly.

Fly ash solids and corresponding leachates were found to have consistently lower IC<sub>50</sub> values than bottom ash or its aqueous extracts. Re-ignited, low carbon ash samples were identified to have even lower IC<sub>50</sub> values. The pH of the test solutions positively correlates with the ash concentration and an impact of the alkaline pH on the mobility of the test organism must be assumed. We conclude that (1) fly ash is comparably more toxic than bottom ash, (2) leachates can be used to depict a worst case scenario, (3) re-ignited ash (particulate and as leachate) seems to be more toxic than native ash samples. Further investigation into pH independent ash toxicity is needed to confirm these findings.

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**The use of dairy waste as a potential means to grow industrially relevant microorganisms**

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Harvest 2020 envisions a 50% rise in milk production following the abolition of milk quotas in 2015. With this rise in milk production a corresponding rise in waste from milk processing is forecast. Wastes from dairy processing (including by-products like sweet and acid whey from the manufacture of cheese and acid casein) have a high polluting potential and can be difficult to treat. A study was undertaken to see if this waste could be potentially used as a media for the growth of industrially relevant microorganisms used to produce industrially useful enzymes or chemicals. A synthetic waste media (W/L) was created (0.35% Whey Protein Isolate, 4.5% Lactose) to act as a growth media for a preliminary study. A panel of industrially relevant microorganism including fungi and bacteria was screened for growth on the media. Two fungal strains, *Penicillium chrysogenum* DSM1075 and *Aspergillus flavus* DSM1959, showed growth in the media and were selected for further study. Growth of the two organisms in the 100 ml W/L media was compared to that of growth in 100 ml of Potato Dextrose Broth (PDB) by the dry cell weight method. Results showed little difference between the two different media (DSM1075 PDB 0.163g  $\pm$ 0.06, W/L 0.237g  $\pm$ 0.04; DSM1959 PDB 0.14g  $\pm$ 0.06, W/L 0.173g  $\pm$ 0.07, n=3 in all cases). In order to potentially increase growth in the W/L media, various concentrations of Yeast Extract (YE) were added (1-5%). Supplementation with 3% YE was found to be the best, increasing biomass production by 273% and 472%, respectively, for DSM 1075 (0.647 g  $\pm$ 0.06) and DSM 1959 0.817 g  $\pm$ 0.08, n=3). The results suggest that whey may represent a suitable and inexpensive substrate for some industrial fermentation processes, with the added advantage of rendering a potentially pollutive substance a valuable industrial commodity in itself.

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## Anaerobic Digestion of Perennial Rye Grass to Produce Biogas and Other Value Added Products

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Many studies have shown that it is possible to use grass as a biomass source for anaerobic digestion resulting in the production of methane; however, cellulosic biomasses are also potential sources of fermentable sugars. This work employed three Leach Bed Reactors to digest ensiled perennial rye grass and pressed cake for the production of soluble high added value products in a biorefinery concept. The reactors were operated at 37°C over the course of 161 days (23 x 7-day batches). Reactors pH was maintained naturally at the range of 4.4-4.7, inhibiting methane production, which reached a maximum yield of 1.236 ml CH<sub>4</sub> g<sup>-1</sup>VS<sub>added</sub>. This reactor configuration allowed soluble compounds accumulation, with yields of 0.15 g COD g<sup>-1</sup>VS<sub>added</sub>. Volatile Solid (VS) destruction was surprisingly lower when ensiled pressed cake was used than when the ensiled grass was used as substrate, being on average 29% (+4.8) and 71% (+4.5), respectively. Microbial molecular analysis (community profiling and abundance) was also carried out on samples taken over the course of the 23 batches. Physio-chemical analysis (pH, solid destruction and biogas production) was also carried out on subsequent batches (26 to 65). The feedstock used was the original pressed cake and Volatile Solid destruction was found to be on average 66% (±0.46) in terms of fresh VS. pH varied over the course of these batches and methane yield was low up until batch 50 when the pH began to increase (>5.0). Subsequent batches then showed increased methane production with yields as high as 16.10 ml CH<sub>4</sub> VS g<sup>-1</sup> in one instance. Overall this study aims to prove that the AD of biosolids through the employment of a mixed microbial community is a feasible method of generating energy in the form of value added products, such as, volatile fatty acids (VFAs) in addition to methane allowing the biomass can be exploited to its maximum potential, thus ensuring a high level of energy recovery.

**Keywords:** Anaerobic digestion, biogas, biorefinery, hydrolysis, Leach Bed Reactors, perennial rye grass.

### **Effluent flow distributor**

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Standard waste water percolation areas are designed with the assumption of uniform effluent distribution to all percolation pipes via a distribution box. The 2009 EPA's Code of Practice: Waste Water Treatment Systems for Single Houses recommends that the distribution box is 'installed with care to achieve a level position', however current industry guidance on achieving this is limited. Hence these systems are heavily dependent on accurate installation. EcoScan have found that off-level installation of the box and moving soil are on-going contributors to a poor effluent in domestic percolation areas. It is also accepted that even distribution at low flow, which is typical for domestic systems, is difficult to achieve. EcoScan, in conjunction with IT Sligo, have carried out extensive research in this area which has culminated in the development of an effluent flow splitter which provides uniform distribution even on a 3° tilt. In this system the effluent is guided towards the centre of a convex shaped surface on which it subsequently spreads and runs into separate chambers. The system has been constructed as a prototype, and tested for comparison with other currently available solutions including adjustable weirs and tipping bucket mechanisms. The compactness, absence of moving parts and simplicity of the EcoScan solution make it easy to service and maintain, and suitable for both new build and retro-fit installations to any manhole. The system provides even, low-flow, distribution for up to 12 outlets and can be placed at primary and intermediate distribution points in any given percolation area.

**Keywords:** Waste Treatment, effluent, flow splitter, percolation

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## Suitability of Municipal WWTPs for the Treatment of Leachate from Landfills in Ireland

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Landfill leachate is the product of water that has percolated through waste deposits that have undergone aerobic and anaerobic microbial decomposition. Its composition is a function of the type of waste in the landfill, landfill age, climate conditions and hydrogeology of the landfill. Leachate contamination of groundwater, rivers, lakes and soils has the potential to negatively affect the local environment and human population. Therefore, the control of a landfill site, including the leachate produced, is important for the protection of surrounding natural resources.

In the EU, landfills are regulated by Council Directive 99/31/EC and the Water Framework Directive (WFD; 2000/60/EC). The WFD has a significant impact on landfill leachate management by regulating discharges to all waters, resulting in stricter discharge limits being imposed on wastewater treatment plants (WWTPs). In Ireland, current practice is guided by the EPA Landfill Manuals (EPA, 2003). Landfill leachate is normally stored in lagoons located on-site, before being transported to WWTPs for treatment. However, transport and treatment costs are considerable. In addition, many of these WWTPs are not designed for the additional loads (e.g. carbon and nitrogen) imposed by leachate, and there are concerns over its impact on the biological treatment process and allowable discharge limits – in particular removal of nitrogen and organic carbon. Current research, funded by the EPA and conducted by NUI Galway, aims to improve current practice in the treatment of landfill leachate in municipal wastewater treatment plants.

**Keywords:** leachate, landfill, wastewater, WWTP

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**Development of a rapid method for monitoring large water volumes for  
Verotoxigenic *Escherichia coli* (VTEC)**

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The reported incidence of human infection with VTEC in Ireland is the highest in Europe, with 408 confirmed cases in 2012. Water is recognised as an important transmission route. This study describes the development and validation of a method for VTEC detection from large water volumes in under 24 hours. A filtration system consisting of a submersible pump, with pre-filter and 142 mm 0.45 µm filter, was evaluated for capture of VTEC using 10 L volumes of water inoculated with decreasing concentrations (to 10 CFU/L) of an *E. coli* O157:H7 (NCTC 12900), with and without a microbial background. Bacterial filters were enriched in buffered peptone water and VTEC was detected from enrichments by real-time PCR targeting virulence genes (*ea*, *vtx1* and *vtx2*) and antigenic determinants for *E. coli* O157 and O26. Strain isolation on CHROMagar<sup>TM</sup> STEC was carried out with and without immunomagnetic separation (IMS). Volumes of up to 33 L of river water were examined for VTEC and the method was validated for capture of VTEC in Group Water Scheme raw water by direct comparison with standard immunomagnetic separation methods (ISO 16654:2001). The limit of detection for the system was 10 CFU/L. Isolation of VTEC from the enrichments testing positive by real-time PCR is a significant challenge, which can be addressed through the application of IMS and incubation of enrichment broths at 42 °C to reduce microbial background. VTEC was detected from river water using real-time PCR on four occasions and in a comparison of VTEC screening methods, this method detected VTEC in 80% of GWS (30 L) raw water samples where the standard method detected VTEC in 13% of (1 L) samples. We have developed a rapid, convenient method for examination of large volumes of water for low-level VTEC contamination.

**Keywords:** VTEC, large water volumes, real-time PCR

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## Using Microalgae to Reduce Inorganic Nutrient Levels in Landfill Leachate

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This project aims at investigating the suitability of microalgae for the bioremediation of landfill leachate, which is generally characterised by high levels of dissolved salts and ammonia as well as a wide range of organic substances. This suite of polluting chemicals may act as a source of nutrients to some microorganisms, including microalgae.

Microalgal strains were isolated during 2013 from coastal areas of North West Ireland, a peat bog from Inishbofin and a sample of treated leachate from an existing MBR Leachate Treatment plant. A total of 26 marine and freshwater strains were successfully brought into culture for initial morpho-genetic characterisation and batch culture growth trials. The potential of the isolated microalgae strains to survive and/or grow in a leachate sample was examined through a number of stress experiments carried out in multiwell microplates across a range of conductivity and ammonia levels.

The strains analysed to date cover a range of taxonomic classes, predominantly chlorophytes, heterokontophyta and cryptophytes. All the strains isolated from the treated leachate sample collected at a landfill site demonstrated substantial survival and growth. Other strains isolated from freshwater or brackish habitats showed moderate growth. Only three marine strains proved suitable for culturing in either low conductivity or relatively lower ammonia concentration (10 mS/cm and up to 50 mg NH<sub>4</sub>/L), although a combination of both inhibited their growth. A small selection of the most promising strains will be used in batch culture experiments to evaluate their ability to reduce COD, total Nitrogen and total Phosphorus in landfill leachate samples.

The safe disposal of landfill leachate is a significant environmental challenge, with this research possessing the potential to deliver an environmentally friendly solution.

**Key words:** bioremediation, landfill leachate, microalgae, ammonia, conductivity, batch culturing

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## Testing a mathematical model of biozone development in Soil Treatment Units

H F Winstanley, A C Fowler

MACSI, University of Limerick

On-site domestic wastewater treatment installations are widespread in Ireland (est. 500,000 installations), as elsewhere. Poor design and maintenance of such systems lead to significant environmental contamination with faecal coliforms and excess P and N by way of both unattenuated inputs to groundwater and surface ponding. In a functioning soil treatment unit (STU), downward-percolating effluent in the vadose zone fuels localised development of a biozone of greatly enhanced soil microbial activity which transforms major contaminants (BOD, NH<sub>3</sub>-N, NO<sub>3</sub>-N, P, pathogens) before entry into groundwater.

Reduced permeability in the biozone due to accumulation of biomass limits the infiltrative acceptance rate, but by providing lateral distribution of effluent flow leads to extension of the biozone and mobilisation of a greater soil volume in attenuation of contaminants. The extent and quality of biozone development (and thereby the efficacy of treatment) are primarily dependent on soil properties, depth of the vadose zone, and effluent quality and loading.

Mathematical modelling of biomat development and extent in the STU has the potential to provide enhanced design protocols tailored to site-specific conditions, and also a quantitative basis for estimating contaminant inputs to the environment. We report on the application of a simple theoretically-based mathematical model of biozone development (Winstanley and Fowler 2013) to site data (Gill et al. 2009).

**Keywords:** mathematical model, biozone, biomat, domestic wastewater, on-site treatment



## **Annual Review 2013**



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---

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---

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---





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---



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**For the year ended 31 December 2013**

---

**ESAI COUNCIL MEMBERS 2013:**

---

## **Index of Presenters (Oral & Poster)**

---

Adley, C.	Coxon, C.
Ahern, E.	Cummins, E.
Alam, M.S.	Dalei, W.
Allen, E.	Daly, E.
Alonso, C.M.	Daniels, E.
Atkinson, S.	Deering, L.
Barry, S.	Dennehy, C.
Bartlett, J.	Denniston, H.
Berry, A.	Dirilgen, T.
Bohan, S.	Dix, E.
Boland, R.	Doherty, E.
Bolger, P.	Doran , L.
Boots, B.	Dowling, A.
Bourk, D.	Downes, F.
Boyce , A.	Dowsett, J.
Braginal, L.	Doyle, B.
Brophy, L.	Dubber, D.
Byrne , S.	Duff, A.
Cass, S.	Duffy, G.
Casu, D.	Duggan, T.
Chen, X.	Duignan, L.
Clarke, R.	Dunphy, N.
Cogan, D.	Dwyer, N.
Collins, F.	Feighan, J.
Connolly, M	Fennell, C.
Conway, O.	Flynn, R.
Corcoran, L.	Fogarty, A.
Corkery, A.	Foley, L.

Freeney, K.	Jones, L.
Fritch, R.	Kavanagh, S.
Fu, D.	Keating, S.
Gallagher, J.	Keegan, M.
Gamble, J.	Keenan, E.
Gavin , M.	Kelly, T.
Gleeson, E.	Kelly, K. S.
Gottsche, J.	Keogh, B.
Grace, M	Kilroy, K.
Green, D.	Kinsella, C.
Haddaway, N.	Kiwanuka, S.
Harris , M.	Lane, R.
Hassett, E.	Lee, C.S.
Hawthorne, D.	Lisik, A.
Hecq, F.	Lucy, F.
Heery, B.	Lydon, T.
Hochstrasser, T.	Macken, S.
Hodgson, J.	Maguire, C.
Hogan, B.	Manton, R.
Holohan, B.C.	Massey, R.
Hunt, K.	Mc Auliffe, F.
Hurley, M.J.	McAuliffe, G.
Hyland, J.	McGee, C.
Iwata, Y.	McGeever, A.
Jagodzinski, L.	McGlade, D.
Jahangir, M.	McGrory, E.
Johnston, P.	McGuinness, C.
Jones, L.	Moran, H.

Morrissey, J.	Prat-Guitart, N.
Mugan, B.	Prendergast, M.
Muldoon, C.	Rabbitt, D.
Murnane, J.	Rathore, R.
Murphy, K.	Ronan, J.
Murphy, B.	Ryan, P.
Murphy, J.	Ryan, M.
Murray, L.	Rymszewicz, A.
Murugesan, J.K.	Saloni , Silvia.
Myers , O.	Schaller, B.
Nolan , M.	Seenivasagam, N.
Nugent, B.	Sheehan, R.
O'Connor, D.	Shortle, T.
O'Connor, E.	Shutenko, G.
O'Connor, M.	Sieira NÃfÃ³voa Uxia
O'Driscoll, A.	Smith, P.
O'Dwyer, J.	Smullen, E.
O'Dwyer, B.	Sullivan, T.
O'Hegarty, R.	Sullivan, C.
O'Neill, F.	Sun, B.
O'Sullivan, J.	Syron, E.
Oppelt, A.	Tangney, S.
Osman, H.	Taylor, C.
Owens, J.	Tene, F.A.
Paolacci, S.	Thomas, I.
Paskuliakova, A.	Tiedeken Erin Jo
Phelan, T.	Tsalaporta, E.
Phoenix, A.	Vaughan, A.

Wall, D.

Walsh, A.

Ware, A.

Westby, T.

Whitfield, M.

Wilson, J.

Winstanley, H.

Zhang , D.

Zimmermann, J.

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## NOTES

## NOTES

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