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 **environ 2012**



**UCD, March 7-9, 2012**

**[www.environ2012.org](http://www.environ2012.org)**



**The 22<sup>nd</sup> Irish Environmental Researchers Colloquium (ENVIRON 2012) is organised in a partnership between the Environmental Sciences Association of Ireland and University College Dublin.**

**Cover Page: Winning photograph of “Focus on the Future” photo competition for Engineers Week 2011 by Seán Kennedy EFIAP, UCD School of Biosystems Engineering.**

**Location: Largan Hill, North Roscommon.**

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## **WELCOME TO ENVIRON 2012**

Dear Delegate,

The ENVIRON 2012 Organising Committee extends a warm welcome to you to the 22nd Irish Environmental Researchers' Colloquium (ENVIRON 2012) and to University College Dublin (UCD). UCD last hosted the ENVIRON colloquium in 2006 and we are very pleased to welcome the colloquium again, particularly as it coincides with the year long celebration of Dublin City of Science 2012.

The ENVIRON colloquium is the largest annual gathering of environmental researchers in Ireland with over 270 researchers attending the event. The event continues to provide a wonderful platform for PhD students and postdoctoral researchers to present their research to a wide audience. Since its establishment in 1990 one of the main strengths of the colloquium has been that it attracts delegates from a wide variety of disciplines, and in a time when science, engineering and environmental science is becoming increasingly fragmented and specialised, the colloquium provides a unique opportunity for specialist researchers to learn what is happening outside their own research area.

We are particularly pleased to welcome a cohort of Undergraduate and Taught Masters students who are availing of our newly introduced student group discount registration rate. We hope the event will prove to be a rewarding and inspiring experience which may provide a springboard for those who may be interested in deepening their knowledge of environmental issues and perhaps, considering a career in research.

The theme of the 2012 ENVIRON colloquium is “Our Environment: Integrating Today’s Research with Tomorrow’s Actions”. The theme will challenge delegates to consider how ongoing research can influence many overarching areas into the future such as environmental quality, policy, legislation, society and the economy. In order to engage fully with the theme, each presenter is asked to address how their research relates to the theme in their abstract and presentation.

We begin the event on Wednesday March 7<sup>th</sup> with a series of workshops on Life Cycle Assessment, CV Preparation & Interview Strategy, and Effective Science Communication. All of the workshops are fully subscribed, so we look forward to a worthwhile and stimulating experience for all concerned. Later that evening, we have a Question and Answers style discussion chaired by Frank McDonald, Irish Times, and featuring panellists Michael Ewing, Environmental Pillar; Michael Phillips, Dublin City Engineer; Dick Warner, Columnist & Broadcaster and Dr Mary Kelly-Quinn, Senior Lecturer, UCD, who will discuss

the theme “Water water everywhere but not a drop to drink!”. In addition, a number of high profile speakers will present at a plenary session on Thursday morning (Mr Michael Hamell, DG Environment; Mr. John O’Dea, Enterprise Ireland; Dr Laurence Gill, TCD; Dr Kevin O’Connor, UCD; and Chairperson Prof. Frank Convery, UCD Earth Institute).

The programme features an Opening Chair Address to introduce each theme: Water Quality, Climate Change, Marine and Coastal Research, Energy, Environmental Management, Environmental Technologies, Environment and Health, Biodiversity and Ecosystems. Overall, there are 84 oral presentations and 39 poster presentations. Following last year’s successful introduction of one minute poster presentations at the end of oral sessions, we again provide the opportunity to poster presenters who wish to give a brief summary of their work.

The success of the ENVIRON 2012 colloquium depends on all who have contributed before and during the event. We extend a sincere thanks to all our sponsors, speakers, workshop presenters, chairs, UCD Conference & Events, UCD Buildings & Services, support staff, and of course, presenters who have made the event possible. We would like to express our appreciation for the support of the ESAI Council under the chairmanship of Dr. Paul Bolger and we would also like to acknowledge the excellent administrative assistance from Ms. Sinead Macken.

We hope that you have an educational and enjoyable experience at ENVIRON 2012 and in Dublin.

Dr Tom Curran, UCD ENVIRON 2012 Colloquium Convenor

*On behalf of the ENVIRON 2012 Organising Committee*

## **ESAI Welcome to ENVIRON 2012 Delegates**

On behalf of the Environmental Sciences Association of Ireland (ESAI), the ESAI Council extends you a warm Dublin welcome to the 22nd Irish Environmental Researchers colloquium (ENVIRON) at University College Dublin (UCD). We are delighted that the ENVIRON colloquium should be held in UCD in the year in which Dublin is the European City of Science and will play host to thousands of international researchers, policy makers, business leaders and journalists.

It is noted that the aim of the City of Science event is to showcase the latest advances in science and technology, and promote a dialogue on the role of science in society and public policy. These objectives could equally be applied to the ENVIRON colloquium which, while providing a platform for Irish researchers to present their research to a wide audience, also aims to engage scientists with the general public. For the last number of years the colloquium has thrown open its doors to the public on the first evening of the event; this year is no different with a Questions & Answers debate on the use and protection of our water resources being held on Wednesday evening. The ESAI strongly believes that public understanding of science is crucial to effective environmental protection and to the continued funding of research by government. This is one of the reasons we have chosen to host a very popular science communication workshop at the colloquium for the last number of years. In fact, communication is the heart of ENVIRON whether it be to a scientific or non-scientific audience and we wish all delegates the very best with their “communication efforts” at the colloquium i.e. presentations, posters or just a chat in the bar afterwards!

The ESAI wishes to sincerely thank Dr Tom Curran and the UCD ENVIRON 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 great time.

Dr Paul Bolger  
ESAI Chairperson

The current ESAI Council members are:

Mr Alan Berry

Dr Paul Bolger

Dr Shane Colgan

Dr Tom Curran

Ms Aoife Delaney

Mr Emmet Jackson

Ms Clare McCambridge

Ms Nuala Murphy

Dr Paul Murphy

Mr Timothy O'Sullivan

Dr Martina Prendergast

Dr Brian Quinn

Mr Joe Noonan

Further ESAI information can be found at:

[www.esaiweb.org](http://www.esaiweb.org)



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

Facebook



LinkedIn



## **ENVIRON 2012 ORGANISING COMMITTEE**

### **Conference Convenor**

Dr Tom Curran            UCD School of Biosystems Engineering

### **University College Dublin**

Dr Enda Cummins        UCD School of Biosystems Engineering

Dr John Fry              UCD School of Agriculture & Food Science

Dr William Magette     UCD School of Civil, Structural and Environmental  
Engineering

Dr Sharon O'Rourke     UCD School of Agriculture & Food Science

Dr John O'Sullivan      UCD School of Civil, Structural and Environmental  
Engineering

Dr Helen Sheridan      UCD School of Agriculture & Food Science

Dr Paddy Solan          UCD School of Biosystems Engineering

Dr Patrick J. Purcell    UCD School of Civil, Structural and Environmental  
Engineering

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

Ms Sinead Macken      ESAI Conference Liaison

Dr Paul Bolger          ESAI Chairperson

ESAI Council

### **Environmental Protection Agency**

Dr Shane Colgan

Sincere thanks to Ms Mai Cass for administrative support and to Mr Bernard Kaye for assistance in designing the book cover. Thanks also to Dr. Brian Donlon and Ms. Sandra Kavanagh in EPA for helping to review colloquium abstracts. Finally, thanks to all graduate students and postdoctoral researchers for their supporting roles at ENVIRON 2012.

## Thanks to Environ 2012 Main Sponsor



## Thanks to Environ 2012 Theme Sponsors



UCD Earth Institute

Institiúid an Domhain

Supported by



## Thanks to Environ 2012 Exhibitors



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Arts, Heritage and the Gaeltacht*



## Thanks to Environ 2012 Coffee Break Sponsors



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## Thanks to Environ 2012 Workshop Hosts



UCD School of Biosystems Engineering

UCD Career Development Centre



School of Communications



# **nviron 2012**



**UCD, March 7-9, 2012**

**[www.viron2012.org](http://www.viron2012.org)**



## **DELEGATE INFORMATION**

## **Registration**

The ENVIRON 2012 Registration Desk will be open at the concourse area outside Theatre M in the UCD Newman Building at the following times:

*Wednesday 7th March: 10.30-17.15*

*Thursday 8th March: 08.15-17.15*

*Friday 9th March: 08.30-12.45*

All enquiries 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 @environ2012 on Twitter for #ENVIRON2012 updates**



## **Delegate badges**

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

## **Locations**

The campus maps on the following pages show the key locations being used for the conference. Most activities are in the UCD Newman Building. The workshops take place in C110. The opening and plenary session will be in Theatre M. The oral sessions are held in C108, C109, C110 and J109. The trade exhibitions take place alongside the Registration Desk in the concourse area outside Theatre M.

The display of posters is located in the downstairs Rendezvous Restaurant in the Main Restaurant Building adjacent to the area for coffee breaks and lunches.

The Q&A session and colloquium dinner take place in the conference hotel, Stillorgan Park Hotel.

## **Delegates giving oral presentations**

After registering for the colloquium, delegates giving oral presentations should upload their presentation at the content management desk (located beside Registration desk). All presentations for oral sessions should be uploaded well

in advance of the session in which the presentation is being 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 room at least 5-10 minutes before the session begins.

## **Posters**

The poster presentation area is in the downstairs Rendezvous Restaurant in the Main Restaurant Building adjacent to the area for coffee breaks and lunches. 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.

Posters can be erected on Wednesday March 7th (14.00-17.00) or on Thursday morning, March 8th (8.00-11.00). All posters should be in place by 11.00 on Thursday, March 8th. Please do not remove posters until the end of the final poster session on Friday morning. There will be 3 poster sessions throughout the colloquium. To ensure that colloquium delegates can meet poster presenters we would strongly encourage poster presenters to be by their posters for these sessions to answer any questions. Each presenter is assigned a unique poster ID number (check ID in poster abstract section in the Delegate Handbook). Your poster should be mounted on the poster board assigned to your ID.

## **Wireless internet access in UCD**

Wireless access to the UCD network is available campus wide in all the main buildings and in the student residences.

To use the UCD wireless network on your laptop you will need to do the following:

- All laptops should have anti-virus and security software installed before connection to the University's Network.
- Check that your web browser options are not manually configured to use any other internet settings you may use elsewhere.
- Select the wireless network to connect to. At the bottom of your screen (windows) or top right (mac) click on the wireless icon and view available networks. Select WaveLan. You may also see an option for eduroam.

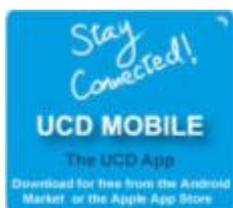
## Smartphones

Further information about connecting by wireless access to the UCD network using smartphones and other equipment is available at:

<http://www.ucd.ie/itservices/itsupport>



UCD Mobile is now available for Android, iPhone, iPods and iPads. Search for "UCD Mobile" and download it for free from the Android Marketplace or the App Store. UCD Mobile is a free app that gives you access to a variety of UCD services via your mobile phone. You can use the Map service to find your way around campus and locate buildings.



## Tea/Coffee and Lunch

Teas, coffees and lunches will be served mainly in the downstairs Rendezvous Restaurant in the Main Restaurant Building, while the initial coffee break during the afternoon workshop on Wednesday March 7<sup>th</sup> will be held near the Registration Desk at the concourse area outside Theatre M.

## Bank

The campus branch of AIB bank is located near the rear of the Tierney Building. Further ATM facilities are available near the entrance to the James Joyce Library Building and at the entrance to the Main Restaurant Building.

## Parking

If travelling by car, there is a mixture of paid and free parking spaces on campus; however, availability can be quite limited. Please note that parking restrictions are severely enforced both on-campus and on the street, and illegally-parked cars are liable to be clamped or towed away.

## **Bus**

The ENVIRON 2012 conference hotel (Stillorgan Park Hotel) will provide a free shuttle bus for delegates between the hotel and UCD at peak times. Pick up/drop off point for the bus will be the taxi drop off point on UCD campus at the steps beside AIB Bank. Check with the ENVIRON 2012 registration desk or hotel for details.

Dublin Bus numbers 2, 3, 11, 17, 39A, 46A, 84 and 145 all provide services to the Belfield campus. The 39A terminates within the Belfield campus, and can be boarded in the City Centre from College Street. The numbers 2, 3, 11 and 46A can be boarded at O'Connell Street. Several additional Xpresso services operate directly to campus during morning and evening peak. For timetable information please visit the Dublin Bus website [www.dublinbus.ie](http://www.dublinbus.ie) and search for "University College Dublin". Real time bus information is available at several stops and online. The 46A and 145 are frequent services that also connect the campus and the conference hotel (Stillorgan Park Hotel). The typical bus fare between UCD and the city centre is €2.15.

Aircoach operates a service from Dublin Airport to Leopardstown/Sandyford/Stillorgan which passes UCD. Further details are available at [www.aircoach.ie](http://www.aircoach.ie).

## **Taxis**

Fair Cabs, Old Dublin Road, Stillorgan. Tel. 01-288 8888

Local Southside Taxi, Three Rock Road, Sandyford. Tel. 01-283 6622

Am-Pm Cabs, 3 Georges Avenue, Blackrock. Tel. 01-278 7878

NCR. Tel. 01-677 2222

Dublin Taxi. Tel. 01-820 2020

Some taxis can be hailed near the 46A bus stop near the main UCD entrance on the N11 Stillorgan Road.

## **Restaurants/Cafes/Takeaways around UCD**

There are several places for delegates to eat, apart from the conference catering options in UCD and at Stillorgan Park Hotel. There are many on-campus

locations serving snacks and beverages. Off-campus venues are generally some distance away. Some examples are:

- The Beaufield Mews Restaurant, Woodlands Avenue, Stillorgan, Co. Dublin. Tel. 01-288 0375. [www.beaufieldmews.com](http://www.beaufieldmews.com)
- The Stillorgan Orchard, The Hill, Stillorgan, Co. Dublin. Tel. 01- 288 6793. [www.stillorganorchard.com](http://www.stillorganorchard.com)
- O'Connells in Donnybrook, 135 Morehampton Road, Donnybrook, Dublin 4. Tel. 01-269 6116. [www.oconnellsdonnybrook.com](http://www.oconnellsdonnybrook.com)

### **UCD Woodland Walks**

Since the 1930s, when University College Dublin's Belfield campus was formed through the purchase of some of Dublin's finest period houses and estates, the campus has provided an important amenity to students, staff and the local community. Today UCD is known for its parkland setting and mature landscaping. Now over 8km of woodland paths have been created and a series of walks developed to open up the beautiful 133 hectare campus to a wider community. The map and guide for the Woodland Walks is available on the UCD web site [www.ucd.ie](http://www.ucd.ie) and the direct link is at:





# envirom 2012

The logo for the 'envirom 2012' event. It features a stylized green leaf icon to the left of the word 'envirom' in a green, sans-serif font, followed by the year '2012' in a larger, black, sans-serif font.

**UCD, March 7-9, 2012**

**[www.envirom2012.org](http://www.envirom2012.org)**



## **PROGRAMME OUTLINE**

***ENVIRON 2012 Programme, Wednesday, March 7<sup>th</sup>***

<b>Wed March 7th</b>	10.30	<b><i>Registration Desk Open, Theatre M Concourse, UCD Newman Building</i></b>
		<b><i>Workshops, C110, UCD Newman Building</i></b>
	11.00-13.00	<ul style="list-style-type: none"> <li>• Introduction to Life Cycle Assessment (Ms. Mingjia Yan &amp; Ms. Fionnuala Murphy, UCD) followed by lunch, Rendezvous Restaurant, Downstairs, Main Restaurant Building</li> </ul>
	14.00-14.55	<ul style="list-style-type: none"> <li>• CV Preparation and Interview Strategy (Mr. Mark Cumisky, UCD Career Development Centre)</li> </ul>
	14.55-17.00	<ul style="list-style-type: none"> <li>• Effective Science Communication (Dr Brian Quinn, GMIT, &amp; Dr. Padraig Murphy, DCU) incl. 15.45-16.00 Coffee break, Theatre M Concourse</li> </ul>
		<b><i>Q &amp; A, Stillorgan Park Hotel</i></b>
	19.15-19.55	<i>Registration &amp; Wine Reception</i>
	19.55-20.00	<i>Welcome by Dr. Paul Bolger, ESAI Chair</i>
	20.00-21.15	<p><i>Q&amp;A Panel Discussion</i>  Theme: “Water, water everywhere but not a drop to drink”  Q&amp;A Chair: Mr. Frank McDonald (Irish Times)  Panel: Mr. Michael Ewing (Environmental Pillar), Mr. Michael Phillips (Dublin City Engineer), Mr. Dick Warner (Columnist &amp; Broadcaster) and Dr. Mary Kelly-Quinn (Senior Lecturer, UCD).</p>

**ENVIRON 2012 Programme, Thursday, March 8<sup>th</sup>**

08.15	<b>Registration Desk Open, Theatre M Concourse, UCD Newman Building</b>			
09.00-09.15	<b>Theatre M, UCD Newman Building</b> Welcome by Dr. Tom Curran, UCD Conference Convenor Official Opening of ENVIRON 2012 by Dr. Hugh Brady, UCD President			
09.15-11.00	<b>Plenary Theme: “Our Environment: Integrating Today’s Science with Tomorrow’s Actions”</b> Chair: Prof. Frank Convery of UCD Earth Institute Panel: Mr. Michael Hamell (DG Environment), Mr. John O’Dea (Enterprise Ireland), Dr. Laurence Gill (TCD), Dr. Kevin O’Connor (UCD)			
11:00-11:30	<b>Coffee break, Rendezvous Restaurant, Downstairs, Main Restaurant Building</b>			
11.30-12.40	Session 1 NewmanC108 Climate Change	Session 2 NewmanC109 Environmental Tech.	Session 3 NewmanC110 Biodiversity & Ecosys.	Session 4 NewmanJ109 Water Quality
12:40-13:30	<b>Lunch &amp; Poster Session 1, Rendezvous Restaurant, Downstairs, Main Restaurant Building</b>			
13.30-14.00	<b>Environmental Sciences Association of Ireland (ESAI) AGM, NewmanC110</b>			
14:00-15.10	Session 5 NewmanC108 Energy	Session 6 NewmanC109 Environmental Mgt.	Session 7 NewmanC110 Marine & Coastal Res.	Session 8 NewmanJ109 Environment & Health
15.10-16.00	<b>Coffee break &amp; Poster Session 2, Rendezvous Restaurant, Downstairs, Main Restaurant Building</b>			
	<b>Irish Society for Ocean Studies (ISOS) AGM, NewmanC110</b>			
16.00-17.00	Session 9 NewmanC108 Energy	Session 10 NewmanC109 Environment & Health	Session 11 NewmanC110 Biodiversity & Ecosys.	Session 12 NewmanJ109 Water Quality
19.15-20.00	<b>Wine Reception, Stillorgan Park Hotel</b>			
20.00	<b>ENVIRON2012 Dinner followed by Streetdance Performance and DJ</b>			

***ENVIRON 2012 Programme Outline, Friday, March 9<sup>th</sup>***

08.30	<b><i>Registration Desk Open, Theatre M Concourse, UCD Newman Building</i></b>			
09.00-10.30	Session 13 NewmanC108 Environmental Mgt.	Session 14 NewmanC109 Environment & Health	Session 15 NewmanC110 Biodiversity & Ecosys.	Session 16 NewmanJ109 Water Quality
10:30-11:30	<b><i>Coffee break &amp; Poster Session 3, Rendezvous Restaurant, Downstairs, Main Restaurant Building</i></b>			
11.30-12.45	Session 17 NewmanC108 Environmental Mgt.	Session 18 NewmanC109 Environmental Tech.	Session 19 NewmanC110 Biodiversity & Ecosys.	Session 20 NewmanJ109 Water Quality
12.45-13.45	<b><i>Awards Lunch &amp; ENVIRON Close, Rendezvous Restaurant, Downstairs, Main Restaurant Building</i></b>			



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**[www.viron2012.org](http://www.viron2012.org)**



## **ORAL AND POSTER PRESENTATION SCHEDULE**

**Oral Presentation Sessions (1-4) - Thurs Mar 8, 11.30-12.40**

<b>Session 1 Climate Change Newman C108</b>	<b>Session 2 Environmental Technologies Newman C109</b>	<b>Session 3 Biodiversity and Ecosystems Newman C110</b>	<b>Session 4 Water Quality Newman J109</b>
<i>Opening Chair Address Prof. M. Bruen, UCD Earth Institute</i>	<i>Opening Chair Address Dr. W. Magette, UCD Earth Institute</i>	<i>Opening Chair Address Dr. L. Lysaght, National Biodiversity Centre</i>	<i>Opening Chair Address Dr. L. Sheils, EPA</i>
W. Fogarty (NUIM) 1. Novel ionic liquids for the absorption and sequestration of CO <sub>2</sub>	S. Troy (NUIG) 4. Influence of sawdust addition and pre-composting on energy production from pig manure pyrolysis	D. Bourke (TCD) 7. Bioenergy crops: implications for farmland biodiversity in Ireland	C. Abberton (NUIG) 10. Determining the activity, diversity and abundance of 16sRNA, yjaA, chuA, TSPE4.C2, VT-1, VT-2 <i>E. coli</i> in a biofilm
M.I. Khalil (EPA) 2. Soil carbon accounting: Global perspectives and approaches at field through national estimates	M. Hodge (CIT) 5. Design of a micro-scale digester for OFMSW in Ireland	L. Connole (LIT) 8. Investigation into the vegetative growth of selected Sphagnum moss species in a controlled environment	C. Briciu-Burghina (DCU) 11. High frequency turbidity data as a decision support tool to aid effective monitoring programs in challenging environments.
F. Linde (UCC) 3. Designing coastal structures in an uncertain climate	E. Syron (UCD) 6. Investigation of the membrane aerated biofilm reactor for the treatment of landfill leachate	J. Roche (BEC Consultants) 9. Assessing the structure and function of EU Annex I Habitats within the Irish uplands	L. Crockford (TCD) 12. Phosphorus eutrophication in an inter-drumlin lake: causes and effects
<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>	<b>Poster Oral Presentations</b>
CC1: C. Mc Groarty CC2: R. Murnaghan	ET1: D. Keane	BE1: F. Afroze; BE2: V. McCarthy BE3: A. O'Rourke; BE4: D. Pedreschi; BE5: I. Reich; BE6: E. Tiedeken; BE7: S. Velivelli	WQ1: M. Gilligan WQ2: K. Twomey WQ3: C. Lyons
<b>12.40-13.30</b>	<b>Lunch &amp; Poster Session, Downstairs Rendezvous Restaurant, Main Restaurant Building</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</b>  <b>Newman C108</b></p>	<p><b>Session 6</b>  <b>Environmental Management</b>  <b>Newman C109</b></p>	<p><b>Session 7</b>  <b>Marine and Coastal Research</b>  <b>Newman C110</b></p>	<p><b>Session 8</b>  <b>Environment and Health</b>  <b>Newman J109</b></p>
<p><i>Opening Chair Address</i>  <i>M. Kennedy,</i>  <i>Mazars</i></p>	<p><i>Opening Chair Address</i>  <i>O. Gaillot,</i>  <i>rx3</i></p>	<p><i>Opening Chair Address</i>  <i>G. O'Sullivan,</i>  <i>Marine Institute</i></p>	<p><i>Opening Chair Address</i>  <i>Dr. S. Colgan,</i>  <i>EPA</i></p>
<p>A. Joyce (NUIG)            13. Investigation of the metaproteome of microbial communities from ryegrass anaerobic digesters</p>	<p>S. Russell (UCD)            16. WAIST: Waste augmentation and integrated shipment tracking</p>	<p>T. Gittings (Atkins)            19. The effects of intertidal oyster (<i>Crassostrea gigas</i>) culture on the spatial distribution of waterbirds</p>	<p>A. Challoner (TCD)            22. Indoor air quality in urban commercial buildings – Do we require legislative limits to protect health?</p>
<p>M. Kennealy (WIT)            14. Effect of co-composting the separated solid fraction of pig manure with various biomass addendums on fuel characteristics</p>	<p>D. Dowd (GMIT)            17. Designing out waste on construction projects</p>	<p>M. O'Shea (UCC)            20. Investigating the hydrodynamic variability along a recently breached barrier beach</p>	<p>P. Downey (LIT)            23. Effects of environmental growth conditions on the accumulation of isoflavonoids in Red clover (<i>Trifolium pratense</i>)</p>
<p>F. McCarthy (CIT)            15. Site selection for a combined sea-water pumped hydro energy storage and wind energy plant and the impact of such a plant on the Irish energy system</p>	<p>J. Brady (TCD)            18. Determinants of residential water demand and analysis of fluctuations in household water consumption across six group water schemes in Ireland</p>	<p>J. Wilson (TCD)            21. Regional scale assessment of submarine groundwater discharge in Ireland combining medium resolution satellite imagery and geochemical tracing techniques</p>	<p>J. Gallagher (TCD)            24. Passive controls of air pollution exposure in Pearse Street, Dublin: A combined measurement and modelling study</p>
<p><b>Poster Oral Presentations</b>            EN1: J. Browne            EN2: B. Fogarty</p>	<p><b>Poster Oral Presentations</b>            EM1: A.M. Brady            EM2: S. Meehan</p>	<p><b>Poster Oral Presentations</b>            MCR1: H. Murray</p>	<p><b>Poster Oral Presentations</b>            EH1: Y. Doris; EH2: R. Mac Sweeney            EH3: T. Skerritt</p>
<p><b>15.10-16.00</b></p>	<p><b>Tea/Coffee &amp; Poster Session, Downstairs Rendezvous Restaurant, Main Restaurant Building</b>  <b>ISOS AGM, Newman C110</b></p>		

**Oral Presentation Sessions (9-12) - Thurs Mar 8, 16.00-17.00**

<b>Session 9 Energy Newman C108</b>	<b>Session 10 Environment and Health Newman C109</b>	<b>Session 11 Biodiversity and Ecosystems Newman C110</b>	<b>Session 12 Water Quality Newman J109</b>
<i>Chair Dr. Joe Harrington, CIT</i>	<i>Chair Dr. Enda Cummins, UCD</i>	<i>Chair Dr. Thomas Cummins, UCD</i>	<i>Chair Dr. Suzanne Linnane, DKIT</i>
N. Dunphy (UCC) 25. The case for considering embodied carbon in planning building energy retrofits	W. Onzivu (U. of Bradford) 29. Optimizing health protection in global environmental law: Can adaptive governance help?	E. Diskin (TCD) 33. How can flamingos help us solve one of the greatest threats to human health?	J. Deakin (TCD) 37. Soils and subsoils as pathways for rainfall and diffuse contaminants reaching a river?
M. Shanley (UCC) 26. Innovative solutions for servicing offshore wind turbines	S. Kaur (NUIG) 30. Lipids in the model diatom <i>Phaeodactylum tricornutum</i> and variability among mutant strains	W. Flannery (NUIG) 34. Stakeholder participation in ecosystem-based marine spatial planning: The case of Canada's Eastern Scotian Shelf Integrated Management Initiative	H. Feeley (UCD) 38. Changes in the hydrochemical conditions and ecological status of forested streams in Ireland: A reassessment of surface water acidification and future considerations
A. Vaughan (NUIG) 27. Microbial production of volatile fatty acids from perennial rye grass in Ireland	F. Lucy (IT Sligo) 31. Monitoring <i>Cryptosporidium</i> in the Irish environment – A review of IT Sligo research	A. Gonzalez (TCD) 35. Integrating biodiversity impact assessment: A methodological approach	Z. Gholamvand (DCU) 39. Adsorption characteristics of pharmaceuticals from water and wastewater using graphene and graphene oxide engineered materials
J. Zimmermann (TCD) 28. The impact of crop patchiness on soil carbon sequestration under <i>Miscanthus x giganteus</i> - a complementary field and GIS study	R. Manton (NUIG) 32. Assessing the carbon savings and carbon footprint of new cycling routes	D. Green (UCD) 36. Invasive oysters alter native biodiversity and reduce the establishment of a protected biogenic habitat	J. Hickey (CIT) 40. Response of phosphorus loads to suspended sediment transport in the River Bandon

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

<b>Session 13 Environmental Management Newman C108</b>	<b>Session 14 Environment and Health Newman C109</b>	<b>Session 15 Biodiversity and Ecosystems Newman C110</b>	<b>Session 16 Water Quality Newman J109</b>
<i>Chair E. Kiernan, CIWM</i>	<i>Chair Dr. F. Lucy, IT Sligo</i>	<i>Chair Dr. D Chapman, UCC</i>	<i>Chair Dr. P. Bolger, UCC ERI</i>
T. Cummins (UCD) 41. Putting the soils of urban Dublin on the map	G. McEneff (DCU) 47. LCMSMS analysis of pharmaceuticals in the Irish aquatic environment and their potential to bioconcentrate and bioaccumulate up the food chain	R. MacNamara (NUIG) 53. Estimating silver eel <i>Anguilla anguilla</i> production on the River Shannon	P. Hynds (TCD) 59. Development and comparison of groundwater source contamination susceptibility models in four rural areas of Ireland
E. Feeney (UL) 42. Use of soil organism activity to assess sustainability in rehabilitated industrial residue in Ireland.	C. Morris (NUIG) 48. Hospital effluent is a source of quinolone residues entering municipal wastewater systems	J. Martins (UCD) 54. Impact of sediment discharges from quarries on macroinvertebrate populations in upland rivers – a case study	M. Keegan (TCD) 60. Assessment of disposal options for treated wastewater from single houses in low permeability subsoil
H. Labite (UCD) 43. Assessing the use of EU focus groundwater vulnerability scenarios for Irish specific conditions	M. Nyhan (TCD) 49. Quantifying particulate matter pollution exposure and relative change in heart rate variability in commuter groups	C. McConigley (UCD) 55. Biodiversity and conservation potential of aquatic buffer zones in Irish forestry	K. Kilroy (NUIG) 61. The transport of bacterial pathogens in on-site wastewater effluent disposal systems
M. Witt (UL) 44. Minimisation of phosphorus in the fermentation media of recombinant <i>Escherichia coli</i> producing a recombinant protein	C. O'Keeffe (LIT) 50. Ragwort: An agricultural nuisance or potential medicinal wonder!	K. Moore (TCD) 56. Factors influencing the ground vegetation diversity of two successive rotations of non-native conifer plantations	S. Kimberley (TCD) 62. An assessment of the environmental supporting conditions for groundwater-dependent terrestrial ecosystems (GWDTEs) within the context of groundwater body classification
<i>Continued on next page</i>	<i>Continued on next page</i>	<i>Continued on next page</i>	<i>Continued on next page</i>

<p><i>Session 13 Continued</i></p> <p>S. Meehan (IT Sligo) 45. Zebra mussel control - an environmentally friendly approach</p>	<p><i>Session 14 Continued</i></p> <p>A. Piwowarczyk (UCD) 51. Adsorption-desorption processes and mobility of different pesticides in agricultural Irish soils</p>	<p><i>Session 15 Continued</i></p> <p>J. Murphy (NUIG) 57. Computational modelling of invasion dynamics to better inform future control strategies for invasive species <i>Spartina anglica</i></p>	<p><i>Session 16 Continued</i></p> <p>P. McCabe (DKIT) 63. A paleolimnological investigation of a series of lakes in County Monaghan</p>
<p>C. O' Flynn (NUIG) 46. Impact of pig slurry amendments to control phosphorus losses in laboratory runoff boxes under simulated rainfall</p>	<p>S. Storey (UCD) 52. Degradation of polycyclic aromatic hydrocarbons (PAH) by microorganisms in soil</p>	<p>P. Perrin (BEC Consultants) 58. Natural regeneration of native woodlands on conifer clearfells at the People's Millennium Forests</p>	<p>F. McTiernan (IT Sligo) 64. <i>Cryptosporidium</i>, <i>Giardia</i> &amp; faecal indicator bacteria: Observations on their occurrence, abundance &amp; relationships in wastewater treatment plants (WWTP's) in Northwest Ireland</p>
<p><b>10.30-11.30</b></p>	<p><b>Tea/Coffee &amp; Poster Session, Downstairs Rendezvous Restaurant, Main Restaurant Building</b></p>		

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

<p><b>Session 17</b>  <b>Environmental Management</b>  <b>Newman C108</b></p>	<p><b>Session 18</b>  <b>Environmental Technologies</b>  <b>Newman C109</b></p>	<p><b>Session 19</b>  <b>Biodiversity and Ecosystems</b>  <b>Newman C110</b></p>	<p><b>Session 20</b>  <b>Water Quality</b>  <b>Newman J109</b></p>
<p><i>Chair Dr. J. Bartlett, IT Sligo</i></p>	<p><i>Chair Dr. C. Zhang, NUIG</i></p>	<p><i>Chair Dr. J. Fry, UCD</i></p>	<p><i>Chair Dr. P.J. Purcell, UCD Earth Institute</i></p>
<p>B. Brazier (UCC)  65. Genetic variation of common carp (<i>Cyprinus carpio</i>) in Irish waters</p>	<p>K. Carney (NUIG)  70. A pilot scale study to examine the treatment of piggery wastewater using woodchip biofilters</p>	<p>E. Ryder (DKIT)  75. Carbon pools and processing in an Irish humic lake.</p>	<p>C. Fenech (DCU)  80. Using an environmental forensics approach to differentiate sewage and manure derived nitrate in Irish surface waters</p>
<p>D. Keneghan (UCD)  66. IBIA &amp; classical biological control: Developing legislative tools for Ireland</p>	<p>S. Darby (UCC)  71. Towards a more sensitive detector for measuring mercury and other environmental pollutants</p>	<p>T. Sullivan (DCU)  76. Monitoring Ireland's only marine reserve: a natural laboratory to support coastal management</p>	<p>D. Morgan (TCD)  81. Stormwater monitoring of an urban residential catchment</p>
<p>A. Kerebel (UCD)  67. Farmer evaluation of slurry spreading conditions compared to predictions from the Hybrid Soil Moisture Deficit model</p>	<p>T. Gordon (IT Sligo)  72. Implementation of an activated sludge wastewater treatment plant optimisation study: Stage 1</p>	<p>V. Thompson (DKIT)  77. Assemblage structure of plant communities along the road corridor: Developing a stable sustainable system</p>	<p>O. Power (NUIM)  82. Remediating hexavalent chromium with polymer modified membranes</p>
<p>V. Vanegas (IT Sligo)  68. Green energy from marine biomass: The effect of drying <i>Saccharina latissima</i> blades on biogas production</p>	<p>Y. Hu (UCD)  73. Innovative enhancement of nitrogen removal in a multi-stage treatment wetlands: Testing methodology and reliability of results</p>	<p>R. Mangan (UCD)  78. Introducing biological control to Ireland Waging a war on invasive species</p>	<p>A. Quinn (UCD)  83. Reclaimed asphalt; environmental assessment of a valuable resource</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>

<p><i>Session 17 Continued</i></p> <p>L. Willuweit (UCD) 69. Sustainability assessment for urban water systems – A critical analysis</p>	<p><i>Session 18 Continued</i></p> <p>R. O'Dwyer (DCU) 74. Development of titanium dioxide composites for the removal of pesticides from water and wastewater using photocatalysis</p>	<p><i>Session 19 Continued</i></p> <p>V. Veerkamp (DKIT) 79. Assessing streamside fencing as a management option in the Milltown Lake catchment</p>	<p><i>Session 20 Continued</i></p> <p>A. Corkery (UCD) 84. A real-time bathing water quality prediction system for Bray, Co. Wicklow</p>
<p><b>12.45-13.45</b></p>	<p><b>Awards Lunch &amp; ENVIRON2012 Close, Downstairs Rendezvous Restaurant, Main Restaurant Building</b></p>		



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The logo for 'environ 2012' features a green leaf icon to the left of the word 'environ' in a green, lowercase, sans-serif font. The year '2012' is in a larger, green, uppercase, sans-serif font.

**UCD, March 7-9, 2012**

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**QUESTIONS AND ANSWERS  
PLENARY SESSION  
OPENING CHAIR PRESENTATIONS**

## QUESTIONS AND ANSWERS

**“Water, water everywhere but not a drop to drink”**

**8pm, Wed March 7th**

**Stillorgan Park Hotel**



**Chair:** Mr. Frank McDonald (Irish Times)

Frank McDonald is Environment Editor of “The Irish Times” and the author of several books, from “The Destruction of Dublin” (1985) to “The Builders” (2008, with Kathy Sheridan). Awarded an honorary DPhil by DIT in 2006, he is an honorary member of the RIAI and was recently elected as an honorary fellow of the RIBA. He was also a Press Fellow at Wolfson College, Cambridge, in 2008.



**Speaker:** Mr. Michael Ewing (Environmental Pillar)

Michael Ewing graduated from Brunel University, England, in Applied Biology (B.Tech. Hons, 1976). He later achieved a First Class Honours Graduate Diploma in Environmental Protection (2002), followed by a Master of Science, First Class Honours (2003). The subject of his M.Sc. thesis was “Public Participation in Environmental Decision-Making”, [www.gdrc.org/decision/participation-edm.html](http://www.gdrc.org/decision/participation-edm.html). Since then, he has worked as a facilitator and an environmental consultant in the fields of environmental governance and ecology, including leading an EEB funded project examining public participation in environmental decision-making across the UNECE region. He worked as Senior Researcher with the Centre for Sustainability at IT Sligo, where he was the co-ordinator of the Environmental Democracy Project from 2006-2008, see

[www.environmentaldemocracy.ie](http://www.environmentaldemocracy.ie) and [www.epa.ie/downloads/pubs/research/econ](http://www.epa.ie/downloads/pubs/research/econ). Since July 2008, he has taken on the role of Coordinator of the Environmental Pillar of Social Partnership which includes 27 national environmental NGOs. [www.environmentalpillar.ie](http://www.environmentalpillar.ie). In January 2010, he was also appointed coordinator of the Irish Environmental Network [www.ien.ie](http://www.ien.ie). His particular interest in public involvement in the decisions that affect them and their environment has been the driving force underlying his work over the last decade.



**Speaker:** Mr. Michael Phillips (Dublin City Engineer)

Michael Phillips was appointed City Engineer for Dublin in 1998 with responsibility for all engineering infrastructure and services. In addition to the above, he was appointed Director of Traffic in 2006 with the further responsibility for the management of traffic and promotion of sustainable means of transport.



**Speaker:** Dr. Mary Kelly-Quinn (Senior Lecturer, UCD)

Dr Kelly-Quinn's primary research activities focus on the assessment of land-use and other anthropogenic activities on the hydrochemical and ecological quality of surface waters. She has completed studies on the aquatic habitats of peatlands, agricultural, upland, urban and forested landscapes as well as constructed wetlands. Much of her work contributes to the information needs of the Water Framework Directive. She led the RIVTYPE project to characterise reference conditions for Irish rivers and develop a typological classification. Current projects will contribute to the development of measures to reduce impacts on the aquatic environment. These include a number of national, multidisciplinary projects, investigating forestry-river ecology interactions (HYDROFOR-STRIVE-funded), the potential for aquatic impacts from pollutant movement along various pathways and riparian zones (PATHWAYS-STRIVE-funded), the

effects of siltation on river water quality (SILTFLUX-STRIVE-funded), and condition and management of riparian zones in forested catchments (CROW-DAFF funded). Another project on riparian zones is investigating how management of bankside vegetation can be used to regulate instream temperatures, an issue in the context of climate change. The NRA is funding her research group to assess the impact of road crossing on stream ecology while a Teagasc-funded project is investigating pollutant attenuation in field drains. In a related study the interaction between nitrogen, phosphorus and light in the eutrophication process is being researched. In this respect she has also investigated the efficiency of constructed wetlands and their potential to enhance local and regional aquatic biodiversity. Her research group has also maintained a strength in fisheries studies, working in close collaboration with Inland Fisheries Ireland on a variety of species and systems. Further afield Dr Kelly-Quinn is collaborating with Operation Wallacea to develop a water quality biotic index for the Merendon Mountains region of Honduras.



**Speaker:** Mr. Dick Warner (Writer & Broadcaster)

Dick Warner is a writer, broadcaster and environmentalist. He took early retirement from his career as an RTE producer and now works freelance for a number of print, broadcast and online media outlets plus public speaking and consultancy work. He lives in rural County Kildare.

## PLENARY SESSION

### “Our Environment: Integrating Today’s Science with Tomorrow’s Actions”

**9.15-11.00am Theatre M, UCD Newman Building**



**Chair:** Prof. Frank Convery (UCD Earth Institute)

Frank Convery has undergraduate and master degrees in forestry from UCD, and master and PhD degrees in resource economics from the State University of New York. He was Assistant and Associate Professor at Duke University, North Carolina, Research Professor at the Economic and Social Institute, and Heritage Trust Professor of Environmental Policy at University College, Dublin. He has chaired the board of the Sustainable Energy Authority of Ireland and Comhar Sustainable Development Council, been a member of the Science Committee of the European Environment Agency, and is on European Commissioner Potocnik’s economic advisory group. His research interests focus on how best to mobilise markets to protect the environment and conserve resources, and integrate concern for the environment into day to day decisions by individuals and companies. Recent publications include: *Pricing Carbon* (with Ellerman and de Perthuis), Cambridge University Press, 2010, and ‘Reflections–Energy Efficiency Literature for Those in the Policy Process’, *Review of Environmental Economics and Policy*, June 2011. He is chair of the Oversight board of UCD Earth Institute, and of the independent think tank [Publicpolicy.ie](http://Publicpolicy.ie) funded by Atlantic Philanthropies.



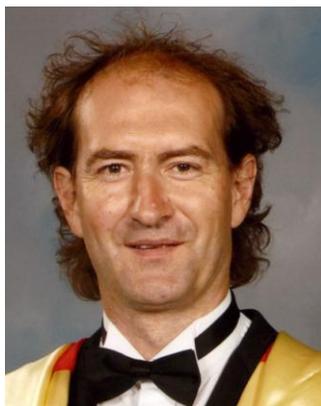
**Speaker:** Mr. Michael Hamell (DG Environment, European Commission)

Michael Hamell has worked for the European Commission since 1983 and is currently Head of the unit "Agriculture, Forests and Soil" within the Directorate General responsible for the Environment. This unit is responsible for environmental integration issues with respect to both the first and second pillars of the CAP, for the implementation of the Nitrates directive, for EU internal environmental policy related to forestry and for the EU's soil strategy presented to the European Parliament and Council in 2006. Michael worked in DG Agriculture during the period 1983-1997 in the "Beef and Sheep" Markets division with responsibilities for sheep policy and trade issues and for technical aspects of beef production. Prior to this, he worked for ten years as a farm manager, lecturer and specialist agricultural adviser with the Irish Department of Agriculture. He holds a Master's Degree in Agriculture from University College Dublin.



**Speaker:** Mr. John O'Dea (Enterprise Ireland)

John started his career as an engineer and has worked in a variety of business sectors since then. For the past four years he has been a manager in Enterprise Ireland's HPSU and Scaling division, which provides a range of supports to entrepreneurs and start-up businesses, including those focussed on the environmental and clean-tech markets.



**Speaker:** Dr. Laurence Gill (TCD)

Laurence Gill's research interests include on-site wastewater treatment, sustainable energy, karst hydrology, water treatment using sunlight, hydraulics and air pollution. His particular interests are the mitigation of human pathogens in the environment using natural attenuation methods and the use of solar disinfection to treat water. In recent years he has also worked on several water and sanitation projects in sub-Saharan countries such as Democratic Republic of Congo, Sudan, Niger, Ethiopia, Kenya and Tanzania. Prior to joining at Trinity College in 1999, he spent several years working in the UK water industry on the design of water and wastewater treatment processes for urban populations.



**Speaker:** Dr. Kevin O'Connor (UCD)

Dr Kevin O'Connor is a Senior Lecturer at the School of Biomolecular and Biomedical Science & A Principal Investigator at the Centre for Synthesis and Chemical Biology at University College Dublin. Dr O'Connor has uniquely developed and patented technology for converting plastic waste into a biodegradable plastic. He has filed 5 patents relating to bioplastic manufacture. He is the founder of Bioplastech a 2008 UCD spin out company converting waste to bioplastic. He has published over 50 International scientific papers. He is the Environmental Technology Action Plan (ETAP) representative on the European Commission ad hoc committee entitled the "lead market initiative for Bio-based products" based on a nomination by the EPA in Ireland. He is a member of the editorial board of Applied Microbiology and Biotechnology.

## PARALLEL SESSION OPENING CHAIRPERSONS



**Session 1, Climate Change,**

**Newman C108, 11.30-12.40, Thurs March 8**

**Opening Chair:** Prof. Michael Bruen (UCD Earth Institute)

Michael Bruen started his academic career teaching on the International Postgraduate Hydrology Programme at University College Galway and then worked for five years at the University of Dar es Salaam, Tanzania as Coordinator of their International Water Resources Engineering Programme (part of UNESCO's ANSTI programme), funded by Ireland's Bilateral Aid Programme. After that he managed a UNESCO Hydrology course in Harare, Zimbabwe, before returning to UCG. Later, Michael moved to UCD, becoming Director of the M.Eng.Sc. (Water Engineering) Programme and then Director of the Centre for Water Resources Research. Michael has undertaken a number of short term assignments for various International agencies, including UNESCO, the World Meteorological Organization (WMO), the Centre de Formation Internationale à la Gestion des Ressources en Eau (CEFIGRE) and the International Union for Conservation of Nature (IUCN). His research interests focus on water resources and environmental engineering with particular emphasis on applications of GIS and computer methods and modelling. Michael is currently Associate Dean of Engineering at UCD.



**Session 2, Environmental Technologies,**

**Newman C109, 11.30-12.40, Thurs March 8**

**Opening Chair:** Dr. William L. Magette (UCD Earth Institute)

William L. Magette, PhD is a Senior Lecturer of Environmental Engineering in the UCD School of Civil, Structural and Environmental Engineering, where he is also the school's Head of Teaching and Learning. His research expertise is in the area of municipal solid waste and agricultural waste management, as well as diffuse water pollution identification and control.



**Session 3, Biodiversity & Ecosystems,**

**Newman C110, 11.30-12.40, Thurs March 8**

**Opening Chair:** Dr. Liam Lysaght (National Biodiversity Data Centre)

Dr. Liam Lysaght is Director of the National Biodiversity Data Centre, a national body responsible for managing and providing access to high quality biodiversity data. Liam has extensive knowledge of conservation issues and policy in Ireland, having worked for National Parks and Wildlife Service and the Heritage Council prior to his current employment.



**Session 4, Water Quality,**

**Newman J109, 11.30-12.40, Thurs March 8**

**Opening Chair:** Dr. Lisa Sheils (EPA)

Dr. Lisa Sheils has been working with the EPA Research programme since 2006. She is currently managing the EPA Water, Environmental Technologies & Cleaner Production programmes. She formerly worked as Project Coordinator in the South Eastern River Basin District (SERBD). She also worked in GIS with Waterford City Council in water conservation

management and for many years as a Water/Pollution Inspector and Catchment Manager for Northern Ireland Environment Agency (NIEA). Previously she carried out soil research with CIPAV and CIAT in Colombia, South America and Climate Change research in the University of Lisbon, Portugal. She holds qualifications in Environmental Science, Soil Science and Physics, Geographical Information Sciences (GIS), Environmental Impact Assessment (EIA) and Project Management.



**Session 5, Energy,**

**Newman C108, 14.00-15.10, Thurs March 8**

**Opening Chair: Mr. Mark Kennedy (Mazars)**

Mark Kennedy is the Partner in Charge of the Corporate Assurance Services group in Mazars. He has been with the firm for over 15 years. Mark provides audit and business advisory services to clients across a wide range of industries and has extensive experience in advising organisations on the diverse issues and challenges they face today. Mark is a regular commentator on the economic environment. He recently co-wrote a book on the National Asset Management Agency Act 2009 which is a reference guide to practitioners in comprehending the complex and technical provisions contained in the legislation. Mark has a particular interest in the Energy Sector and has recently co-authored a paper on the policy challenges facing Ireland in this sector. He is a fellow of the Institute Of Chartered Accountants in Ireland. Mazars Ireland is one of the Big 8 professional services networks in accountancy and professional services in Ireland. Services include audit and assurance, consultancy, corporate finance and taxation services.



**Session 6, Environmental Management,  
Newman C109, 14.00-15.10, Thurs March 8**

**Opening Chair:** Mr. Olivier Gaillot (rx3)

Olivier is the Project Manager for rx3, a Department of Environment, Communication and Local Government initiative to develop market for recyclables materials. He is also a Technical Director at RPS one of Ireland's leading multi-disciplinary, all island consultancies providing Planning, Engineering, Environmental and Communications services. Olivier is an environmental engineer and recently completed a MBS in Strategic Procurement. He has 14 years experience of environmental engineering, resource efficiency, waste strategy, waste planning and implementation. Olivier has been project manager for RPS on a large number of high profile projects including two EPA national municipal waste characterisation campaigns, the development of a protocol to monitor biodegradable municipal waste going to landfill, the second Irish hazardous waste strategy and associated SEA. He also worked on District Heating market development projects in Dublin and in an EU funded project for the European District Heating Association.



**Session 7, Marine and Coastal Research,  
Newman C110, 14.00-15.10, Thurs March 8**

**Opening Chair:** Mr. Geoffrey O'Sullivan (Marine Institute)

Mr. Geoffrey O'Sullivan is a Senior Policy Advisor (International Co-operation) in the newly established Office of the CEO of the Marine Institute, Ireland's national agency for marine RTDI ([www.marine.ie](http://www.marine.ie)). A graduate of UCD and the University of Bangor (N.Wales), he has over 30 years experience in the public, academic and private sectors. Since joining the Marine Institute in 1995, he has been actively involved in marine science, technology & innovation policy

development, contributing to both Irish and European marine research policies and programmes. Mr O’Sullivan is a national expert on the EU FP7 Environment (including Climate Change) Programme Committee and the INTERREG-IV Ireland/Wales Steering Committee; a board member of the Ostend-based Marine Board-ESF and a board member of the Lisbon-based European Centre for Information on Marine Science and Technology (EurOcean). He is the Team Leader of the Atlantic Network of Marine Research Funding Organisations in the current FP7 SEAS-ERA project (2010-2014) and is a co-author of the recent SEAS-ERA Discussion Document A draft Marine Research Plan for the European Atlantic Sea Basin (October 2011).



**Session 8, Environment and Health,**

**Newman J109, 14.00-15.10, Thurs March 8**

**Opening Chair: Dr Shane Colgan (EPA)**

Dr. Shane Colgan has a degree in Agricultural and Food Engineering from UCD where he also obtained a M.Eng.Sc and a PhD. He has worked with the Environmental Protection Agency since 2001 and directs EPA funding activities in the area of Sustainable Environment – including Environment & Health. Shane also oversees communication and dissemination activities for the research programme.



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## **WORKSHOPS AND TRAINING SEMINARS**

## **Introduction to Life Cycle Assessment**

**11am-1pm, Wed, March 7, C110, UCD Newman Building**

Life cycle assessment (LCA) is a method for evaluating the environmental impact of a product, process or service over its entire life-cycle, from raw materials acquisition through processing, use, to the point of final disposal and recycling. It has gained popularity in recent decades and terms such as “carbon footprint”, “low carbon economy” and “sustainable development” have emerged from life cycle thinking. The Introduction to LCA workshop will introduce the main concepts of LCA including basic theory and methodology. The four steps of an LCA; goal and scope definition, inventory analysis, impact assessment, and interpretation, will be explained. The workshop will involve interactive group activities that will encourage participants to start life-cycle thinking. Current LCA research in the areas of renewable energy and dairy production, carried out in UCD School of Biosystems Engineering, will be presented.



**Speaker:** Ms. Mingjia Yan (UCD)

Ms. Mingjia Yan is a PhD student of UCD School of Biosystem Engineering, University College Dublin. She has degrees in Applied Chemistry and Ecology and is now working on the life cycle assessment of Irish milk production in conjunction with researchers from Teagasc. The main themes of her study are 1) defining an LCA framework for modeling Irish milk production; 2) investigating the potential of white clover for reducing life-cycle greenhouse gas emissions associated with milk production; and 3) evaluating the effect of upscaling mitigation strategies from research farm to commercial farms. She has presented widely at national and international conferences and has published An evaluation of life cycle assessment of European milk production in the Journal of Environmental Management (vol 92, p372-379). Further papers are in press.



**Speaker:** Ms. Fionnuala Murphy (UCD)

Fionnuala Murphy is a PhD student in the Bioresources Research Centre in UCD. Her PhD research is focused on the Holistic Evaluation of Biomass-to-Energy Systems using Life Cycle Assessment (LCA) modalities. After a year-long exchange at Virginia Tech in the USA, she graduated from UCD in 2010 with a BE (Hons) in Biosystems Engineering. After graduation, Fionnuala completed an internship with the Ecology Foundation where she worked on calculating the carbon footprints and developing carbon strategies for a number of businesses. In January 2011, Fionnuala began her PhD in UCD. Her current research uses LCA modalities to assess the overall energy efficiency and environmental impacts of biomass-to-energy systems. Various biomass sources; including wood chip, wood pellets, sawdust, short rotation coppice willow and Miscanthus, are considered. This work is central to the holistic evaluation of the environmental impacts of bio-energy systems and will enable a comprehensive national impact assessment to be made of various scenarios.

## **CV Preparation and Interview Strategy**

**2.00-2.55pm, Wed, March 7, C110,**

**UCD Newman Building**

Simply writing down a summary of your research and/or experience to date as an application, and then talking about your previous research in its own context at interview is insufficient. Recruitment panels routinely bemoan the standard of applications and/or applicants for positions: poor grammar, misspellings, incorrect titles, wrong addresses, generic letters, inarticulate candidates, lack of relevance, ambition, or motivation are commonplace.

“The candidates just didn’t do themselves justice.”

“I’ve worked with that candidate and I know she (he) is better than that.”

These are regular comments from recruitment panels who genuinely want candidates to put their best foot forward, after all, they have an interest in selecting the best person for their team.

This workshop will enable participants to identify key themes in job specifications and relate their previous experience to the skills required in the advertised role. It will highlight the transferable skills most sought by employers and place them in context. It will focus on how to develop the most effective written applications and how to manage the interview processes to get your message across clearly and succinctly. It will enable participants to manage the selection process to their best advantage.



**Speaker:** Mr. Mark Cumisky (UCD Career Development Centre)

Mark is the Career Development Adviser for Post-Doctoral Researcher Staff at the UCD Career Development Centre. Prior to that he was Manager of the Career Development Centre at the University of Otago in New Zealand, New Zealand’s leading research university, (2005-2010), and previously a Careers Adviser at UCD (1994-2005). He has been actively involved in the profession at national and international level, having been Chair of The University Careers Advisers' Association of New Zealand and Secretary of

the Association of Graduate Career Services in Ireland (now the Association of Higher Education Careers Services), as well as sitting on various committees. He is also a member of the Association of Graduate Career Advisory Services and the National Association of Colleges and Employers (US). Mark is passionate about the necessity for people to engage with their careers in a proactive fashion to better optimise their career fulfilment.

**Effective Science Communication**  
**2.55-5.00pm, Wed, March 7, C110,**  
**UCD Newman Building**

**Communicating Environmental Science in Public**

The issue of environmental science communication has become an increasingly pressing one with growing public awareness of the extent of environmental damage and global warming. There is public expectation for information and often we are awash with information. However, the lead-up to the COP15 Climate Change Summit in 2009, including the infamous ‘Climategate,’ was seen as a major turning point by science communicators: political structures floundered, scientists were accused of malpractice, and there were public reactions from hostility to indifference to the environmental agenda. Arguably, environmental science itself was coming under attack. It could also be argued that climate scientists should have handled this crisis better, using more effective communication.

In this workshop, we will explore how effective science communication can be done when interacting in the public arena through various media channels. We will, first of all, outline the personal benefits to environmental scientists when communicating to a wide audience. We will then explore the societal benefits of engaging with various publics – not just for imparting environmental data but the real benefits of engaging where, in a ‘mediatised’ world, there is a growing desire for dialogue between science and society. We will explore news headlines, media and reports to look at examples of communication that is effective and those that are not so effective. Finally, our audience will be expected to identify the challenges they face when communicating their research. The golden rule is however: scientists cannot easily predict how their communication efforts will take effect in society. But we can learn how to act and react in a media-savvy, and sometimes rhetorical, manner. We may not all be scientists who regularly do media engagements. But scientists are increasingly expected to engage outside their areas of expertise: with policy-makers, venture capitalists, Government agencies consumers, and of course other scientists, particularly in the interdisciplinary processes of environmental science.



**Speaker:** Dr. Pádraig Murphy (DCU)

Dr. Pádraig Murphy is Lecturer in Communications at Dublin City University and Chair of the MSc in Science Communication programme. His teaching and research interests include science communication, public participation in, and public representations of, science and technology; concepts of nature and culture in science education; and emerging technologies and new media in education. An environmental science graduate, Pádraig's recent research – at PhD and postdoc levels - has focused on deliberative and participatory dialogue models for biotechnology, nanotechnology, and sustainable technologies. He is currently DCU Principal Investigator on the FP7 project PERARES (Public Engagement with Research and Research Engagement with Science). Pádraig also has wide experience as a science communication trainer for scientists.

## **Effective Scientific Writing**

Writing and publishing science is of obvious importance for scientists to communicate their results with both their peers and the wider community. It is also your currency as a scientist and the yardstick by which you are evaluated. For many young scientists starting out, the prospect of writing your first publications can be a daunting one. The idea behind this talk is to give an understanding and insight into the basic principles to adhere to and pitfalls to avoid when writing scientific publications. The presentation shall contain an insight into how to write peer reviewed scientific publications, offering practical tips on how best to structure your paper (how long should your paper be?), the logical progression through the paper and identify the most basic mistakes (e.g. simple grammar). We shall investigate the review process of a peer reviewed journal, explain impact factors, why the choice of journal is so important and finally look at examples of good and awful scientific writing in order to illustrate these points.



**Speaker: Dr. Brian Quinn (GMIT)**

Brian Quinn is an environmental toxicologist and is currently principle investigator on an EPA funded DERP project based in the Irish Centre for Environmental Toxicology, which he established in GMIT. Brian's research investigates the ecotoxicological effects of novel contaminants (pharmaceuticals) in the environment by the development of novel biomarkers. Previously Brian completed his PhD in Trinity in 2002, a post-doc with Environment Canada and has also worked in industry.



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**ORAL PRESENTATION ABSTRACTS**  
**(Listed by Presentation No. 1-84 in Timetable)**

## 1. Novel ionic liquids for the absorption and sequestration of CO<sub>2</sub>

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There is a growing consensus that carbon dioxide (CO<sub>2</sub>) emissions are contributing to global climate change. This is a man-made problem, born from the reliance on fossil fuels which are still the main energy source for both industrial and domestic use. With the adoption of the Kyoto protocol in 1991 there has been a global effort to reduce climate change and it seems that reducing CO<sub>2</sub> levels is key to achieving this. Unfortunately, in terms of their economic importance there is currently no question of Ireland being able to stop using coal and peat as primary fuels. Therefore new technologies that may be used to contain, or prevent, the emitted CO<sub>2</sub> from entering the atmosphere are essential now and in the future. Various approaches are currently under investigation including chemical absorption and sequestration. Many materials to date are in the development stage to absorb CO<sub>2</sub> from gas streams, but it is the amine technologies that have attracted the most interest. These amines, while in limited operation in industry, do have some disadvantages such as expense, low thermal stability and release of NOXs into the atmosphere. Our approach is the use of ionic liquids (ILs) as CO<sub>2</sub> sorbents. ILs are composed solely of ions and exist as liquids at room temperatures. These liquids have also been shown to demonstrate high thermal stability, reducing the potential of breakdown material entering the atmosphere. In preliminary studies the ILs have shown a high affinity and selectivity for CO<sub>2</sub> making them ideal candidates as CO<sub>2</sub> sorbents and they may also be potentially exploited as CO<sub>2</sub> separation membranes.

**Keywords:** ionic liquid, CO<sub>2</sub>, carbon dioxide, absorption, separation

## **2. Soil carbon accounting: Global perspectives and approaches at field through national estimates**

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Soil organic matter has significant contributions to productive and sustainable land uses in various ecosystems. Organic carbon stored in soils is the largest sink, resulting in a significant impact on sequestering atmospheric carbon dioxide, compared to other reservoirs. Biospheric carbon sinks and sources originating from human-induced activities allowed under Articles 3.3 and 3.4 of the Kyoto Protocol could have huge implications to meet emission reduction targets during the commitment period of Kyoto Protocol. Variations in soil organic carbon (SOC) levels can have serious consequences on many environmental processes e.g., soil fertility and greenhouse gas fluxes. Thus, verifiable precise estimation of SOC changes has become pivotal to global environmental policies, allowing carbon offset or credit benefits. The Intergovernmental Panel on Climate Change default approaches should be replaced by country-specific ones through eliminating complex methodological difficulties. For this, reasonable standard protocol should be developed for measuring SOC, which is independent of its origin and decomposition, at the field level considering topography, soil type, land use classes, etc. SOC is a measure of the total amount of organic (inorganic where applicable) carbon in soil. For comparative study, its reliable estimates over years depend on the sampling strategy e.g., techniques, tools, location, timing, soil depth/profile as well as calculation procedures at the field scale. Upscaling to national level, high resolution soil and land use database, and the application of coupled models (to derive missing data) and GIS techniques could be highly useful. This paper presents updated approaches to measure and calculate SOC at field level, and thereby upscale to national SOC stock accounting.

**Keywords:** Soil organic carbon, measurement, modelling, GIS technique, upscaling.

### **3. Designing coastal structures in an uncertain climate**

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Coastal structures (revetments, breakwaters etc.) protect the shore from extreme storm events and are designed to provide an adequate safety level often defined by local wave and water level conditions. However potential climate change is making the design of these structures more difficult. The 4th IPCC (Intergovernmental Panel on Climate Change) assessment report concluded an accelerated sea-level rise and increased storminess for the 21st century. Thus, existing structures could become undersized and a failure to meet safety standards could lead to disastrous effects such as damage to the environment, properties, infrastructures and even loss of life. There is no accepted methodology for including future weather patterns in the design process. Even though increasing crest level elevations may seem a solution, modifying an existing structure can be complicated and expensive, and the structure's size cannot be expanded indefinitely. Therefore, new methods of future proofing current designs are required. This study focuses on examining innovative crest designs for coastal structures enabling them to provide the same safety level without increasing crest height or incurring excessive cost. The study focuses on the following two scenarios: New structures where a level of future proofing can be incorporated at the design stage and; Existing structures where a future proofing system would need to be retrofitted. Existing future proofing methods that are either in planning or have been applied were first examined and this knowledge was used to design new systems. Physical model testing at the Hydraulics and Maritime Research Centre wave testing facility has been carried out and showed significant reductions in overtopping discharge. Work is currently ongoing to fully parameterise the model behaviour by undertaking a comprehensive set of tests. It is envisaged that the study will provide detailed recommendations on two systems of future proofing coastal structures.

**Keywords:** Coastal, Climate Change, Future Proofing

#### **4. Influence of sawdust addition and pre-composting on energy production from pig manure pyrolysis**

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The cost of manure disposal is rising for pig farmers, especially those based in pig-dense regions. One alternative to the problem of landspreading of these pig manures may be to use pyrolysis to produce renewable energy and biochar. Pyrolysis experiments were conducted on the separated solid fraction of anaerobically digested pig manure (SADPM). The aim of these experiments was to investigate the influence of (1) sawdust addition and (2) composting the feedstock, on the products of pyrolysis and on the net energy yield from the pyrolysis process. The following mixtures were examined: SADPM, SADPM and sawdust mixed at a ratio of 4:1 on a weight-to-weight (w/w) basis, and SADPM and sawdust mixed at 3:2 (w/w). These mixtures were pyrolysed in a laboratory-scale reactor at 600°C both before and after 56 days of aerobic composting. The yields of the biochar, bio-liquid and gas were impacted by the addition of sawdust to the SADPM and by composting of the feedstock. With the addition of sawdust to the feedstock, higher heating values (HHV) of biochar and gas increased, while bio-liquid HHV decreased. More than 70% of the original energy in the feedstock remained in the biochar, bio-liquid and gas after pyrolysis, increasing as the proportion of sawdust increased. The HHV of the biochar decreased, while the HHV of the bio-liquid increased, after the feedstocks were composted. An energy balance was conducted to determine the potential of pig manure pyrolysis for renewable energy generation. The net energy yield was calculated for the entire treatment process, which included four stages: separation, composting, drying and pyrolysis. The option of using the biochar as a soil addendum, rather than as a fuel, was also investigated. The energy balance showed that increasing the rate of sawdust addition to SADPM resulted in an increased net energy yield. The addition of a composting stage increased the net energy yield for the SADPM feedstock. However, a composting stage reduced the net energy yield when sawdust was added.

**Keywords:** pyrolysis, pig manure, energy, sawdust, biochar.

## 5. Design of a micro-scale digester for OFMSW in Ireland

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The EU Landfill Directive 1999 and Waste (Food Waste) Management Regulations 2009, combined with the lack of centralised digestion facility in Ireland give rise to the opportunity for the development of decentralised micro-scale digestion of the Organic Fraction of Municipal Solid Waste (OFMSW). Localised digestion reduces waste disposal costs and generates biogas that can be used as a source of energy. This research is based on the design and optimisation of a micro-scale digester. The approach used in finalising a digester design involves undertaking a review of all commercial large scale anaerobic digestion facilities currently operating in Europe, as well as of existing small scale digestion facilities. The ability to scale down large-scale plant technology, along with analysis of the efficiency, yields and ease of operation of current small scale digesters, is the basis for the digester design. The digester design combines leach bed technology with a Downflow Fixed Film Reactor (DFFR). The digester comprises of 3 combined sections to form a cylindrical vessel 1.5 meters in height. The top section of the digester houses 90 litres of solid waste that can be semi-continuously fed through a top-feed hopper that also serves as a fully immersed pre-treatment stage for hydrolysis of the lignocellulosic fraction. Recirculated leachate passes through a perforated plate to a DFFR where a predominant methanogenic biofilm converts the VFAs present in the leachate to methane and carbon dioxide. Constant temperature throughout the digester is achieved via a heating jacket in the solids section, and a heating element in the leachate sump. A facility for recycling both leachate and digestate has been incorporated into the design of this prototype. Using a consistent feed stock, an initial batch test will serve as the basis for optimising the design for widespread use.

**Keywords:** micro-scale digestion, OFMSW, leach bed

## **6. Investigation of the membrane aerated biofilm reactor for the treatment of landfill leachate**

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As a way of tackling the problem of shipping landfill leachate to already over taxed municipal wastewater treatment plants for treatment, it was decided to investigate the potential use of the energy efficient Membrane Aerated Biofilm Reactor (MABR) for treating Landfill Leachate on site. The MABR shows enormous potential as an alternative technology for the biotreatment of wastewater. The principle benefit of the MABR is the ability to minimise the energy required to supply the oxygen for the aerobic bacteria. Due to its ability to achieve over 90% Oxygen Transfer Efficiency, it significantly reduces the amount of air needed and because the oxygen is directly supplied to the active biofilm, all liquid/gas interface mass transfer can be neglected. A 4 litre Sequencing Batch Reactor (SBR) was set up in the laboratory treating leachate from Arthurstown Landfill, Co Kildare. The SBR was initially set up to mimic the existing treatment process, with a 12 hour cycle time and an 8 hour aeration phase. After achieving steady state operation and oxidising over 80% of the influent Ammonia at a loading rate of 0.2kgN-NH<sub>4</sub>/m<sup>3</sup> day, a membrane aeration unit was installed external to SBR, with the Mixed Liquor being recycled between the SBR and the membrane aeration Unit. The membrane unit had a volume of 120ml and a membrane surface area of 5cm<sup>2</sup>. Air was supplied independently to both the SBR and the membrane aeration unit. Initial performance results show an increase to over 90% Ammonia oxidation due to the addition of the membrane aeration unit. Air flow rates and oxygen transfer rates for both the sparger in the SBR and membrane aeration unit were also measured, to calculate the total energy required per kg of Oxygen transferred. This data will then be used for future scale up calculations.

**Keywords:** Wastewater treatment, landfill, leachate, biofilm

## 7. Bioenergy crops: implications for farmland biodiversity in Ireland

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The urgency for mitigation actions on CO<sub>2</sub> emissions has encouraged the rapid expansion of the bioenergy sector, potentially resulting in major land-use changes. This paper reports on a study that assessed the impact of replacing traditional agricultural crops with *Miscanthus x giganteus* on plant, pollinator and carabid beetle diversity and abundance and the composition of their communities. Fifty sites were selected across south-east Ireland, ten replicates of five treatments (crop types): (1) *Miscanthus* on former tillage, (2) *Miscanthus* on former grassland, (3) oilseed rape, (4) tillage control and (5) grassland control. Plants, pollinators and carabid beetles were surveyed at the margin (next to hedgerow), edge (next to crop (~3m from hedgerow)), and centre of fields on two occasions during summer 2009. Different responses to the treatments were shown for the plants when compared with pollinators and carabids in terms of species richness and abundance. Communities within *Miscanthus* were most similar to other perennial crops, and most dissimilar to the annual crops: replacing traditional crops with *Miscanthus* did not result in novel communities except for the plants. We also investigated the effect of surrounding landscape structure on field scale biodiversity to disentangle crop type and landscape effects. The structure of agricultural landscapes (1 km<sup>2</sup>) was characterised using remotely sensed data and habitat survey, combined with GIS based landscape metrics (e.g. habitat/land-use proportion, patch size, shape, isolation). Preliminary results show that landscapes in south east Ireland are composed of between 0 and 14% semi-natural habitats per km<sup>2</sup> and approximately 10 km of hedgerow per km<sup>2</sup>. A full analysis of the data will reveal the influence of landscape complexity on species richness, diversity and community structure. Overall, growing *Miscanthus* did not result in an obvious negative impact on biodiversity measured at the field scale. However, achieving targets of reducing biodiversity losses by 2020 will be quite challenging.

**Keywords:** biodiversity, bioenergy crops, climate change mitigation measures

## 8. Investigation into the vegetative growth of selected *Sphagnum* moss species in a controlled environment

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*Sphagnum* moss is the main building block of peatlands; ecosystems including raised bogs and fens, in which *Sphagna* forms a carpet over waterlogged lands, creating a ‘floating’ island effect. These *Sphagna* mats host an unusual acidic ecosystem for unique floral and faunal species. Intensive industrial peat harvesting for fuel and horticultural growth medium has extensively damaged peatlands across Ireland and Western Europe, resulting in scarring of landscapes and endangerment to the ecosystems’ flora and fauna, in particular *Sphagna*. The role of *Sphagna* in water purification and retention, significantly contributes to the long term storage of CO<sub>2</sub> making bogs highly important carbon ‘sinks’, thus removing excess CO<sub>2</sub> from the atmosphere. Peat harvesting significantly impacts upon this process. In addition, *Sphagna* growth rates are known to be as low as 5 cm year<sup>-1</sup> in some species, depending on weather patterns making potential regeneration of a peatland time consuming and problematic at best. Development of methods for propagation of *Sphagna* species and re-establishment of bogs in Canada and Europe are currently being adapted for Irish conditions. This study investigates induction, promotion and optimization of growth in 3 *Sphagna species* using controlled environment technology. Growth environment chambers were used to control the light, humidity, and temperature for growth. Two hydroponic systems were evaluated for feasibility of use in propagating *Sphagnum*; a recirculating system, whereby the nutrient solution was continuously circulated through the moss, and a static system with the moss sitting in undisturbed nutrient solution. Apical and lateral growth was observed on *S. magellanicum* and *S. recurvum* in both static and recirculating systems. Growth of *S. cuspidatum* was not as vigorous as the other two cultivars. Preliminary data suggests rates of up to four times average growth can be achieved (>2 cm/month). Research is on-going to define the effects of growth conditions using controlled environments.

**Keywords:** sphagnum moss, bogs, growth chambers, controlled environment, vegetative growth

## **9. Assessing the structure and function of EU Annex I Habitats within the Irish uplands**

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The uplands form Ireland's largest expanses of semi-natural vegetation and include numerous habitats listed in Annex I of the EU Habitats Directive. Member states are obliged to monitor the conservation status of Annex I habitats and to work towards achieving their favourable conservation status. The National Survey of Upland Habitats (NSUH) was commissioned by the National Parks and Wildlife Service in 2010 following a pilot survey in 2009. The main focus of the survey is habitat mapping, relevé recording and the conservation assessment of twelve Annex I habitats. The four most abundant habitats are 4010 Wet heath, 4030 Dry heath, 4060 Alpine and Boreal heath and \*7130 Blanket bog. To date nine sites have been surveyed. One aspect of the conservation assessment procedure is structure and function, which is assessed in the field by recording a series of monitoring stops. Structure and function provide an overview of the condition of each habitat, using habitat specific criteria that assess the vegetation composition, vegetation structure and physical structure of the habitat. Results indicate that high levels of sheep grazing in the past have significantly impacted the structure and function of the four main Annex I upland habitats. Peat erosion is a major impact on the physical structure of \*7130 Blanket bog, while burning is an issue in 4030 Dry heath, and to a lesser extent in 4010 Wet heath. As a result, the structure and function of these habitats have largely been assessed as unfavourable. Whilst there has been recent destocking of sheep in the uplands, if favourable conservation status is to be achieved and maintained it may also be necessary to implement integrated farm management agreements and habitat restoration projects. The NSUH is providing the vital baseline scientific data to help inform policy and practice in this regard.

**Keywords:** uplands, Annex I habitats, monitoring, grazing, erosion

## **10. Determining the activity, diversity and abundance of 16sRNA, *yjaA*, *chuA*, *TSPE4.C2*, *VT-1*, *VT-2* *E. coli* genes in a developing biofilm.**

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Safe, clean drinking water is a fundamental human right. Contamination of Water Distribution Systems (WDS) can have considerable effects on human health, often encouraging waterborne illnesses. The aim of this research is to develop quantitative PCR (qPCR) and reverse transcriptase-qPCR (RT-qPCR) assays to detect the presence and activity of *E. coli* in drinking water and distribution pipe biofilms. These assays permit the detection, quantification and expression of specific *E. coli* functional genes - *yjaA*, *chuA*, *TSPE4.C2*, *VT1*, *VT2*, and mRNA transcripts. Samples are sourced from a globally exclusive pipe loop test facility located at the University of Sheffield, which simulates a fully functioning WDS capable of determining any physical, chemical and biological variations in the water and the pipe biofilm. Removable coupons, located in the wall of the WDS, enable both quantitative and qualitative compositional descriptions, allowing determination of biofilm formation. Assays have been extensively tested and optimised and will be applied to quantify the abundance of introduced *E. coli* and determine the maturation of the WDS biofilm. The 16sRNA standard curves were highly linear ( $r^2 > 0.999$ ), the amplification efficiency was 0.88, and the detection limit was  $10^2$ . Early experimental results indicate a change in 16sRNA gene abundance with biofilm maturation, highlighting the influence of biofilm habitat on *E. coli* multiplication. This project is highly collaborative, utilizing novel facilities and expertise at the University of Sheffield and the National University of Ireland, Galway. It is also vastly interdisciplinary, incorporating aspects of microbiology, engineering and computing. Ultimately, the outcomes of this research aim to improve drinking water quality, and WDS operation and management on a global scale.

**Keywords:** Q-PCR, Water Distribution Systems, Biofilm, *E. coli*

## **11. High frequency turbidity data as a decision support tool to aid effective monitoring programs in challenging environments**

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Recent advances in communication and sensor technologies have catalyzed progress in remote monitoring capabilities for water quality. Emerging sensor technologies can provide additional information on temporal and spatial variability of pollutants as well as early detection of special events. Further work is required to demonstrate the utility and reliability of these tools in field trials. A successful demonstration project in Dublin Port from September 2010 to May 2011 shows how state of the art technology can be implemented for cost effective continuous monitoring. The site is known to be a dynamic, rapidly changing aquatic environment affected by tidal movement, ship traffic and Liffey river inflow. Data was collected every 15 min using one YSI multi-parameter sonde connected to a telemetry system. The measured parameters were: temperature ( $^{\circ}\text{C}$ ), conductivity ( $\text{mS cm}^{-1}$ ), turbidity (NTU), optical dissolved oxygen (ODO) ( $\text{mg L}^{-1}$ ) and pH. Collected data was processed and analysed and the temporal fluctuations in the above mention water quality parameters are discussed. Trends arising from tidal movements, climate conditions, ship traffic, seasonal variations and fouling of the sensors will be presented. Results obtained from turbidity data point out the impact of motorised ship traffic on the resuspension of river bed material and underline the dependency between time of sampling and water quality in the area. More specifically the results show that ship traffic causes an artificial upwelling and changes considerably the water quality during the course of 24 h. Concurrent monitoring of both turbidity and ship traffic was used to indicate appropriate times for sampling regimes in these conditions. The results obtained and observations of trends illustrate that a single multi-parameter sonde can provide valuable information to act as a decision support tool to aid an effective monitoring program.

**Keywords:** remote sensing, water monitoring, turbidity, Dublin Port

## 12. Phosphorus eutrophication in an inter-drumlin lake: Causes and effects

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Sustainable use of EU water resources and maintaining a high ecological status in water bodies are key aims of the Water Framework Directive. A widespread water quality challenge in developed countries is eutrophication from point and diffuse loadings of nutrients, such as phosphorus (P) and nitrogen (N), from land to water. Related directives such as the Nitrates and Urban Waste Water Treatment Directives are the main regulatory instruments to manage these transfers and the efficacy of the measures are being evaluated in national monitoring programmes. This project is investigating the role of external and internal P loading to a meso-eutrophic inter-drumlin lake. Seasonal anoxia and wind induced resuspension of sediments are both linked to the ongoing eutrophication of lakes where historical external P loads have accumulated in lake sediments. A database is being built showing the extent of catchment derived P loading (external pressure), wind influences and stratification/mixing (internal pressure). This will be augmented using water column monitoring of algae and ancillary parameters. The results of the P monitoring and high frequency data from data sondes, installed on the lake in three locations, have shown that the lake is experiencing periods of eutrophication which may be linked to stratification followed by episodic events. Influences of wind mixing were also examined using the results of the surface samples at two locations. The difference between the long-term means of the two locations (one of which is sheltered and the other more susceptible to fetch-induced re-suspension) for total P, soluble reactive P and total particulate P concentration were found to be non-significant which provides evidence that wind may not be a predominant factor in seasonal eutrophication episodes as observed in the dataset so far. Ultimately, untangling the comparative effects of external/internal P loads in sensitive standing waters will provide policy makers with expectations of recovery from eutrophication episodes against the targets set out in the Water Framework Directive.

**Keywords:** Phosphorus, eutrophication, lake, agriculture, chlorophyll

### **13. Investigation into the metaproteome of microbial communities from ryegrass anaerobic digesters**

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Anaerobic digestion (AD) consists of a chain of biological reactions, namely hydrolysis, acidogenesis, acetogenesis and methanogenesis, which are carried out by the sequential and cooperative action of various microbial trophic groups. Though it is a widely used process for the treatment of wastewater, recent studies have been carried out utilizing grass and solid waste as feedstock for AD-mediated biofuel (methane) production. There is relatively little known about the functional activities of the microbial consortia involved in AD. Advancement of the process relies on a greater knowledge and understanding of the behaviour of these microbial populations. Metaproteomics should allow for exposing new functional genes and metabolic pathways and establishing the link between identity and functionality (protein assignment). In this work, we demonstrate the feasibility of metaproteomics applied to mixed communities of an AD bioreactor, digesting perennial ryegrass as substrate. We successfully analysed protein expression from samples contained in a grass bioreactor using two-dimensional gel electrophoresis. Differential protein expression patterns were observed from the leachate (re-suspended biomass and extracellular protein), granules (seed biomass) and biofilms on the grass itself. This would suggest a specific microbial organisation within the bioreactor.

**Keywords:** Anaerobic Digestion, Grass, Metaproteomics

#### **14. Effect of co-composting the separated solid fraction of pig manure with various biomass addendums on fuel characteristics**

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The aim of this study was to assess the effect on fuel characteristics of co-composting the separated solid fraction of pig manure (SPM) with various biomass addendums. Three trials with a total of eight treatments were conducted – SPM only (repeated in all three trials), SPM/sawdust (4:1), SPM/greenwaste (4:1), SPM/straw (13.5:1), SPM/woodchip (4:1), SPM/sawdust/woodchip (8:1:1), SPM/sawdust (4:1) and SPM/sawdust (3:2) (ratios based on fresh weight). Treatments were composted in tumblers for 56 days. The purpose of composting these mixtures was to ensure complete mixing, to reduce moisture & odour and to remove pathogens. Ash content and gross & net calorific value (GCV & NCV) were used to assess the fuel characteristics of the composted manure for use as a biofuel. During composting, the inorganic fraction increased over time. GCV of all 8 treatments was determined to have similar values to existing biofuels ranging between 17-19 MJ/kg on day 0. Ash content increased from day 0 and continued to increase to day 56 in Trial 1 ( $P < 0.001$ ), Trial 2 ( $P < 0.05$ ) and Trial 3 ( $P < 0.05$ ). The increase in ash content was associated with a reduction in GCV in all three trials ( $P < 0.001$ ). High ash content was the primary problem encountered in Trial 1 and 2. Ash content on day 0 ranged from 14-27 %, which further increased to 15-33 % by day 56. Trial 3 consisted of varying the C/N ratio of the SPM/sawdust. The reduction of SPM and increase of sawdust reduced the ash content significantly; SPM/sawdust (3:2) ranged from 8 - 11% between days 0 and 14. However, microbial analysis found that 3-7 days composting was sufficient for removal of pathogens and that limiting composting to seven days would lessen the negative effects of composting with respect to GCV and ash content. Analysis of major and minor elements showed that metal content became more concentrated during composting.

**Keywords:** separated solid fraction of pig manure, biomass, Ash, GCV

## **15. Site selection for a combined sea-water pumped hydro energy storage and wind energy plant and the impact of such a plant on the Irish energy system**

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Ireland has one of the best wind energy regimes in Europe but is limited in its capacity to harness this energy primarily due to an infrastructure deficit. Wind power is intermittent in nature and thus has either to be utilised instantaneously or stored for use when required. Pumped Hydro Energy Storage (PHES) is a well established process allowing energy to be stored for use when required. Coastal regions in Ireland are particularly suited to the development of sea-water PHES plants, combined with wind power, due to the proximity to coastal valleys at suitable base elevations. This paper assesses the benefits of combined wind/seawater PHES in an Irish context and develops a model for selecting and comparing viable sites. A software package has been developed to assess the technical, power, environmental and economic elements of a project or site. A weighted scoring mechanism has been developed which attributes values to each of the individual project elements. The software package assists the decision making process in terms of selecting the most suitable or optimum site for a specific project. Preliminary model results have shown that sites with base levels greater than 100m, within a distance of 500m from the sea and having upper lake volumes greater than  $59.8 \times 10^{-6} \text{m}^3$  appear to be most viable. In financial terms, sites with power output greater than 1Gw would appear to produce lower cost / Mw both from an operational and construction cost perspective. This economy of scale is an important factor as it eliminates many sites due to power output capability. The model has been tested against existing operational sites where Pumped Hydro Energy Plants have been installed. Relevant data on financial, economic and social aspects of these projects, has been used to validate data in the model which has been developed. A survey of potential users has also been undertaken to validate the model and the weighting system applied. Systems, similar to those in operation internationally have also been analysed to validate the output data from the software package developed. In an international context the trend is towards the construction of PHES plants with high power output. Analysis from the model confirms this trend of selecting high power output plants due to the financial, infrastructural and environmental requirements.

**Keywords:** Sea-water Pumped Hydro Energy Storage, Wind Energy, Site Selection.

## **16. WAIST: Waste Augmentation and Integrated Shipment Tracking**

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Illegal disposing of waste is a growing problem in many OECD countries including Ireland. Within the waste management cycle the issue of tracking waste from collection to delivery in a transparent yet verifiable fashion is of particular importance. This research presents a pioneering prototype waste tracking application designed to address this issue. This application utilises wireless sensor network technologies, both hardware and software to form an integrated software and hardware system with two goals; 1. Tracking the current location of licensed hauliers as well as a history of their previous locations; 2. Detecting tampering with the cargo and matching these events with the location where they occurred. Through the use of GPS technology as well as a number of motion sensors a live stream of data can be provided to the application. Data is managed through the use of the SIXTH middleware platform for the sensor web which combines physical and cyber sensing technologies within a single unified framework. The application uses this data to achieve the stated objectives by providing a number of different techniques to visualise the incoming data either in real-time or by replaying the data at a later date. Analysis of the sensed data is used to automatically detect suspicious events such as movement of the waste containers which could be consistent with illegal dumping.

**Keywords:** Waste Management, Waste Tracking, Wireless Sensor Networks

## **17. Designing out waste on construction projects**

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Construction and Demolition (C+D) waste levels in Ireland have dropped significantly since 2007, with waste levels now at less than one third of that produced at the height of the construction boom. While this is positive news for the environment, it does not show that the construction industry has become more efficient, it simply demonstrates that a smaller construction industry produces less waste. Research into waste prevention on construction projects is being carried out by GMIT in conjunction with key industry stakeholders. This research aims to bridge the gap between the theory of waste prevention and the current on site working practices in order to provide realistic solutions that will provide environmental and economic benefits by reducing waste through practical measures. Waste in the construction industry has been regarded by many as an inevitable by-product of the construction process and so many construction firms accept it as normal and do not actively attempt to reduce waste and the costs associated with it on site. The competitive nature of the building industry at present should focus the minds of construction managers to reduce wastage, thereby providing a competitive advantage while also reducing the detrimental impact of the development on the environment. Case studies have been examined, at both the design and construction phases of major projects, where waste prevention strategies have been trialled for the first time in an Irish context. Many of these strategies were successful in reducing waste volumes, and aided the best practice management of discarded materials. By implementing the findings of this research it may be possible to reduce substantially the levels of waste produced in this sector in years to come, thereby increasing resource efficiency and reducing the sector's dependence on environmentally unfavourable disposal options such as landfill.

**Keywords:** Waste, Resource Management, Construction Waste

## **18. Determinants of residential water demand and analysis of fluctuations in household water consumption across six group water schemes in Ireland**

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Ireland's water sector is set to experience major reform following recent announcements to implement a national water authority and domestic water charges. Knowledge of domestic consumption patterns is well established particularly in developed nations following implementation of domestic metering and charging over the last few decades. However, there is a paucity of baseline information relating to water consumption patterns in Ireland particularly with regard to residential consumption as the vast majority of households are neither metered nor charged for water. This is despite household usage accounting for 60% of total water demand. Obtaining a detailed understanding of determinants of residential consumption and fluctuations in usage is crucial for future policy planning with the aim of achieving sustainability of future water supplies as required by the Water Framework Directive 2000/60/EC. The aim of this research is to establish a detailed picture of variations in domestic consumption on a daily, monthly and seasonal basis and also to determine factors influencing water demand through analysis of 85 group water scheme (GWS) households across 6 schemes. As many schemes are metered, GWS households provide valuable insight into usage patterns and manual reading of water meters was undertaken over a 13 month period. Subsequently, a questionnaire incorporating questions on householders' water usage behaviour and attitudes to conservation was completed by participants and utilised in conjunction with consumption data. Determinants assessed include economic, socio-psychological, environmental and socio-demographics. Results from this analysis and continued research to understand usage patterns and their drivers is key to managing water resources efficiently and planning for future demand in light of increasing pressures such as climate change and population growth. Continuity of a high quality water supply is vital to the social and economic development of Irish society and societies globally.

**Keywords:** residential water demand, metering, group water schemes, Ireland, determinants of demand

## 19. The effects of intertidal oyster (*Crassostrea gigas*) culture on the spatial distribution of waterbirds

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The potential impact of aquaculture activities on Special Protection Areas for birds (SPAs) is subject to Appropriate Assessment under Article 6(3) of the EU Habitats Directive. The culture of the Pacific Oyster (*Crassostrea gigas*) takes place within 16 SPAs. This study aimed to identify whether there are consistent patterns of positive or negative association between waterbird species and oyster trestles, in order to contribute to an assessment of whether the spatial distribution of waterbirds is affected by the presence of oyster trestles. The study included an extensive study across six sites (Poulnasherry, Co. Clare; Castlemaine, Co. Kerry; Ballymacoda, Co. Cork; Dungarvan & Woodstown, Co. Waterford and Bannow, Co. Wexford) and an intensive study at one site (Dungarvan). Oystercatcher (*Haematopus ostralegus*), Redshank (*Tringa totanus*) and Turnstone (*Arenaria interpres*), and probably also Curlew (*Numenius arquata*) and Greenshank (*T. nebularia*), all showed a neutral or positive response to the presence of oyster trestles. Grey Plover (*Pluvialis squatarola*), Knot (*Calidris canutus*), Dunlin (*Calidris alpina*) and Bar-tailed Godwit (*Limosa lapponica*), and probably also Shelduck (*Tadorna tadorna*), Ringed Plover (*Charadrius hiaticula*), Lapwing (*Vanellus vanellus*), Sanderling (*C. alba*), Black-tailed Godwit (*L. limosa*) and Great Black-backed Gull (*Larus marinus*), showed negative responses. The species that showed a neutral/positive response included waders that tend to feed in small flocks or as widely dispersed individuals/loose flocks. The species that showed a negative response are mainly species that tend to feed in large flocks of tightly packed individuals. These species also generally favour open mudflats or sandflats and usually do not occur in large numbers in mixed sediment or rocky shores. Therefore, selection of mixed sediment or rocky shore sites for intertidal oyster culture would be likely to reduce the potential impact on waterbirds.

**Keywords:** aquaculture, SPA, oyster trestles, waterbirds.

## **20. Investigating the hydrodynamic variability along a recently breached barrier beach**

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Identifying key drivers of extreme erosion can be relatively straight forward. Severe flooding, large storms and even human interaction have all been responsible for drastically altering the coastline over short time periods. However when events such as barrier breaching occur with no obvious contributory factors, a deeper understanding of the underlying coastal processes is required. Ideally conclusions on morphological drivers should be drawn from field data collection and remote sensing over a long period of time. Unfortunately when the barrier beach at Rossbeigh, County Kerry, Ireland, started to erode rapidly in the early 2000's there was no such data collection conducted. By 2008 approximately 1.5million m<sup>3</sup> of sand had been eroded and during the winter period of that year the dune breached, resulting in the formation of a barrier island and a new tidal inlet. An initial analysis of the breaching suggested that erosion had slowed and regeneration of the dune was occurring; however further monitoring indicated that as the breach was stabilising other areas of the barrier beach were experiencing increased erosion. As a result of this a field monitoring campaign consisting of wave and tidal data collection was undertaken in the summer of 2011 to gain a clearer understanding of the hydrodynamic processes influencing the erosion patterns. Analysis of this data provides a new insight into the active coastal processes in Dingle bay. The magnitude of tidal currents, directionality of incident waves at high tide and the presence of high frequency energy along shoreline Rossbeigh are significant findings that influence morphology. On a fundamental level of coastal process research interesting conclusions regarding the hydrodynamic variability between the drift and swash aligned sections were made.

**Keywords:** Coastal Erosion, Sediment Transport, Hydrodynamics, Waves, Tidal Currents

## **21. Regional scale assessment of submarine groundwater discharge in Ireland combining medium resolution satellite imagery and geochemical tracing techniques**

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Submarine groundwater discharge (SGD) is defined broadly as any and all flow of water from land to the ocean across the seabed and is receiving considerable attention in the literature as a major pathway for anthropogenic pollutants to coastal waters. Despite acknowledgment of its potential impact on coastal ecosystem functioning SGD is a poorly understood and over looked process when implementing coastal monitoring and management programmes. For instance, EU directives such as the Water Framework Directive (2000/60/EC) do not acknowledge SGD as a potential nutrient source for assessment or monitoring. This is because the spatially and temporally heterogeneous nature of groundwater seepage renders locating and quantifying rates of SGD an appreciable challenge. This research sets the foundation for the use of freely available Landsat Enhanced Thematic Mapper (ETM+) thermal infrared (TIR) imagery in a regional scale assessment of SGD to coastal waters. A comprehensive, tiered, three-step approach is proposed as the most effective and affordable means to determine the spatial extent and scale of SGD. First, Sea Surface Temperature (SST) values derived from Landsat ETM+ TIR imagery are used to successfully detect plumes of colder water eventually associated with SGD in close proximity to the shoreline. Second, potential sites of SGD are linked to geological features on land acting as possible sources, by combining within a Geographical Information System (GIS), mapped temperature anomalies with ancillary on-shore spatial datasets describing bedrock geology including aquifer fault lines. Finally, nearshore surveys mapping the activity of  $^{222}\text{Rn}$  (radon) and salinity are carried out to verify the presence of SGD and provide a qualitative assessment of fresh groundwater inputs to the coastal zone. The study demonstrates the potential of the combined applications of remote sensing methods and geochemical tracing techniques for a cost-effective regional-scale assessment of groundwater discharge to coastal waters.

**Keywords:** thermal remote sensing, Landsat ETM+, submarine groundwater discharge, geochemical tracing, radon, salinity

## **22. Indoor air quality in urban commercial buildings – Do we require legislative limits to protect health?**

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Research shows people now spend up to 90% of their day indoors yet in Ireland no legislative indoor air pollutant limits exist. Legislative reductions in air pollutant limit values seek to improve outdoor air quality, in turn reducing associated illnesses such as asthma, acute bronchitis, strokes and lung cancer. This research focuses on the two air pollutants, NO<sub>x</sub> (NO<sub>2</sub> + NO) and PM<sub>2.5</sub> (particulate matter with aerodynamic diameter less than 2.5µm), that the 2008-2012 Dublin Regional Air Quality Management Plan stated were of most concern. The aim of this research is to determine the relationship between exposure of staff to specific air pollutants in Irish working environments (e.g. shops, offices) and outdoor air pollutants, investigating controlling factors such as ventilation systems and door design for such buildings. NO<sub>x</sub> and PM<sub>2.5</sub> concentrations have been measured simultaneously indoors and outdoors of the buildings under investigation. Outdoor concentrations were measured in two locations either directly outside the building at ground level or at the air intake of the buildings ventilation system. To date ten work places located on busy street canyons within Dublin city centre have been monitored. Results indicate that indoor concentrations can be significantly greater than outdoor concentrations for certain sites, e.g. Indoor Outdoor ratios (I/O) of up to 2.0 for NO<sub>2</sub> and 2.1 for PM<sub>2.5</sub>. Other sites however, have shown significant reductions in pollutant concentrations indoors compared to outdoors, with I/O ratios as low as 0.32 for NO<sub>2</sub> and 0.45 for PM<sub>2.5</sub>. Clear differences in lag times and I/O ratios for PM<sub>2.5</sub> and NO<sub>x</sub> were also observed for working and non-working hours. The building with the greatest reduction for NO<sub>2</sub> was a naturally ventilated office while the greatest PM<sub>2.5</sub> reduction was seen in the mechanically ventilated office.

**Keywords:** Air Pollution, urban, indoor, outdoor

### 23. Effects of environmental growth conditions on the accumulation of isoflavonoids in red clover (*Trifolium pratens*)

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Isoflavonoid concentrations in Red clover (*Trifolium pratens*) tissues grown hydroponically within environmental growth chambers were assessed to explore the potential affect of changing environmental conditions on isoflavonoid biosynthesis and accumulation. Red clover seedlings were grown for 28 days under different light qualities (cool white fluorescence and high intensity discharge-high pressure sodium (HID-HPS)) as well as different light quantities ranging from 150 - 1000  $\mu\text{mol m}^{-2} \text{sec}^{-1}$  with concurrent changes in ambient growth temperatures ranging from 11 - 23 °C. Isoflavonoid concentrations (daidzin, genistin, biochanin A and formononetin) in leaf, stem and root tissues of the seedlings were analysed. Exploration into isoflavonoid extraction methods was carried out using direct solvent extraction on fresh and freeze-dried tissue and by means of super-critical fluid extraction. Preliminary result show that clover biomass increases with increasing light up to 300  $\mu\text{mol m}^{-2} \text{sec}^{-1}$ , at 450  $\mu\text{mol m}^{-2} \text{sec}^{-1}$  evidence of photooxidation was present hindering plant growth. Preliminary results also show that isoflavonoid accumulation differs between each of the three tissue types, leaves, stems and roots. Also, isoflavonoid extract concentrations were higher when using direct solvent extraction with freeze-dried tissue. Isoflavonoids have become a staple of the human diet in recent years being a large component of soy-based foods. Their phytohormonal activity has numerous biological benefits to both human nutrition and agriculture. However, commercial isoflavonoid extracts and supplements don't give specifics as to the quality of quantity of isoflavonoids present. By analysing environmental effects on accumulation, products can be optimized.

**Keywords:** Environmental Growth Chambers, Isoflavonoids

## **24. Passive controls of air pollution exposure in Pearse Street, Dublin: A combined measurement and modelling study**

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This study investigates the potential of passive controls to reduce personal air pollutant exposure in an urban street canyon. The implementation of a low boundary wall (LBW) can minimise the exposure to pollutants as it acts as a baffle within a street canyon, increasing pollutant dispersion at street level. Previous passive control investigations have been limited to generic CFD modelling studies, therefore this study combines real-time traffic data collection, meteorological measurements and air pollutant monitoring, with a geometrically accurate simulation for the development of a calibrated model of Pearse Street in Dublin, Ireland. This study assesses the spatial distribution of concentrations of NO in the urban canyon in winter conditions before and after the implementation of passive controls. The average concentrations are measured along the centre of both footpaths at breathing height to determine the percentage difference between air pollutant concentrations in a canyon with and without passive controls. The investigation assessed the calibrated canyon model in varying wind and traffic conditions based on traffic data and meteorological measurements collected. The model showed a very good agreement with the data collected from the monitoring study of Pearse Street. The results indicated that wind speed and direction affects local pollutant dispersion and that the implementation of a LBW can reduce the pollutant concentrations on the footpaths. Reductions in pollutant concentrations were induced by the presence of a LBW over its absence on both footpaths. The study highlighted the potential of passive controls in a real street canyon to increase dispersion and improve air quality at street level.

**Keywords:** Passive Controls, Low Boundary Walls, Street Canyons, Large Eddy Simulation, NO<sub>x</sub> Monitoring

## **25. The case for considering embodied carbon in planning building energy retrofits**

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The need to increase energy efficiency and reduce the carbon intensity of buildings has been well established, not least because, as acknowledged in the EU Energy Efficiency Action Plan 2011, the built environment offers greater potential savings than any other single area of activity, with buildings estimated to be responsible for 30 - 40% of total energy use worldwide. Current approaches to selecting energy retrofit solutions have not significantly changed since the drive to improve the energy efficiency of building stock arose in response to the 1970s oil crises. Selection is based primarily on predicted operational energy savings; the embodied energy represented by the materials has heretofore not been considered to be significant because firstly, it does not affect the financial return of the choice and secondly, as Ramesh et al. (2010) comment, embodied energy (and carbon) has not been seen as significant vis-à-vis the operational energy consumption of a building over its life. The primary objective behind current EU and national policies aimed at raising the energy efficiency of buildings is the reduction of greenhouse gases emissions - this contextual change means there is a disconnect between the policy drivers and the 'on-the-ground' decision-making for energy efficiency within buildings. Furthermore, as buildings become more energy efficient, operational energy consumption decreases and as a consequence the relative significance of embodied carbon increases. These changes mean that the on-going bias towards operational energy is no longer appropriate in decision-making on building energy retrofits. This paper discusses the changing significance of embodied carbon in calculation of whole-life carbon emissions of buildings, examines the factors behind these changes and, using a case study, presents the case for including embodied carbon in a holistic decision-making process for planning building energy retrofits.

**Keywords:** Building, Energy Retrofit, Embodied Carbon, Whole-life, Life-cycle

## 26. Innovative Solutions for Servicing Offshore Wind Turbines

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Servicing an offshore wind farm requires the transfer of personnel from shore to wind turbine. Currently the ‘step over’ method is limited to a wave height of 1.5 m. In the North Sea, wind turbines are only accessible 40% of the time. However, these turbines are in relatively sheltered coastal areas. Wind turbines are being installed in progressively unsheltered areas of the North Sea and the Irish Sea, with the eventual aim of placing wind turbines in the Atlantic Ocean. According to the Carbon Trust, being able to access wind turbines at a wave height of 3 m would be worth 3.5 billion euros to the offshore wind industry. Accessibility at a wave height of 3 m would make wind turbines in the Atlantic accessible 40% of the time, but only 15% of the time using current vessels. The research is addressing this issue by examining a concept hull design for an offshore wind service vessel. The objective of this work is to carry out a feasibility study to determine if further development of the concept is warranted. The proposed design is being optimised using hydrostatic and hydrodynamic analysis using the computational fluid dynamic (CFD) package ANSYS CFX. Physical testing of the optimised design in the National Ocean Test Facility’s wave basin to determine the accuracy of the analysis will also be carried out. Initial analysis suggests that the concept will be beneficial to the personnel transfer, but travel time to the wind farm will be increased. If used as part of a combined system providing transport around the wind farm and transfer, this design should have economic benefits by dramatically increasing the practicability of accessing offshore wind farms in unsheltered locations. This will ensure that the turbines are always able to produce electricity, and have a greater operating lifespan.

**Keywords:** Wind Energy, Offshore Wind, Operation and Maintenance, Renewable Energy, Personnel Transfer, Wind Farm Service Vessel

## 27. Microbial production of volatile fatty acids from perennial rye grass in Ireland

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Traditionally bioenergy projects have focused on the production of methane from anaerobic digestion. However, methane is not a high value product when compared with investment costs and so it is often uneconomical to produce unless subsidised. This project intends to harvest other more valuable products (Volatile Fatty Acids; VFAs) during the conversion process. VFAs are more expensive in the markets and can be used in the production of bioplastics and other products. Grass is a natural substrate for VFA production in Ireland due to the suitable climate for its growth, its abundance and its lack of competition with food crops. Since this is a novel approach the optimum operational conditions for the reactor and yields and types of VFAs which can be produced are to date unknown. At present, leach-bed reactors are operating at different pH and their performance is assessed by evaluating hydrolysis and VFA yields and profile and by measuring solids destruction and COD. First results show that pH affects hydrolysis and VFA profile. Reactors operated at pH ~7 had a substrate degradation of 60% and produced mainly acetic acid, while as pH dropped so too did hydrolysis reaching 30% at pH ~5 with butyric acid being the main VFA present. Butyric acid yield reached 0.05 g gVS<sup>-1</sup><sub>added</sub>. Future work will evaluate the effect of solid and hydraulic retention times on reactors' performance. Monitoring and studying the community structure and dynamics during the reactors operation will be crucial to allow optimisation and control of process. Advanced molecular techniques will be used to quantify the abundance of microbes present (qPCR) and to map their diversity (DGGE).

**Keywords:** anaerobic digestion, hydrolysis, perennial rye grass, Volatile Fatty Acids (VFAs)

## 28. The impact of crop patchiness on soil carbon sequestration under *Miscanthus x giganteus* - A complementary field and GIS study

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In recent years *Miscanthus x giganteus* has increasingly been proposed as a source of biomass for energy production in Ireland. The Bioenergy Scheme launched in 2012 will support the planting of another 1400 ha of *Miscanthus* and willow. In addition to its potential to replace fossil fuels it has been shown that growing *Miscanthus* can sequester a significant amount of carbon into soils, further mitigating carbon emission. However, recent studies on commercial *Miscanthus* fields have shown a varying patchiness of the crop, raising concerns of the overall efficiency of soil carbon sequestration. In this experiment soil samples from both, open patches and adjacent areas of high *Miscanthus* density were taken on 8 commercial farms in SE Ireland. The analysis of the *Miscanthus*-derived carbon showed significantly lower values in open patches compared to high crop density in the upper 30 cm of the soil column ( $0.41 \pm 0.72$  Mg ha<sup>-1</sup> and  $0.80 \pm 0.82$  Mg ha<sup>-1</sup>, respectively). To assess the possible impact at field level a simple GIS model has been used. The *Miscanthus*-derived carbon data was interpolated using ordinary kriging to form two raster maps (high density *Miscanthus* and open patch) covering the respective field-boundaries. Given numbers of points (50, 100, 150, and 200) were randomly distributed within each field-boundary. These points were then used to create a polygon mask representing the patchiness of the field, the size of the patches was randomly generated using parameters (mean patch size and standard deviation) measured in the field by Cass (2010). Using the mask, the open-patch raster could be overlaid onto the high density raster creating a raster representing the *Miscanthus*-derived carbon distribution in a patchy field. Initial results show that on average *Miscanthus*-derived soil organic carbon values are 9.26 % lower in fields with 200 random patches compared to a high density *Miscanthus* field.

**Keywords:** Bioenergy, *Miscanthus*, soil carbon sequestration, climate change

## **29. Optimizing health protection in global environmental law: Can adaptive governance help?**

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Focusing on case studies in international, European and UK environmental law and policy, the paper discusses evidence to show that health protection has not been effectively optimised in environmental law and regulation. It reinforces this evidence by revisiting the history of environmental law, the scope of health protection objective in environmental law and regulation, the status of social protection in environmental regulation and notions on effectiveness of environmental law and regulation. Case studies have included climate change, water and trans-boundary waste regulation. The study examined functional options to optimise health protection in environmental law and regulation. It proposed a conceptual framework of adaptive governance to address the health protection deficit in environmental law and regulation. The research concluded that an adaptive governance approach to reinvigorating health in environmental law and regulation requires repositioning at its core essential support pillars. These pillars include reinforcing environmental justice, multi-sectoral collaboration, evaluation and environmental ethics in environmental law and policy. The research further found that this reinvigorated form of adaptive governance provides an effective framework for optimising health protection in environmental law and regulation.

**Keywords:** Human health, environmental regulation, adaptive governance, environmental justice, environmental ethics, evaluation

### **30. Lipids in the model diatom *Phaeodactylum tricornutum* and variability among mutant strains**

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The diatoms are important components of the phytoplankton community in the marine environment and account for 40% of the primary production in world oceans. The pennate marine diatom *Phaeodactylum tricornutum* accumulates a high content of eicosapentenoic fatty acid (EPA), which is commercially exploited as a nutraceutical. Chemical mutagenesis studies using ethyl methane sulfonate (EMS) were undertaken to improve the lipid content and the fatty acid profiles of the natural strain. The mutagenised diatom populations without selection pressure were screened using lipophilic fluorescent stains as proxy measures for intracellular lipids. Mutant cells with high fluorescent intensity were sorted using flow cytometry. In another approach, mutagenised cells were screened under the selection pressure of a metabolic inhibitor of fatty-acid synthesis enzymes. The surviving mutant colonies were grown and total lipids were extracted. Using these strategies, we have generated novel mutant strains with a higher lipid content in comparison to the progenitor wild type cells. Morphometric analysis of the mutant strains highlighted a significant decrease in the cell sizes of the mutant cells. Quantitative analysis of composition of the individual fatty acid composition is underway.

**Keywords:** *Phaeodactylum*, lipids, mutants

### **31. Monitoring *Cryptosporidium* in the Irish environment – A review of IT Sligo research**

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*Cryptosporidium* has been implicated in several recent Irish gastrointestinal epidemics. This protozoan parasite, is released as resistant oocysts from faeces of infected humans and animals. The widespread practice of agricultural slurry spreading and the release of wastewater end products to Irish river basins are environmental risk factors. Research on *Cryptosporidium* in the Irish aquatic environment has been carried by IT Sligo researchers on a number of waterbodies, constructed wetlands and wastewater treatment plants in the period 2003-2010. Wastewater and wetland samples were collected using long-handled samplers. Zebra mussels (*Dreissena polymorpha*), freshwater and marine mussels (*Anodonta* and *Mytilus edulis*) and hog-louse (*Asellus aquaticus*) were collected utilising hand, netting and snorkelling methods from various waterbodies for use as biomonitors of *Cryptosporidium*. In the laboratory, samples were pre-processed by homogenising and settling. Samples were then analysed using combined IFA (immunofluorescence antibody assay) and FISH (fluorescent in situ hybridisation) to determine presence of potentially viable oocysts. Overall, the results demonstrate long-term contamination of Irish waters with consequent public health risk factors for drinking-water abstraction and water-based activities. Environmental results will be highlighted for the current EPA STRIVE funded project, ‘Cryptosporidiosis human, animal and environmental interface’, which IT Sligo partners with UCD.

**Keywords:** *Cryptosporidium*, waterbodies, drinking water, public health

## **32. Assessing the carbon savings and carbon footprint of new cycling routes**

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Current commuting patterns in Ireland are unsustainable. 1.1 million people (58% of the commuting population) drive a car to work every day and only 36,000 people (2% of the commuting population) cycle. This is despite the fact that 30% of commutes are less than 5km – a reasonable cycling distance. To encourage a five-fold increase in cycling, the Irish government has introduced a range of measures including the establishment of a National Cycle Network (NCN). The NCN will be formed by a range of cycle route types including: (i) on-road; (ii) cycle lanes; and (iii) greenways (traffic-free cycle trails). The carbon emissions for an average Irish passenger car is approximately 160 g CO<sub>2</sub>/km and emissions from all Irish passenger cars totalled 5.8 million Tonnes CO<sub>2</sub> in 2009. This research quantifies the potential carbon saving of a fivefold increase in cycling. Adversely, the construction of new cycling routes, particularly greenways, has an associated carbon footprint, which has the potential to negate the carbon savings made by the modal shift of many commuters. This will be particularly relevant in rural areas where a greenway has been constructed (perhaps due to dangerous traffic and poor road quality), yet usage is low, i.e. the carbon footprint is distributed over few Passenger Kilometres Travelled. Carbon emissions from pavement construction are a result of the materials (asphalt/concrete, aggregate etc.), machinery, construction method, transport of materials, water and power used etc. This research models the carbon footprint of each cycling route type and determines the usage necessary to offset the carbon footprint of construction.

**Keywords:** Cycling, carbon emissions, pavement design

### **33. How can flamingos help us solve one of the greatest threats to human health?**

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The use of antibiotics has increased dramatically in recent years. With this has come an increase in the prevalence of antibiotic resistance, cited by the World Health Organization as one of the greatest threats to human health. Initially recognized as a problem within urban (i.e. clinical) environments, more recently, a large body of research has provided evidence of the spread of antibiotic resistant bacteria into natural environments. These natural environments serve as reservoirs for resistant bacteria, which can potentially be transferred to humans. The current research sought to investigate geographic variation in antibiotic resistance in natural environments by evaluating the prevalence of antibiotic resistant bacteria in wild Greater Flamingos across southern Europe. Using antibiotic disc-diffusion and MIC analyses, we obtained resistance profiles to eight antibiotics for bacterial isolates from Greater Flamingos at five sites. Resistant bacterial species were then identified by DNA sequencing. Our results, which indicate widespread multidrug resistance for several bacterial species, provide evidence of the extent to which European wetlands serve as reservoirs of antibiotic resistant bacteria. This research project now aims to explore the extent to which factors, such as land-use and landscape characteristics, drive antibiotic resistance in natural environments. The innovative methodology adopted by this research has used the Greater Flamingo as a sentinel to link wildlife, ecosystem, and human health, and has involved collaboration with experts from within each of these fields. This integrative approach is critical, as antibiotic resistance is a problem that will ultimately require the involvement of individuals from across many sectors. Indeed, looking forward, it is expected that this research will generate specific recommendations that will ensure the future health not of ecosystems, wildlife, or humans alone, but indeed, of all three.

**Keywords:** Antibiotic resistance, Greater Flamingos, Europe, One Health

### **34. Stakeholder participation in ecosystem-based marine spatial planning: The case of Canada's Eastern Scotian Shelf Integrated Management Initiative**

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Stakeholder participation is viewed as a key element of ecosystem-based marine management. There is much debate, however, over the effectiveness of participatory approaches to ecosystem-based management (EBM) in general and the form participation should take. A case-study of the Eastern Scotian Shelf Integrated Management (ESSIM) initiative, which has adopted a collaborative planning model to implement EBM, is presented in order to explore these issues further. A set of criteria, derived from a review of the collaborative planning literature, is employed to evaluate the effectiveness of this model. The ESSIM model is found to be a useful consensus-building tool, fostering links amongst a diverse range of stakeholders and nurturing social learning. Although a strategic level plan has been adopted, however, the initiative has encountered difficulties transitioning from plan development to plan implementation. These difficulties are attributable in large measure to deficiencies in the design of the collaborative model. Useful lessons relating to stakeholder engagement, the role of the lead agency, and implementation strategies are advanced for those engaging in coastal and marine management processes.

**Keywords:** Marine spatial planning, collaborative planning, stakeholder participation, ecosystem-based management, integrated ocean management

### **35. Integrating biodiversity impact assessment: A methodological approach**

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Impacts on biodiversity (broadly defined) need to be assessed under the EU's Habitats, SEA and EIA Directives, as well as under additional provisions such as the Water Framework and Environmental Liability Directives. Therefore, biodiversity impact assessment of plans, programmes and projects is required under various legislative remits to ensure that potential negative impacts in both protected and unprotected areas are efficiently identified in a timely manner, quantified and subsequently avoided or mitigated. The procedural requirements of these legal obligations vary; SEA processes, for example, evaluate potential flora and fauna impacts on designated and undesignated areas, while Appropriate Assessment (AA) under the Habitats Directive focuses on the detailed assessment of any potential effects on the qualifying features of designated European Natura 2000 sites. As a result, differing methodological steps, data gathering and processing methods, as well as impact assessment techniques, are commonly applied under each legislative requirement, often leading to uncoordinated assessment efforts and results (in terms, for example, of scale and assessment detail). The Irish Environmental Protection Agency has commissioned research into developing a national procedure termed Integrated Biodiversity Impact Assessment (IBIA). The overall aim of IBIA is to provide a spatially-specific methodology that integrates EU requirements for AA with SEA and EIA to enhance the efficiency of legal, administrative and operational procedures. This paper presents the draft IBIA methodology, describing the progress made in relating impact assessment domains, as well as exploring the key constraints to such integration and the anticipated benefits of its application.

**Keywords:** Soil organic carbon, measurement, modelling, GIS technique, upscaling

### **36. Invasive oysters alter native biodiversity and reduce the establishment of a protected biogenic habitat**

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Invasive species have been identified as a serious threat to global biodiversity, particularly in habitats of conservation value. The Pacific oyster, *Crassostrea gigas*, can form very dense populations affecting the abundance and distribution of native organisms through their physical structure and biological activities. *C. gigas* occurs in various habitats including intertidal boulder-fields, an important habitat for many species including the Honeycomb worm, *Sabellaria alveolata*, which creates habitats protected under Annex I of the EU Habitats Directive. Here an experiment was used to separate the effects of density, structure and activities of oysters on the development of assemblages on boulders. Increasing densities of living (biologically active) and dead (physical structure only) oysters were added to the tops of new boulders, deployed within an intertidal boulder-field and sampled through time. After 14 months, diversity, evenness and assemblage structure were all affected by oysters, with patterns differing depending on the density and state of oysters. Boulders with oysters, regardless of their density or state, supported more diverse and even assemblages, but boulders with the lowest density of living oysters had the greatest diversity and evenness. Assemblage structure was also altered by oysters regardless of their state. These differences were driven by changes to the establishment of a few key species including *S. alveolata*, which despite mainly establishing on the underside of boulders, was greatly reduced by increasing densities of oysters, regardless of their state. This work highlights the importance of understanding the different mechanisms by which invasive species can alter biodiversity and affect habitats of conservation interest.

**Keywords:** Invasive species, biodiversity, protected habitats, *Crassostrea gigas*, *Sabellaria alveolata*

### **37. Soils and subsoils as pathways for rainfall and diffuse contaminants reaching a river?**

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Diffuse contaminants with an origin on the land surface can make their way into rivers via a number of different pathways through the landscape, including overland flow, interflow, shallow groundwater flow and deep groundwater flow. Identifying the key pathway(s) that delivers contaminants to a river, and characterising the attenuation processes along them, is important for understanding water quality in rivers. Little is known about the interflow pathway in Ireland, and its relative importance in delivery of flow and contaminants to rivers. Interflow can include unsaturated or saturated (perched) flow in soils and subsoils, and may include flow through artificial field drains. Four test catchments are being monitored to gain insights into the interflow pathway. Flow and water chemistry is being sampled and used to identify the contribution of each pathway to the river. A range of soil monitoring equipment has also been installed in one catchment to measure the responses of the soil waters to rainfall, and the processes of development of overland flow and interflow. Results to date from a catchment in Co. Louth/Meath, which has low permeability soils, show that artificial field drains play an important role in the delivery of interflow to the river, both during and between rainfall events, depending on antecedent conditions. Research into characterising the delivery of contaminants along the interflow pathway is now being carried out. This project is part of the EPA Strive funded 'Pathways Project' which is developing a catchment management tool to assist catchment managers to implement targeted and cost-effective Programmes of Measures under the Water Framework Directive.

**Keywords:** pathways for flow and contaminants, water quality management, soils and subsoils

### **38. Changes in the hydrochemical conditions and ecological status of forested streams in Ireland: A reassessment of surface water acidification and future considerations.**

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In the 1990s, plantation conifer forestry was shown to exacerbate acidification in acid-sensitive regions of Ireland through increased interception of non-marine sulphur ( $\text{SO}_4^{2-}$ ) and nitrate ( $\text{NO}_3^-$ ) from anthropogenic sources. Ecological impact was severe in some areas, with the loss of acid-sensitive benthic macroinvertebrates (e.g. Ephemeroptera) in acid-sensitive catchments. Over the subsequent 20-years policy driven pressure has led to reductions in sulphur and nitrogen emissions. These reductions have been mirrored in the water chemistry of acid-sensitive surface waters throughout Ireland. However, our current research highlights the continuing occurrence of episodic acidification in acid-sensitive areas, although a change in acidic drivers seems to have occurred. Currently, stream acidity is predominantly driven by base cation dilution and organic acidity, with % forest cover still remaining a factor in the magnitude of pH change. Concurrently, our ecological research identifies seasonal shifts in 'impacted' conditions with temporal changes in the ecological status of forested streams. Key acid-sensitive taxa (e.g. Ephemeroptera) show periodic recovery even within high forest (> 50% cover) catchments. This complex ecological interaction between forestry, water quality and macroinvertebrate assemblages in acid-sensitive streams seems to relate to the combination of macroinvertebrate life cycle dynamics and preceding antecedent weather conditions. Ultimately, this study aims to provide current up to date information on forestry and surface water acidification in Ireland, leading to the development of potential mitigation measures reducing potential ecological impacts on Ireland's forested waterways into the future.

**Keywords:** anthropogenic pollution, benthic macroinvertebrates, streams

### **39. Adsorption characteristics of pharmaceuticals from water and wastewater using graphene and graphene oxide engineered materials**

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In recent years large amounts of pharmaceuticals are being detected in the aquatic environment and the normal sewage treatment plants are not able to remove these compounds efficiently. Adsorption by carbonaceous materials such as activated carbon and carbon nano-tubes is showing promise to remove pharmaceuticals from water and wastewater with no harmful by-products. As a new member of carbon-based materials, graphene and graphene oxide (GO) are showing potential as an alternative material for adsorption processes due to their planar structure, having functional groups, light weight, large surface area, and hollow geometry. The aim of this study is to investigate the feasibility; kinetics and efficiency of using Graphene, GO and GO immobilized on the surface of a common adsorbent to remove pharmaceuticals found in water. The process involves GO production from graphite through modified Hummer's method, chemical reduction of GO to graphene by hydrazine and thermal reduction at different temperatures. The next step is coating the product on the surface of porous materials such as alumina foam and glass beads to build an adsorption column. Famotidine and Amoxicillin were chosen as model pharmaceutical absorbates and their concentration was measured using HPLC techniques. Results indicate that this novel approach is capable of extracting different compounds rapidly with a higher efficiency than that of activated carbon and with the ability to thermally regenerate. The advantage of using graphene is the ability to remove hazardous compounds containing benzene rings in water and wastewater through strong  $\pi$ - $\pi$  interaction and high affinity to functional groups such as oxygen epoxies, carbonyl ( $=CO$   $C=O$ ), hydroxyl ( $-OH$ ) and phenols attached to both sides.

**Keywords:** Graphene oxide, Graphene, Adsorption, pharmaceuticals, HPLC

#### **40. Response of phosphorus loads to suspended sediment transport in the River Bandon**

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Suspended sediment is a key contributor to contaminant transfer within river/estuary systems. The relationship between the transport of suspended sediment and nutrient loading influences the behaviour and the sustainability of aquatic habitats and water quality. This paper quantifies the total suspended sediment and associated phosphorus loads transported on the River Bandon. As part of a structured field monitoring programme undertaken at the Curranure Gauging Station, grab samples have been collected periodically and tested for suspended sediment concentration (SSC), turbidity and five species of phosphorus; total phosphorous (TP), particulate phosphorus (PP), total reactive phosphorus (TRP), soluble reactive phosphorus (SRP) and soluble unreactive phosphorus (SUP). Results from analysis of the data indicate that turbidity is an excellent surrogate for suspended sediment concentration ( $R^2 = 0.984$ ). A strong relationship ( $R^2 = 0.806$ ) has been found between SSC and TP concentration with weaker relationships found for TRP ( $R^2 = 0.482$ ), SUP ( $R^2 = 0.413$ ) and SRP ( $R^2 = 0.403$ ). Turbidity may thus also be used as an indicator surrogate for TP. The particulate phosphorus (PP) is also strongly related to SSC ( $R^2 = 0.736$ ), with the fraction of PP within the TP varying to a maximum of 81%. The annual estimated and true suspended sediment loads for the full catchment are 126 kg/ha and 127.6 kg/ha respectively. The true annual phosphorus load has been quantified for each of the phosphorus species using linear regression techniques applied to the continuous data with loads as follows: TP = 41 tonnes per annum, PP = 18.2 tonnes per annum, TRP = 19 tonnes per annum, SUP = 22 tonnes per annum and SRP = 12 tonnes per annum. Annual phosphorus loads from the full catchment ranged from 0.2 to 0.67 kg/ha for the different species which is generally consistent with other Irish catchments.

**Keywords:** turbidity, suspended sediment concentrations, phosphorus, water, sampling, loads.

## 41. Putting the soils of urban Dublin on the map

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Existing information on the soils of urban Dublin derives from geotechnical site investigations, and point-sampling for chemical analysis in publicly-accessible areas. There is no soil mapping, classification, or description of urban-area soils equivalent to standard soil-survey descriptions available in rural areas. This study addressed the structural limitations that have prevented urban soil survey in Dublin. These include the absence of a suitable classification system; of appropriate descriptive terms for soil materials; of a suitable soil-landscape model to allow extrapolation from point observations; and of field observations of soils made with soil-survey motivation. Classification has been provided by the *World Reference Base for Soil Resources* (WRB), which introduced the term Technosol in 2006. Descriptive terms for urban soil materials follow the International Committee on Anthropogenic Soils (ICOMANTH) and WRB. A preliminary soil-landscape model is proposed relating soil materials to urban landforms, working from direct field observations. Preliminary soil-profile descriptions have been made. With these advances, a map of urban soils has been drawn for Dublin for the first time, applying the soil-landscape model through aerial photography and map interpretation. While the necessary fieldwork has yet to be done, the map and legend demonstrate that urban soils can be represented in ways that are compatible with rural, agriculturally-inspired soil survey, and that it is no longer necessary to leave the urban areas blank when mapping soils. This work facilitates the implementation of the proposed *Soil Framework Directive*, specifically in its concerns for soil sealing, reducing brownfields, and remediation. The continuation of the study will ultimately provide a sound basis for understanding Ireland's urban soils, in a way that is compatible with other soil surveys, and represents a primary resource inventory.

**Keywords:** Soil Survey, Urban, Dublin, Technosol, World Reference Base

## **42. Use of soil organism activity to assess sustainability in rehabilitated industrial residue in Ireland**

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In rehabilitated industrial residue areas the main restoration objective is to develop a sustainable natural ecosystem and to eliminate or amend undesirable properties, such as pH extremes. A key factor to a successful self-sustainable ecosystem is a continuous nutrient cycling system and an active soil community system. There is limited information on soil biological activity in decomposition and nutrient cycling in relation to rehabilitated industrial residues. In the present study plastic litterbags were used to monitor spatial and temporal variation in decomposition rates in a restoration chronosequence (0-8 years). In addition, physical and chemical soil analyses were carried out to characterise soil properties. Tullgren extraction was used to determine arthropod assemblages, and soil enzyme activity was also analysed. Preliminary results have shown promising signs of a self-regulating ecosystem with evidence of plant litter decomposition and the natural establishment of large invertebrates such as earthworms. This research has potential to determine the success of the rehabilitation process in an industrial residue and can be used to monitor the recovery of other disturbed and degraded sites.

**Keywords:** sustainability, process, industrial residues, self-regulated ecosystem, decomposition, soil enzymes

### **43. Assessing the use of EU focus groundwater vulnerability scenarios for Irish specific conditions**

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In Europe, the risk of groundwater contamination resulting from the use of pesticides is evaluated using nine vulnerability scenarios known as the *EU Focus Groundwater Scenarios*. However, these scenarios have been developed and have their basis in other European countries, which may not have the same soil climate or management practises as Ireland. This calls into question the suitability of EU focus scenarios to accurately represent Irish specific conditions and hence the accuracy of these models for use in Ireland. The aim of this study is to assess the applicability of these scenarios in Ireland and compare them to site specific scenarios based on Irish conditions. Two EU Focus models (PELMO and MACRO) were selected for this study; PELMO is easy and flexible in its manipulation, while MACRO is the only model based on macropore pollution movement. Preliminary results indicate significant overestimation of pesticide leaching for given sites using these FOCUS scenarios compared to models run with site specific conditions. Model parameterisation was conducted and trend analysis presented with the view to create a more suitable Irish specific scenarios to model solute leaching in Ireland.

**Keywords:** EU focus groundwater scenarios, MACRO

#### **44. Minimisation of phosphorus in the fermentation media of recombinant *Escherichia coli* producing a protein**

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Little consideration is traditionally given within the biotechnology sector to the potential environmental impacts of media ingredients unutilized during microbial fermentation. The main goal is the production of high cell (and hence product) yields. As media ingredients are usually relatively inexpensive they are often added in excess to actual cell growth requirements. This study investigated the scope for reducing the quantities of phosphorus present in both a complex (TB) and semi-defined (M9/YE) fermentation media used to culture a model *E. coli* strain constructed to produce a recombinant protein ( $\beta$ -galactosidase). Reductions of up to 70% of exogenously added phosphorus salts did not adversely affect biomass yields attained. Further reductions lead to a drop in mean dry cell weight recorded. This was particularly evident in the case of the semi-defined media, most likely due to reduced phosphate-mediated media buffering capacity. Removal of all exogenous phosphorus from TB media had little effect upon total recombinant protein expression levels achieved. Reductions greater than 70% of exogenously added phosphorus negatively affected product expression levels in the case of M9/YE media. Protein functionality, assessed by the kinetic parameters  $K_m$  and  $V_{max}$ , was not influenced by the type of media nor the phosphorus concentration present. Overall the results indicate that the phosphorus salts added to both types of fermentation media can be reduced by a minimum of 70% without adversely affecting the biomass yield, the recombinant protein yield or protein functionality. Such reductions would lead to significant phosphorus savings in the large-scale production of biopharmaceuticals and other proteins produced by genetic engineering in *E. coli*. Lower phosphorus levels would reduce the extent of fermentation waste stream treatment required and reduce the pollutive potential of the spent media while simultaneously decreasing the production costs and the rate of industrial utilisation of a finite natural resource.

**Key words:** Phosphorus, eutrophication, waste minimisation, biopharmaceutical

## 45. Zebra mussel control - An environmentally friendly approach

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Due to the invasion of zebra mussels in European and North American waters there is currently a need for an environmentally friendly mussel control method to replace chlorine and other control products currently utilised in drinking water plants and other infested facilities. Marrone Bio Innovations (MBI), an American company that develops natural pesticides, is commercialising a natural product, Zequanox<sup>TM</sup>, comprised of *Pseudomonas fluorescens* CL 145A that effectively controls zebra and quagga mussels. Dr. Dan Molloy, formerly of New York State Museum, discovered and demonstrated the efficacy of *P. fluorescence* CL 145A on zebra and quagga mussels. MBI is the commercial licence holder. A drinking water plant in Co. Sligo, with a zebra mussel infestation was selected for this research. Since 2009 they have used hypochlorite to control zebra mussel settlement in their three concrete water chambers. Although effective, chloramines are known to have undesirable environmental impacts. The objective of this study was to compare the efficacy of Zequanox<sup>TM</sup> and chlorine by running a biobox trial with Zequanox<sup>TM</sup> in conjunction with chlorine treatment at the plant. Three biobox flow through systems were set up outside the plant in April 2011. Three 15cm x 15cm PVC plates were inserted into each of these bioboxes and remained there until testing began in October 2011 to allow for natural juvenile mussel settlement on these plates. Three plates were also inserted into each of the plant's main chambers. Each week settlement was counted. In October 2011 MBI-401 was injected into these bioboxes while chlorine treatment took place in the water chambers. The settlement on plates in both locations was compared as well as mortality of adult mussels seeded in the bioboxes and the water chambers. These results provide important insights into zebra mussel control methods and potential future use of Zequanox<sup>TM</sup>.

**Keywords:** Zebra Mussels, Zequanox, drinking water plant, veligers, chlorine.

## **46. Impact of pig slurry amendments to control phosphorus losses in laboratory runoff boxes under simulated rainfall**

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If spread in excess of crop requirements, incidental phosphorus (P) losses from pig slurry applications to land can lead to eutrophication of receiving waters. The addition of amendments to pig slurry in targeted areas may help reduce the possibility of surface runoff of nutrients. They may also have the potential to enable higher rates of P application in areas of high pig density without impacting on P loss in runoff. The aim of this study was to evaluate the effectiveness of pig slurry amendments in reducing incidental P and suspended solids (SS) losses from laboratory runoff boxes under simulated rainfall. To do this, intact grassed soil samples, 100 cm-long, 22.5 cm-wide and 5 cm-deep, were placed in runoff boxes and pig slurry, or amended pig slurry, was applied to the soil surface. The amendments used were: (1) commercial grade liquid alum (8% Al<sub>2</sub>O<sub>3</sub>) applied at a rate of 0.88:1 [Al: total phosphorus (TP)] (2) commercial-grade liquid ferric chloride (38% FeCl<sub>3</sub>) applied at a rate of 0.89:1 [Fe:TP] and (3) commercial-grade liquid poly-aluminium chloride (PAC) (10% Al<sub>2</sub>O<sub>3</sub>) applied at a rate of 0.72:1 [Al:TP]. The grassed soil was then subjected to three rainfall events, each with an intensity of 10.3 ± 0.15 mm h<sup>-1</sup>, at time intervals of 48, 72, and 96 h following land application of slurry. The effectiveness of the amendments at reducing TP in runoff water were (in decreasing order): PAC (70 %), FeCl<sub>3</sub> (58%) and alum (50%). However, TP levels in runoff remained above those from soil only, indicating that, although incidental losses can be mitigated by chemical amendment, chronic losses cannot be reduced. The amendments were in the same order when ranked for effectiveness at reducing SS: PAC (74%), FeCl<sub>3</sub> (66%) and alum (39%).

**Keywords:** phosphorus, pig slurry, amendments, runoff

## **47. LCMSMS analysis of pharmaceuticals in the Irish aquatic environment and their potential to bioconcentrate and bioaccumulate up the food chain**

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An increased demand for pharmaceuticals in recent years has led to their emergence as environmental micropollutants. These novel contaminants, which include non-steroidal anti-inflammatory drugs (NSAIDs), anti-lipemic drugs, anti-biotics and anti-epileptics, are resisting water remediation techniques carried out currently in Irish wastewater treatment plants (WWTPs), thus being released into receiving waters where they can be found at concentrations in the high ng/L to low ug/L range. Some marine organisms may be used as indicators for water pollution due to their filter feeding abilities. Low levels of lipophilic pharmaceuticals, continuously absorbed into the fatty tissue of mussels, can bioconcentrate over time and result in subsequent toxicological effects for the mussel and potential for pharmaceutical bioaccumulation. The objective of this project is to investigate the bioavailability of a range of highly prescribed pharmaceuticals in Ireland. A twelve month *in situ* study was carried out, exposing previously uncontaminated mussels to two different sources of wastewater effluent. Qualitative and quantitative pharmaceutical analysis was carried out on seawater, effluent and mussel samples collected using solid phase extraction (SPE) followed by reversed phase LC separation (Waters Sunfire C<sub>18</sub> 3.5 µm 2.1 mm x 150 mm column, gradient elution using an acetonitrile:water mix with 0.1 % ammonium acetate) with ESI-MS/MS detection. Preliminary Results show that Gemfibrozil, Diclofenac, Mefanamic acid, Trimethoprim, Nimesulide, and Salicylic acid were detected in treated effluent samples from Ringsend sewage treatment works. The ability of pharmaceuticals to bioaccumulate up the food chain with the potential for human exposure will also be investigated. This will be accomplished by assembling a simple food chain model e.g. algae-mussel-fish, for *in vivo* testing. Also, a direct comparison of contaminated uncooked and cooked mussels will highlight the human risk, if any, to pharmaceuticals in the environment.

**Keywords:** pharmaceuticals, aquatic environment, bioaccumulation

#### **48. Hospital effluent is a source of quinolone residues entering municipal wastewater systems**

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A proportion of therapeutic antimicrobial agents administered to patients are excreted unchanged or in the form of active metabolites in urine and faeces and enter the sewage system in hospital effluent. In Ireland wastewater containing hospital effluent generally is subject to secondary wastewater treatment (SWT) prior to its release into the general environment. The objective of this study was to assess the levels of fluoroquinolones in hospital effluent, in municipal effluent, and the environment impacted by hospital effluent. Over a period of two years, 215 effluent/seawater samples were collected from 18 sample sites. The samples sites include; hospital effluent from a large capacity hospital H1 and a smaller capacity hospital H2 and municipal effluent upstream (UH1 and UH2) and downstream of both hospitals (DH1 and DH2). Samples were taken from municipal effluent entering and at various stages through two SWT facilities (one of which received hospital effluent) and from the sea nearby the outflow point from the SWT facility. Quinolone like activity was detected by a biological assay and the specific fluoroquinolone compound ciprofloxacin was detected by high performance liquid chromatography with mass spectrometry (HPLC/MS). Fluoroquinolone like activity was detected in H1 effluent at estimated levels corresponding to 0.5 µg/L to 7.27 µg/L of ciprofloxacin and in DH1 effluent from 0.05 µg/L to 0.54 µg/L. HPLC/MS confirmed the presence of ciprofloxacin in H1 and DH1 samples; however we have not been able determine the quantity with any degree of precision. No fluoroquinolone like activity was detected in any other effluent thus indicating that antimicrobial residues do not persist in the municipal wastewater system. Hospital effluent may be a significant source of fluoroquinolone agents entering the environment. As ciprofloxacin is undetectable in setting other than hospital effluent it is unlikely to be present in the environment at levels that directly impact on human health however an indirect impact through selection for resistance determinants in the environment cannot be excluded.

**Keywords:** Antimicrobial agents, wastewater, hospital effluent

#### **49. Quantifying particulate matter pollution exposure and relative change in heart rate variability in commuter groups**

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Exposure to particulate matter (PM) air pollution has been linked to cardiovascular morbidity and mortality. Consistent links between PM exposure and decreased heart rate variability (HRV) have been documented in studies of older, susceptible individuals and those with existing cardiovascular conditions. The relationship is not as clear in young healthy adults. This study quantitatively assesses the relative variation in HRV with PM exposure of young healthy cyclists, pedestrians, bus users and train users performing differing levels of physical activity and having differing physiological states. Personal PM<sub>10</sub> exposure, HRV and activity level were monitored simultaneously over 24 hour periods using ambulatory devices. Linear mixed models were used to examine exposure and cardiac response relationships. Increased PM<sub>10</sub> exposure was found to have a significant association with increased heart rate in 24-hour samples ( $\beta=0.065$ ,  $p<0.001$ , 95% CI: 0.051, 0.080) and in commuting intervals ( $\beta=0.033$ ,  $p<0.05$ , 95% CI: 0.013, 0.054). Elevated PM<sub>10</sub> exposure had significant ( $p<0.05$ ) associations with decreased HRV in 24-hour samples ( $\beta=-0.155$ , 95% CI: -0.238, -0.071) and during commuting periods ( $\beta=-0.120$ , 95% CI: -0.190, -0.050). Covariance structures identified this inverse exposure-HRV relationship as strongest in pedestrians and cyclists but they also had the highest baseline HRV. Activity level was significantly ( $p<0.001$ ) inversely related to HRV ( $\beta=-0.128$ , 95% CI: -0.138, -0.119) in all groups. However, covariance structures identified activity as having the strongest positive impact on pedestrians and bus users HRV in 24-hour samples and the largest adverse effect in cyclists HRV in commuting intervals. The results suggest that higher overall activity levels can improve general HRV but cause a temporary decline in HRV while commuting. The findings indicate that daily exercise while commuting has an influence on fitness and cardiac health which counteracts the adverse health effects of particulate matter exposure in pedestrians and cyclists.

**Keywords:** air pollution, particulate matter, heart rate variability, commuting

## 50. Ragwort: An agricultural nuisance or potential medicinal wonder!

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Ragwort (*Senecio jacobaea*) has long been identified as a threat to Irish horse breeders and farmers due to the toxic effects suffered by livestock when ingested. Legislation (Noxious Weeds (Thistle, Ragwort and Dock) Order, 1937) is in place enforcing the removal of all traces of ragwort from fields where livestock are grazing. Severe penalties can be handed down to any farmers and/or breeders who allow ragwort to flourish. However, from a medicinal point of view, folk remedies suggest the use of ragwort extract as an external treatment for ulcers and wounds as well as a rinse for throat infections indicating an antimicrobial aspect to some compound(s) found in the plant (MacCoitir, 2008). The question is, are the medicinal properties of this plant due to a single compound or family of compounds? New research conducted at the Limerick Institute of Technology has shown that ragwort has the potential to become an economically viable commodity. Wild ragwort has been found to contain large quantities of antioxidants, specifically polyphenols, which provide a wide variety of medicinal properties. Studies using the Oxygen Radical Absorbance Capacity (ORAC) assay, and a series of different extraction solvents, have shown that ragwort contains between 18 and 85 $\mu$ M Trolox equivalents per gram ( $\mu$ M TE/g) of fresh plant material. Upon further analysis of these samples, it was found that these samples contained large quantities of polyphenols in the ranges of 280-2900 Gallic acid equivalents per gram of fresh plant material. These figures suggest that ragwort contains similar antioxidant activities to that of common vegetables e.g. peas (19  $\mu$ M TE/g), carrot (60 $\mu$ M TE/g), white cabbage (61 $\mu$ M TE/g), tomato (67  $\mu$ M TE/g), snap bean (79  $\mu$ M TE/g) and white onion (85  $\mu$ M TE/g) (Ou et al., 2002).

**Keywords:** Ragwort, Antioxidants, Medicinal properties, Polyphenols

## 51. Adsorption-desorption processes and mobility of different pesticides in agricultural Irish soils

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The use of pesticides in the agricultural environment is of great relevance today because of adverse effects on human health and ecosystem function due to dispersal to non-target organisms. Sorption is one of the most important processes controlling the fate of any chemical in the soil and its estimation is required for many models used to predict the fate of any pesticide in the environment. Two different commonly used pesticides have been studied using the batch equilibrium method: (1) chlorothalonil and (2) MCPA. Chlorothalonil is an organochlorine, non-polar, non-systemic foliar fungicide, applied for the control of fungal diseases in different commodities. MCPA is an aryloxyalkanoic acid, systemic, polar herbicide used for post-emergence control of annual and perennial broad-leaved weeds in a range of crops, in grasslands and also to control aquatic broad-leaved plants. Chlorothalonil sorption data fit the Freundlich and the linear model very well ( $R^2 > 0.99$ ). The adsorption of chlorothalonil was affected by its concentration in the solution that caused a decrease in available sorption sites when chlorothalonil concentration increased. Between 3 and 8 % of adsorbed chlorothalonil could be desorbed in a single desorption step, meaning that there is a strong binding of chlorothalonil in the soils. The organic carbon coefficient ( $K_{oc}$ ) ranged from 979 to 2363 L kg<sup>-1</sup> indicating slight to low mobility of chlorothalonil in the soils studied. MCPA adsorption data gave better fit with the linear model ( $R^2 > 0.999$ ), although the fit to the Freundlich model for adsorption and desorption was very good ( $R^2 > 0.99$ ). MCPA adsorption was almost linear for the soils studied meaning that there was a constant partitioning of the solute between the solution and the adsorbent. MCPA was easily desorbed from the soils compared to chlorothalonil as over 30% of adsorbed MCPA was desorbed. Unlike chlorothalonil, MCPA had high to very high mobility in the soils studied ( $K_{oc} = 41$  to 107 L kg<sup>-1</sup>), meaning that the risk of groundwater contamination is high but strongly adsorbed chlorothalonil may pose a risk of surface water contamination. This study also showed that tillage soils offer less protection to both surface and ground waters.

**Keywords:** sorption isotherms, pesticides, chlorothalonil, MCPA, environment

## **52. Degradation of polycyclic aromatic hydrocarbons (PAHs) by soil microorganisms**

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Polycyclic aromatic hydrocarbons (PAHs) are toxic compounds composed of at least two benzene rings in various configurations. They are released to the environment mainly through incomplete combustion of fossil fuels and are associated with soils surrounding manufactured gas plants and coal and gas liquefaction sites. Microorganisms capable of degrading PAHs have been found at most contaminated sites and strategies stimulating PAH-degradation by the innate microbial community have been employed with varying degrees of success. It is difficult to predict the outcome of bioremediation, as results vary from site-to-site due in part to differences in soil composition. It has been suggested that plant-bacterial interactions in the rhizosphere may increase rates of PAH degradation and may also have an effect on bacterial community structure. The aims of this research were; (1) to determine the effect of PAH contamination on bacterial communities in soil (2) to examine the effect of soil structure on PAH degradation and the microbes that degrade them and (3) to determine the effect of plant roots on bacterial communities and degradation of PAHs. Microcosm experiments were set up; one in which a range of PAHs were added to soil, one in which soil composition was altered and another in which PAH-contaminated soil was planted with *Lycopersicon esculentum*. PAH degradation and microbial growth were measured over a time course and 16S rDNA fingerprinting was used to assess changes in microbial communities. Results indicated that microbial communities were altered by PAH contamination in soil, that soil composition affected both the rate of PAH degradation and bacterial community structure and that rates of PAH degradation and bacterial community dynamics were altered in the rhizosphere.

**Keywords:** PAHs, microbial ecology, phytoremediation, TRFLP, ARISA, bioremediation

### 53. Estimating silver eel *Anguilla anguilla* production on the River Shannon

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The European eel (*Anguilla anguilla*) is undergoing a population collapse throughout its range. EU legislation (EC No.1100/2007) aims to increase the biomass of potential spawners (*i.e.* silver eels) leaving continental waters, through locally-implemented Eel Management Plans (EMP). On the hydropower-regulated River Shannon, the EMP specifies closure of the commercial eel fishery, and implementation of a silver eel ‘trap and transport’ programme. Accurate silver eel production estimates are therefore essential to assess the impact of hydropower on eel populations, and to enable post-evaluation of conservation actions (*e.g.* stock enhancement, fishery closure). Annual silver eel production on the River Shannon (for the area upstream of the hydropower dams) was estimated for the period 2008–2012. This involved incorporation of mark-recapture experiments at the lowermost fishing site (Killaloe eel weir) with silver eel catch data (Killaloe and upper catchment). In addition, a novel eel counting protocol using a DIDSON sonar camera was developed during a 17-day closure of Killaloe eel weir caused by extreme floods in 2009. The biomass of eels captured annually on the River Shannon was 25.0–28.4 t (10.5–12.7 t at Killaloe and 13.0–16.7 t in the upper catchment). A potential catch of 3.8 t was estimated by DIDSON observations at Killaloe during the closure in 2009. The Killaloe mark-recapture experiments indicated a capture efficiency of 20.8–25.0%, giving an annual silver eel production estimate of 67–90 t, considerably lower than 1980s levels (*c.* 140 t.yr<sup>-1</sup>). The current silver eel productivity of the River Shannon was estimated at 1.6–2.1 kg.ha<sup>-1</sup>, lower than some other Irish (*e.g.* Lough Neagh; 4–4.6 kg.ha<sup>-1</sup>) and European river systems. It seems that eel stock recovery is unlikely to occur in Ireland in the short to medium term due to the recruitment collapse.

**Keywords:** European eel, conservation, productivity, hydropower, mark-recapture

## 54. Impact of sediment discharges from quarries on macroinvertebrate populations in upland rivers – A case study

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Quarrying activities generate large quantities of fine sediments that are spread from the point of origin to other areas either by air, or in suspension with water. Through different pathways, a large amount of these sediments are transported to surrounding watercourses. The addition of one-off, short duration of fine particulate material to freshwater ecosystems, while not desirable, is unlikely to have any lasting adverse impacts. However, continuous high levels of sediment input may completely change the natural faunal assemblage. While a river's sediment augmentation has been profusely studied regarding geologic and physical-chemical effects, the impacts of quarry discharges in natural streams are less well studied. Through case study research in Portugal, the impact of quarry discharges on the ecological status of nearby watercourses was studied and this research forms the basis of this paper. The work used benthic macroinvertebrates as an indicator community and by recording physical-chemical characteristics and macroinvertebrates in three zones of three watercourses the impacts were assessed. Zone 1 in each stream was the zone directly influenced by a quarry discharge; Zone 2 was the area upstream of the discharge points (used as reference) and Zone 3 was downstream from the discharge points and was not affected by other anthropogenic river impacts. Conductivity, Total Solids and Total Suspended Solids were the main physical-chemical characteristics contributing for the disturbance. Macroinvertebrate sampling identified a depletion on abundance and diversity indices downstream of the quarry discharges and multivariate analyses has identified clear differences among invertebrates assemblages. Furthermore, downstream sites were shown to be largely dominated by the *Potamopyrgus* - an invasive species. This study shows that there are direct and indirect ecological impacts caused to streams by effluent discharges from quarries.

**Keywords:** disturbance, fine sediment, granite, macroinvertebrate, quarry, stream

## **55. Biodiversity and conservation potential of aquatic buffer zones in Irish forestry**

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In 1991, the Forest Service in Ireland introduced the Forestry and Fisheries Guidelines which stipulated the establishment at forest planting of aquatic buffer zones (10 – 25 m in width) in riparian zones along all rivers, streams and brooks within the national forest estate. Aquatic buffer zones (ABZs), established and managed using current best practice, play an important part in conserving and expanding woodland and other habitat biodiversity, in addition to protecting water quality and associated terrestrial and aquatic biota. To assess the biodiversity and conservation potential of ABZs in Irish forests, habitats within afforested and reforested conifer sites, and native woodland in addition to upland controls were investigated across six different soil types (peat, peaty podzols, peaty gley, well-drained mineral, mineral gley and mineral alluvium). Habitat type and condition were recorded along 300 metres of the ABZ and classified according to previous studies. Habitat richness was highest for control (semi-natural woodland and upland) sites and lowest for reforested sites. This suggests that the length of time since establishment of the ABZ is an important factor for diversity, as those in reforested sites are generally younger than in afforested or control sites. There was no difference in habitat richness between peat and mineral soils for control sites. However for afforested sites, peat soils recorded higher habitat diversity, whereas on reforested sites mineral soils were more diverse. Six habitat types (i.e. semi-natural woodland, non-native woodland, semi-natural grassland, fens, bogs, and heaths) were common to all forestry types, with wet grassland (6410), dry siliceous heath (4030) and wet heath (4010) being EU Annex I habitats. Preliminary results from this research indicate that the implementation of ABZs enables a diverse range of habitats to be retained and to become established, increasing the biodiversity and conservation potential of commercial conifer forests in Ireland.

**Keywords:** aquatic ecosystems, aquatic buffer zone, conifer forests plantations, habitat diversity, native woodlands

## **56. Factors influencing the ground vegetation diversity of two successive rotations of non-native conifer plantations**

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Forestry plantations have the potential to add to the biodiversity of an area and Sustainable Forest Management (SFM) promotes the enhancement and conservation of biodiversity in plantations. In Ireland and Britain afforestation rotation stands, the first plantation in a previously unwooded area, are increasingly reaching commercial maturity and being clearfelled. Subsequent replanting of these areas means an increasing proportion of many forest estates are reforestation rotations, however, the biodiversity potential of reforestation is underrepresented in published literature. This research, undertaken in Ireland, investigated ground vegetation diversity (species richness) during the structural development stages in reforestation Sitka spruce (*Picea sitchensis*), and compared results from a previous afforestation study. Trends in total species richness were high during early stages, decreased to a minimum during closed canopy mid-rotation stages, but increased again as the canopy reopened during mature stages. Total typical woodland species richness increased significantly over each forest cycle; however, expected gains of typical woodland species richness in reforestation compared to afforestation were not found. Despite very different starting points for both rotations in terms of community composition, there was floristic convergence between them over the forest cycle. Diversity indicators identified for both rotations by modelling were canopy cover, rotational stage, area of old woodland within 1km and soil pH. Also for vascular diversity there was an interaction between canopy cover and area of old woodland and, for bryophytes between canopy cover and coarse woody debris volume. These results suggest that for plantations to support more typical woodland species, thinning should occur earlier and more regularly preventing canopy closure and deadwood should be retained after thinning and felling. This research supports the improvement of environmental quality, in terms of increasing the diversity of woodland species in plantations, and it supports policy, by offering scientific support for environmental policies in Irish forestry.

**Keywords:** Forest plantation ground vegetation, biodiversity, reforestation, Sustainable Forest Management, clearfell

## **57. Computational modelling of invasion dynamics to better inform future control strategies for invasive species *Spartina anglica***

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Biological invasion is one of the principal environmental problems influencing future economic and social development in the world. Invasive non-indigenous plant species can have serious detrimental effects on local ecosystems, and costly control efforts often have to be put in place to protect habitats. It is important to gain a greater understanding of the ecosystem dynamics affecting invasion in order to be able to manage this phenomenon and minimise the economic and environmental costs associated with mechanical/chemical control treatments. One example of an invasive problem on a global scale is the species *Spartina anglica* a rhizomatous perennial salt marsh grass that forms extensive meadows via clonal growth in inter-tidal zones. *S. anglica* appeared in Britain in the late 19<sup>th</sup> century as the result of a hybridization (F2 generation) between *S. maritima* and introduced *S. alterniflora*. Since then, the spread of *S. anglica* has drawn much concern due to its ability to convert coastal habitats into cord-grass monocultures thus altering native and commercial food webs and threatening natural biodiversity. Our research involves applying computational models of coastal ecosystems to better inform strategies for control of invasive plant species and understand ecosystem dynamics. We have developed an individual-based model of *S. anglica* to investigate its patterns of growth and dynamics in coastal habitats. The model can be used to simulate the development of invasive *S. anglica* over two spatial scales: local vegetative spread due to rhizomatous growth, and long distance dispersal via seeds. We use this model to analyse the impact of factors such as the shape/pattern of colony development on invasion dynamics, and the respective roles of clonal growth and seed dispersal on their performance. We also analyse the impact of different spatial strategies for control/eradication of *S. anglica* populations in order to be able to better inform rational control strategies.

**Key words:** Invasive Species, Modelling, Coastal Ecosystem, *Spartina anglica*

## 58. Natural regeneration of native woodlands on conifer clearfells at the People's Millennium Forests

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The People's Millennium Forests project conducted woodland restoration at sixteen sites nationwide, planting a tree on behalf of every household in Ireland, some 1.2 million trees. At four of these sites, areas of conifer clearfell were allowed to regenerate naturally rather than being planted. A long-term ecological monitoring project was initiated in 2003 to study the natural regeneration process by establishing a 200 m transect at each site. Along each transect a series of 5 m x 5 m plots was used to record vegetation, regeneration, carabid beetles, soil data and fixed-point photography. A resurvey of the transects was conducted in 2009. Two of the sites have been securely fenced against deer and at these sites there has been vigorous regeneration. The Coill an Fhaltaigh site has developed from clearfell dominated by *Juncus effusus* to a *Salix cinerea* and *Fraxinus excelsior* thicket stage with abundant *Rubus fruticosus*. The Rosturra site has developed from sparsely vegetated clearfell with ruderal species to a dense thicket of *Betula pubescens*, *Alnus glutinosa* and *Ulex europaeus*. The other two sites have not been securely fenced against deer and at these sites there has been little change in vegetation. The Ballygannon site, that had already developed to birch woodland by 2003, is aggrading. A substantial part of the Cullentra site has remained heathland dominated by *Calluna vulgaris* and the majority of regeneration is of non-native conifer species. In terms of future policy, the project demonstrates that natural regeneration can be used to rapidly establish native woodlands on clearfell sites in the absence of browsing animals. However, regeneration of non-native species from surrounding forestry is an issue that needs monitoring and appropriate action.

**Keywords:** natural regeneration, long-term monitoring, vegetation analysis

## **59. Development and comparison of groundwater source contamination susceptibility models in four rural areas of Ireland**

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A study of 211 private wells across four study areas in the Republic of Ireland was undertaken during the 3-year period 2008-2010. The microbial quality of groundwater was assessed using the presence of *E. coli*. Assessment of potential risk factors was undertaken at each source, while relevant meteorological data were also acquired. In all, just under 30% of sampled private sources (n = 62) tested positive for *E. coli* during the study. Hierarchical logistic regression with stepwise parameter entry was used to develop four area-specific source susceptibility models. All models were developed and refined in order to predict *E. coli* presence/absence with good accuracy (>85%). The only potential risk factor common to all area-specific models was the vicinity of (point or non-point) agricultural activities within a 100 m radius of the wellhead. The system variability elucidated by this risk factor accounted for between 8% (high vulnerability area underlain by limestone/sandstone) and 22% (high vulnerability area underlain by mixed bedrock types). Septic tank proximity (setback distance and gradient with respect to the wellhead) was a significant risk factor within three of four developed models, accounting for 16-39% of system variability. Additionally, where well design/construction was a significant risk factor, it accounted for a high level of variability (13-45%). Notably, well design/construction accounted for 45% of variability within the assessed low vulnerability area, which may suggest direct contaminant ingress at the wellhead as a significant contamination mechanism within areas characterised by relatively thick layers of low permeability subsoils. Local precipitation was also a significant factor within two of the four models, accounting for up to 34% of model variability. The results of this study indicate that a significant proportion of private well contamination in Ireland is “source-specific”. Therefore, these findings may be used to produce management tools, which may aid in decreasing current levels of private well contamination.

**Keywords:** *E. coli*, Statistical Modelling, Contamination, Groundwater, Health

## **60. Assessment of disposal options for treated wastewater from single houses in low permeability subsoil**

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In Ireland, it is often assumed that septic tanks with old soakaways are a major source of pollution and yet very few studies have set out to quantify the effect of the 440,000 septic tanks located throughout the country. Through this study the performance of six traditional septic tank soakaways will be monitored across a range of subsoils: two in areas of high permeability, two in moderate and two in low permeability subsoils. The aim of the project is to determine the chemical and microbiological pollutant attenuation in the subsoil of these existing septic tank soakaways with respect to groundwater and surface water pollution. The selected sites will be monitored for 12 months with the effluent passing through the subsoil being sampled on average once per month at a range of depths by the suction lysimeters. All samples will be analyzed for a range of chemical and microbiological determinants. Soil moisture potential measurements will be made at the same depths in the subsoil, whilst rainfall data and other meteorological parameters will be measured to determine the effect of recharge at different times of the year on the effluent concentrations with depth. The second stage of this project will focus on the issue of onsite wastewater disposal in areas of low permeability. Design criteria will be developed for two alternative wastewater disposal options, drip dispersal and low pressure pipe distribution systems. Both of these systems are shallow, pressure-dosed wastewater distribution systems consisting of a network of small diameter pipe work. It is hoped that these systems will provide a solution for householders with onsite wastewater disposal in low permeability areas thus aiding in the protection and improvement of water quality in Ireland.

**Keywords:** Septic Tanks, Subsoil, Water Quality

## 61. The transport of bacterial pathogens in on-site wastewater effluent disposal systems

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The domestic wastewater of over 1/3 of the population in Ireland is treated by on-site treatment and disposal systems. The inefficient disposal associated with these systems means the generated effluent load can leak into local waterways and promote the outbreak of disease by human enteric pathogens associated with faecal contamination of water sources. This project aims to confirm by microbial source tracking (MST), the source of faecal microorganisms detected in groundwater, surface water and effluent samples, and to monitor the transport of specific pathogens to wastewater outflows. MST is routinely employed to determine the environmental health risks associated with faecal pollution in watershed areas. MST markers based on host-specific *Bacteroidales* bacteria for human, cow, dog and horse-derived faecal matter are being employed to determine quantitative target occurrence using real-time Polymerase Chain Reaction (qPCR) assays. In combination with MST, the diversity and abundance of both archaeal, bacterial 16sRNA and functional nitrification and denitrification genes (i.e., *amoA*, *nirS*, *nirK*, *qnorB*, *cnorB* and *nosZ*) will be determined and compared in all sites, with a view to reduce nitrate loading to local water-ways. Experimental sites of low permeability subsoil have been selected and are located in Co. Monaghan and Co. Kilkenny. These specific sites are monitored before and after remediation to determine if any variation occurs though the physical, chemical, and microbiological analysis of water sampled using suction lysimeters located at various depths (1.8m; 1.4/1.5m; 1.2m). Initial results indicate the successful development of a DNA extraction method applicable to both sites. Also, the physio-chemical data varies with lysimeter depth between sites. Ultimately, this novel project aims to assess the effectiveness of remediation at reducing pathogen transport to local ground and surface waters.

**Keywords:** qPCR, Microbial Source Tracking, domestic effluent, pathogens

## **62. An assessment of the environmental supporting conditions for groundwater-dependent terrestrial ecosystems (GWDTEs) within the context of groundwater body classification**

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The EU Water Framework Directive and associated Groundwater Directive demand the protection of groundwater for its environmental value in addition to its protection as an important resource. We must ensure that all groundwater bodies (GWBs) maintain good groundwater quantity and quality and the status of each GWB must be classified as either 'good' or 'poor'. As part of this classification process, a series of chemical and quantitative status tests must be applied to GWBs identified as at risk from anthropogenic pressures. Assessments of GWB-mediated significant damage to Groundwater Dependent Terrestrial Ecosystems (GWDTEs) are an essential component of these status tests. GWDTEs are habitats that occur where the water table is at or near the surface of the ground and they directly depend on groundwater for a significant proportion of their water supply. Work to date has identified major information deficiencies in relation to assessing significant damage to GWDTEs and consequently the status tests have been applied to only a few sites. This project was commissioned by the Environmental Protection Agency to inform the development of appropriate status tests relevant to GWDTEs and to highlight knowledge gaps. The GWDTE types under investigation by the project include alkaline fens, cladium fens, transition mires, petrifying springs, turloughs, active raised bogs (lagg zone), blanket bog flushes, wet heaths, machair and alluvial forests. The project aims to improve the conceptual ecohydrogeological understanding of these GWDTE types using cross-section schematic diagrams and associated narratives for illustrative and descriptive purposes. In relation to groundwater quality, we are currently identifying GWDTE sites with hydrologically linked groundwater and drinking water monitoring points as part of an attempt to determine trigger and threshold chemical values for GWDTEs using similar methodology to that being explored in the UK. Finally, we will also propose a methodology to determine groundwater flow and/or water level standards for a range of GWDTE types.

**Keywords:** Groundwater-dependent terrestrial ecosystems, Water Framework Directive, groundwater bodies, significant damage

### **63. A paleolimnological investigation of a series of lakes in County Monaghan**

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A deterioration in ecological and physico-chemical conditions has been recorded in a number of shallow lakes in County Monaghan, despite the objectives of the Water Framework Directive. Thus, further research is needed to determine the drivers of this deterioration, which in turn will advance the limited knowledge on shallow Irish lakes. In addition, many of these eutrophic lakes are used as a source for drinking water abstraction, regardless of the associated treatment costs and human health concerns. This project is investigating four lakes located in Co. Monaghan, all of which are used for drinking water purposes by their local Group Water Scheme (GWS). Three of these lakes (Baird Shore, Killcorran Lough and Moynalty Lough) are exposed to agricultural activities, while Lough Antraicer is an upland lake with limited catchment pressures. Due to a lack of historical limnological data, a paleolimnological examination of these lake's sediments has been carried out.  $^{137}\text{Cs}$  and  $^{241}\text{Am}$  were measured by gamma spectrometry to determine sediment chronologies. Biogenic silica (BSi) and gross pigment measurements were analysed as proxies for lake productivity, whilst sedimentary total phosphorus (TP) and diatom inferred TP (DI – TP) were examined to relate changes in primary production to nutrient loading. Trace metals including iron (Fe), manganese (Mn), magnesium (Mg), potassium (K) and copper (Cu), in conjunction with carbon (C) and nitrogen (N) was analysed to determine whether nutrients were of autochthonous and/or allochthonous origin. An evaluation of results to date has indicated that substantial increases in external TP loading has occurred in the lower altitude lakes over recent years. In comparison, TP concentrations for the upland lake, Lough Antraicer, are low and have remained stable over time. In cores where TP concentrations were found to increase over time, corresponding increases in total chlorophyll and total carotenoid concentrations have also been recorded. By comparing this data to past and present land use activities, information can be provided which can be used to aid catchment management and source protection strategies in terms of the WFD.

**Keywords:** paleolimnology, eutrophication, diatom, source protection

#### **64. *Cryptosporidium*, *Giardia* & faecal indicator bacteria: Observations on their occurrence, abundance & relationships in wastewater treatment plants (WWTP's) in Northwest Ireland**

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The transmissive stages of the parasitic protozoans *Cryptosporidium* and *Giardia* were isolated and identified in two major wastewater treatment plants (WWTP's) in the northwest of Ireland. Along with these protozoans, a suite of indicator bacteria including *Escherichia coli*, *Clostridium perfringens* and faecal *Enterococci* were also enumerated. Samples from primary influent, final effluent, liquid-sludge and sludge-cake were taken over a period of twelve months. *Cryptosporidium* oocysts and *Giardia* cysts were detected and enumerated via fluorescence microscopy, after incubation of the samples with FITC-conjugated monoclonal antibodies (mAbs) specific to each genera. 4'-6-Diamidino-2-phenylindole (DAPI) and Propidium iodide (PI) were used in aiding the determination of the cyst/oocyst integrity and hence viability as an infective agent. Indicator bacteria were enumerated using standard pour-plate methods. Raw-data displayed a high degree of variation in terms of the numbers of protozoan transmissive stages present in the samples over time, with the majority of cysts/oocysts concentrated in the sludges. However, definite temporal peaks, both in terms of positive sample percentage and in sheer numbers of parasites counted per sample, were identified. The utility of indicator bacteria in predicting these peaks in the future (and hence possible risks to human health) was investigated also, with varying results but little readily apparent application. Overall, the two organisms with most in common in terms of distribution (physical and temporal) and abundance were the two protozoans themselves. This, along with an ability to withstand the activated sludge process better than its apicomplexan counterpart and a larger and more readily identifiable transmissive stage, has led to the conclusion; *Giardia* should not be neglected in future research, and should be a possible candidate "indicator organism" in its own right, should future health/environmental policy demand the need for the surveillance of similar protozoan parasites, including *Cryptosporidium*, in WWTP's with less ambiguity.

**Keywords:** *Cryptosporidium*, *Giardia*, wastewater treatment, *Escherichia coli*, *Clostridium perfringens*, *Enterococci*

## **65. Genetic variation of common carp (*Cyprinus carpio*) in Irish waters**

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Common carp *Cyprinus carpio* are an introduced fish species in Irish freshwaters, having been present since at least the early 17<sup>th</sup> century. Their distribution has expanded substantially in recent years, due to an increased interest in recreational angling. Despite this, there has been little scientific study on Irish carp. Genetic data are now considered a necessary prerequisite to effective ecological study, fisheries management and conservation (including strain identification and assessment of the impact of hatchery fish on feral populations). This study investigated genetic composition of several lacustrine populations at seven microsatellite DNA loci, with the aim of providing a genetic baseline for Irish carp. In addition, results were used to compare with historical data on the species in Ireland and to characterise the different genetic strains currently present in Irish waters. Four distinct strains were identified. With these data it should now be possible to differentiate between strains in terms of their biological and recreational angling characteristics. This will aid in the formation of a carp management plan for Irish waters.

**Keywords:** Common carp, genetics, impacts, management, microsatellites

## **66. IBIA & Classical Biological Control: Developing legislative tools for Ireland**

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Increasing biological invasions are a major driver of biodiversity loss, and also affect the economy and, possibly, human health. Climate change, removal of trade barriers and increased travel all aid the spread of exotics. Invasive species management has therefore become of great interest to policymakers; however, the need to address the protection of biodiversity from invasive species has been secondary. Prevention, eradication and control of Invasive Alien Species (IAS) in Europe has improved, but still lacks legal tools to remedy the problem. Classical Biological Control (CBC), involving release of an exotic species to control invasives, has been practiced with considerable success to alleviate the effects of IASs on ecosystems worldwide. The USA, Republic of South Africa and Australia are experienced CBC practitioners and have released Biological Control Agents (BCA) to control an array of weeds and pests. Europe has some experience, but lags on home-grown legislation for invasive aliens and potential control agents, and follows the FAO's International Standards for Phytosanitary Measures ISPM No. 3 if sanctioning the release of exotic control agents. Environmental Impact Assessment and Pest Risk Assessment procedures have been used by some countries. Although EIA could provide a valuable evaluation framework, CBC does not constitute a 'project' under current EU EIA procedures. PRA, on the other hand, is a constituent procedure within ISPM No.3. Integrated Biodiversity Impact Assessment (IBIA) is under development to streamline Irish assessments of proposals with potential biodiversity impacts. This integrates Appropriate Assessment (AA) with Strategic Environmental Assessment (SEA) and EIA. This paper presents a review of worldwide CBC practice, analysis of potential relationships between IBIA and measures for assessing/evaluating CBC, and development of biocontrol assessment for Ireland to be tested using relevant alien invasive species.

**Keywords:** invasive alien species, biodiversity, classical biological control, integrated biodiversity impact assessment.

## **67. Farmer evaluation of slurry spreading conditions compared to predictions from the Hybrid Soil Moisture Deficit model**

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Although a number of measures have been implemented in the recent legislation to prevent water pollution from agricultural sources, nitrate and phosphate still pressurise Irish waters. A Sustainable Nutrient Management Decision Support System (SNM-DSS) has been designed to assist farmers in preventing water pollution by reducing coincidence of land spreading with nutrient transport processes. The Hybrid Soil Moisture Deficit (HSMD) model which is at the core of the SNM-DSS predicts soil water content relative to field capacity. When the soil is wetter than field capacity, free water is theoretically available to move nutrients from the soil. The aim of this study was to evaluate whether the output of the HSMD model corresponded to farmer opinion of when it was safe to spread slurry. A mobile phone text message survey was conducted in cooperation with 175 farmers over one year. Each farmer was randomly sent around 40 SMS messages with questions related to slurry management issues (trafficability, weather forecast, storage limitations and nutrient efficiency). Each farmer was georeferenced to a 10 km × 11 km grid covering Ireland and daily SMD was calculated for each grid cell using interpolated weather data. It was found that storage limitations would encourage farmers to spread slurry almost 50% of the time, with major concern before and after the closed period, and early in the growing season. Both trafficability and weather forecast would prevent farmers to spread when the soil was wetter than field capacity. On the other hand they would expect a more efficient nutrient uptake by plants in dry conditions. The correlation of farmer opinion of slurry spreading opportunities and SMD predictions highlighted the potential of the HSMD model (and thus the SNM-DSS) for predicting when nutrient spreading will be optimum for plant uptake and reducing leaching/runoff depending on soil and weather conditions.

**Keywords:** Soil Moisture deficit, Decision Support System, farmer opinion, Survey, SMS messaging

## 68. Green energy from marine biomass: The effect of drying *Saccharina latissima* blades on biogas production

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As natural petroleum resources are rapidly depleting, and concern about climate change is increasing, the need for new sustainable energy sources is well recognised. Seaweed has emerged as an alternative feedstock for the production of a myriad of renewable fuels, such as biogas. Biogas production from the anaerobic digestion (AD) of seaweed has great potential because seaweed contains easily hydrolysable sugars and has no lignin. However, the hydrolysis of seaweed is not a straightforward reaction, and treatment is required. Seaweed in its fresh state (75–85% water), is perishable and could degrade within a few days of harvesting. As a result, drying is an essential step before it can be used in industrial-scale processing. An effective drying process reduces the storage volume, and at the same time improves the AD process by changing the phytochemical composition of the seaweed. Nevertheless, energy is required to evaporate the water resulting in a significant increase in the overall operating costs. The work presented was designed to compare drying methods for *Saccharina latissima* and to evaluate the extent to which drying conditions influence cumulative biogas production. For this purpose, fresh seaweed samples were oven-dried at 75°C for 24 hours (A), air-dried at room temperature for 48hrs (B) and dried by a combination of both methods (C). Results show that cumulative biogas production increased when compared to raw fresh seaweed (218 ml biogas/gVs). Drying seaweed following A, B and C methods produced 590, 569 and 496 ml biogas/gVs, respectively. Methane generation showed a similar trend. The results highlight the benefit of drying *S. latissima* at room temperature over oven-dried method in terms of cumulative biogas and methane yields. Drying will result in a substantial reduction and energy consumption from the overall process.

**Keywords:** *Saccharina latissima*, seaweed, biogas, drying

## 69. Sustainability assessment for urban water systems – A critical analysis

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In light of developments such as urbanisation, economic and population growth, climatic changes and water pollution, the world is moving through a fundamental transition in water resource development, management, and use. A paradigm shift in how we view our urban water resources is required to face the scale of these issues. Managing the transition will require changes in how we resource our water supply and efficiently use our water. It is essential that this is done sustainably and for this to be ensured, methods for the assessment of the sustainability of urban water systems are required. The purpose of sustainability assessment is to provide decision-makers with an evaluation of the current state of a given system, often by analysing the interfaces between technical, social and natural systems so that proposed modifications to the system can be benchmarked against current sustainability levels. An important element is the degree to which the sustainability assessment tools for urban water systems fulfil their objectives. The objectives of sustainable water management include avoiding degradation of the environment over both short- and long-term periods, protecting human health, providing required water services to the whole population and to minimise non-renewable resource use and these objectives should be reflected in available sustainability assessment tools. This paper identifies the important components of a sustainability assessment method for Dublin and presents through a critical analysis of methods used elsewhere in the world, suitable assessment methods for addressing the urban water issues in the city. Methods used include indicator based tools such as triple bottom line accounting and life cycle assessment, risk analysis, and integrated tools such as multi-criteria decision aid and simulation models. However, these methods are characterised by uncertainties that render them unsuitable for Dublin and these are presented.

**Keywords:** sustainable urban water management, sustainability assessment, sustainable development

## **70. A pilot scale study to examine the treatment of piggery wastewater using woodchip biofilters**

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The Nitrates Directive restricts the land area suitable for landspreading of pig manure so separation and treatment warrants consideration. Six identical pilot scale woodchip biofilters were established to treat the separated liquid fractions of raw pig manure (SR) and pig manure following anaerobic digestion (SAD). Each biofilter had dimensions of 1.5m(W) × 1.5m(W) × 1.5m(H), comprising a 1 m aerobic layer above a 0.5 m anoxic layer of lodgepole pine woodchips. SR and SAD were obtained using a decanter centrifuge. 3 replicate woodchip biofilters were used to treat both the SR and SAD at a hydraulic loading rate of 10 L/m<sup>2</sup>/day. The biofilters were operated for 228 days. On average, the SR biofilters were successful in removing 50 % dry matter (DM), 72 % chemical oxygen demand (COD), 89 % total nitrogen (TN) and 91 % total phosphorus (TP). Removals of 59 % DM, 82 % COD, 89 % TN and 81 % TP were observed for the SAD biofilters. High levels of nitrate (SR: 292 mg/L, SAD: 494 mg/L) were observed in the aerobic layer in both the SR and SAD biofilters indicating the occurrence of nitrification, which was confirmed with the observed reduction in pH. Low levels of nitrate (SR: 5.2 mg/L, SAD: 10.6 mg/L) and an increase in pH were observed in the final woodchip biofilter effluents. This indicates that denitrification occurred in the bottom anoxic layer. The woodchip biofilter is a simple, effective, sustainable method of removing a large proportion of DM, COD, TN and TP present in the liquid fraction of SR and SAD. However, further polishing is needed to bring the final effluent to a water quality suitable for discharge.

**Keywords:** biofilter, denitrification, nitrification, pig manure, woodchip

## **71. Towards a more sensitive detector for measuring mercury and other environmental pollutants**

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Many types of environmental monitor use optical absorption to detect the species they measure. Optical cavities are commonly used to increase the sensitivity of these instruments, but have not been extensively exploited below 300 nm, mainly owing to the limited light sources at these wavelengths. Sensitive absorption measurements at 254 nm are particularly relevant for detecting several gases of environmental concern, including ozone, aromatic compounds, and the global pollutant, mercury. To realise a detector at this wavelength, Cavity-Enhanced Absorption Spectroscopy (CEAS) is combined with an inexpensive low vapour pressure mercury lamp. The cavity-enhanced absorption here is 50 times greater than that found with a single-pass configuration. This gives limits of detection of 8.1 pptv (66 ng/m<sup>3</sup>) for mercury and 8.4 ppbv for ozone, which are already comparable to or better than commercial absorption instruments for these analytes. The performance of the system and potential applications of this approach are discussed.

**Keywords:** atmosphere, pollution, monitoring, mercury

## **72. Implementation of an activated sludge wastewater treatment plant optimisation study: Stage 1**

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Research to date has shown that it is quite common for activated sludge wastewater treatment plant (AS WwTP) managers to adopt an uninformed and unsystematic approach to plant operation and control. The cost of treatment is rarely considered by plant management if the plant is meeting discharge criteria. This presentation outlines the improved operational concepts and innovative process control methodologies associated with the development and implementation of an activated sludge wastewater treatment plant optimisation study. Ultimately, this study should result in measurable benefits to the environment both in terms of final effluent toxicity and treatment plant operational footprint. An optimisation study involves nurturing an atmosphere for change whereby a more holistic approach to treatment plant operational philosophy can be implemented. Most plant managers appear to be unaware of the versatility of treatment plants which inhibits the identification of areas where treatment efficiency can be improved. It was found that the current routine nature of site sampling and testing means that effective use is not being made of process and quality data. In many cases, sampling and testing is carried out solely for record keeping purposes thus making it difficult for the plant manager to optimise plant efficiency under current exhausted regimes. A properly designed plant optimisation study ensures that plant data and associated trend graphs will allow the plant manager to make data-based process control decisions. Effective data management and analysis will allow cause and effect relationships to be clearly identified. A plant specific process spreadsheet was developed and implemented at a local WwTP in the Northwest of Ireland. In conjunction with structured testing methodologies, key parametric data from this spreadsheet empowers the plant manager to implement a restructured plant operational approach which targets optimisation study parameters (OSP) thus allowing plant treatment efficiency to be increased and energy consumption to be reduced whilst meeting current and potentially future discharge criteria.

**Keywords:** optimisation, improved efficiency, activated sludge, improved operational concepts, data-based decisions, cost of treatment, environmental benefits.

### **73. Innovative enhancement of nitrogen removal in a multi-stage treatment wetlands: Testing methodology and reliability of results**

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The aim of this study is to enhance total nitrogen (TN) removal in a five-stage alum sludge-based tidal flow constructed wetlands (AIS-TFCWs) system by incorporating pre-denitrification and post-denitrification. The laboratory AIS-TFCWs system was composed of five reed beds in series (stage 1 to stage 5) and operated in batch mode. Anoxic condition was created in stage 1 and stage 3 by adopting upflow pattern and short bed resting time (1 min). The rest stages were remained as the original down flow tidal flow pattern with substantial bed resting time, which were regarded as the aerobic stages in the combined system. In addition, part of the nitrified outflow from stage 3 was recirculated to stage 1 to perform pre-denitrification. The rest outflow from stage 3 was then introduced into stage 4, where post- denitrification took place by utilizing the residual carbon source. Finally, the residual organic matter (OM) and  $\text{NH}_4^+\text{-N}$  were further removed in last stage, i.e. the stage 5. Diluted piggery wastewater was used as the influent with COD of 402-1636 mg/l, TP of 2.4-42.9 mg/l and TN of 101-229 mg/l. Results from 214 days operation showed excellent nitrification capacity and denitrification potential of the proposed system. Desirable TN removal of  $86.9\pm 3.8\%$  was achieved under high nitrogen loading rate (NLR) of  $29.1 \text{ g N/m}^3\cdot\text{d}$ , which is a substantial improvement compared to the TN removal of 60-70% in the original AIS-TFCWs and the applicable NLR of  $3.7\text{-}9.2 \text{ g N/m}^3\cdot\text{d}$  in the conventional hybrid constructed wetlands system. Even under carbon limitation situation (influent COD/TN=5.5), the proposed system still had the potential to achieve TN removal of  $>85\%$ . The study has provided a good showcase that the combination of pre-denitrification, post-denitrification and tidal flow operation can bring enhanced TN removal performance under high loading rate.

**Keywords:** alum sludge, constructed wetlands, nitrification, post-denitrification, pre-denitrification, tidal flow

#### **74. Development of titanium dioxide composites for the removal of pesticides from water and wastewater using photocatalysis**

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The EU Water Framework Directive specifies that measures must be adopted at EU level against pollution of water by contaminants presenting a significant risk to the aquatic environment. A list of 33 priority hazardous substances including pesticides has been published. This project focuses on the removal of selected analytes by undertaking the development of three titanium dioxide (TiO<sub>2</sub>) composites. The analytes that were investigated were 4-Chloro-2-methylphenoxy acetic acid (MCPA) and 2, 4-Dichlorophenoxy acetic acid (2, 4-D). 2, 4-D is a known endocrine disruptor. These chemicals are herbicides that are widely used and have the potential to enter wastewater streams. Therefore research into the removal of these pesticides from wastewater streams is of significance to water quality standards. The first composite investigated was composed of activated carbon and TiO<sub>2</sub> (also known as Integrated photocatalytic adsorbents or IPCAs). These IPCAs were used to remove the herbicides in the presence of UV light by combining the adsorption capabilities of activated carbon with the photocatalytic properties of TiO<sub>2</sub>. The second TiO<sub>2</sub> composite investigated was based on porphyrin dyes. Porphyrins are dyes that strongly absorb in the 400-450 nm and 500-700 nm regions. The porphyrin dyes were used to enhance the photocatalytic properties of TiO<sub>2</sub>, allowing for photocatalysis to occur in both the UV and visible region of the solar spectrum. Results show that the IPCA removes the target analyte mainly by adsorption and that a porphyrin/TiO<sub>2</sub> composite is a superior photocatalyst to unmodified TiO<sub>2</sub> in studies involving certain pharmaceuticals but not those which involved the selected herbicides. Future work will include the use of a third TiO<sub>2</sub> composite, composed of a natural commonly found mineral adsorbent, for the removal of the herbicides and the optimisation of the most effective composite system. Other pollutants will then be used to challenge the selected optimised system.

**Keywords:** photocatalysis, TiO<sub>2</sub>, Activated Carbon, photosensitisers, dyes, pesticides, porphyrins

## **75. Carbon pools and processing in an Irish humic lake**

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Humic lakes receive high levels of dissolved organic carbon (DOC) from their peatland catchments. While primary production contributes autochthonous carbon to such lakes, this allochthonous carbon source plays a major role in productivity. Processing of DOC within lakes is likely to be impacted by climate change, in particular changes in uptake and decomposition rates. Lough Feeagh, Co. Mayo is unique in Ireland in having a highly instrumented catchment and is part of a global network of such sites. The project is using high resolution fluorescence data to quantify in-lake carbon pools, thus providing insight into carbon processing under current conditions. The initial stage of this project involved the calibration of in-situ instrumentation to measure DOC and chlorophyll fluorescence, with particular emphasis on the assessment of the impact of temperature quenching on fluorescence. The project extension will involve modeling future climate impacts on carbon processing using the model DYRESM CAEDYM. Additional experimental data will also be obtained on in-lake carbon processing by zooplankton to validate model parameterisation. Future climate data, required to run the model, are available for the catchment from the recently completed RESCALE project.

**Keywords:** Dissolved organic carbon, Peatlands

## **76. Monitoring Ireland's only marine reserve: A natural laboratory to support coastal management**

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Monitoring and maintaining the healthy status of protective marine reserves is vital against the backdrop of a general decline in coastal water quality. Lough Hyne Marine Reserve (Est. 1981) was Europe's first marine reserve and is currently still Ireland's only statutory marine reserve. In recent years, a decline in the water quality associated with increased eutrophication has been implicated in changes in the abundance of key species present within the Lough. Additionally, increasing evidence of the development of algal blooms and changes in the extent of the seasonal anoxic zone within the Lough has been reported. Continuous monitoring of environmental parameters to discover the consequences and reasons behind this decline has been highly desirable; however until recently the capacity to do such monitoring at the reserve has not been routinely available. In this paper, the results of the first continuous monitoring of a suite of environmental parameters using autonomous sensor technologies are presented from two sites within the reserve over a summer period. A discussion of how collected data can contribute to an improved overall scientific understanding of biological and hydrodynamic processes within Lough Hyne is given. Finally, the current challenges and future requirements of aquatic monitoring on a continuous basis are discussed as a key management tool in remote marine reserves in the context of Lough Hyne.

**Keywords:** Sensing, Marine, Lough Hyne

## **77. Assemblage structure of plant communities along the road corridor: developing a stable sustainable system**

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Ecological impacts of highway construction on the wider landscape are considerable, including those visited upon existing plant communities. This is important as the value of vegetation communities, in their support and provision of ecosystem services, becomes increasingly apparent. Highway corridors crossing intensively managed agricultural land offer potential refuge for native flora and improvement in the wider landscape's overall interconnectedness. In 2006, Ireland's National Roads Authority published an updated set of guidelines for road landscaping to be implemented along new national road schemes. In 2009, the N25/N22 corridor was surveyed between Rosslare and Tralee. Sites had been landscaped to either pre- or post-guidelines specifications. The following year a soil seed bank trial was conducted with soil taken from the location of the original plant quadrats. A sample of the data will be presented which concern those road verges engineered with a 1:2 slope and having a rock/scree basis. These consider what differences are emerging in the early stages of verge development: in particular the species diversity found in pre- and post-guidelines sites. Furthermore, the importance of the soil seed bank trial is considered. The results also consider resistance to non-native invasive species. The ultimate output is expected to inform those involved in the planning, design and maintenance of road schemes of the most ecological and, ultimately, cost-effective way of creating and maintaining vegetation communities in the road corridor.

**Keywords:** plant communities, road ecology, biodiversity, landscaping

## **78. Introducing biological control to Ireland: Waging a war on invasive species**

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*Lagarosiphon major* is a submersed non-native macrophyte, first recorded in Ireland in 1966, which has become noticeably invasive in the past decade. In an effort to circumvent the limitations associated with the chemical and mechanical control of substantial infestations in Lough Corrib, a biological control programme has been initiated using natural enemies imported from the country of origin, South Africa. Alternative, sustainable options like classical biological control has seen the effective control of other aquatic species in other parts of the world. A newly described leaf-mining fly *Hydrellia lagarosiphon* (Diptera: Ephydriidae) was imported from South Africa into a quarantine facility at UCD in July 2009 as a candidate biological control agent on *Lagarosiphon major*. An ideal candidate is required to fit into the Irish ecoregion, impose sufficient damage ensuring a reduction in plant vigor and complete its life cycle on the target organism but not on non-target plants. Rearing techniques have been developed and temperature based studies have been conducted to determine how *Hydrellia lagarosiphon* may fit into the Irish ecoregion. Larval feeding damage of the fly reduces the photosynthetic potential of lagarosiphon shoots, with the capacity of each shoot supporting up to 3-4 larvae. The short generation time, large levels of damage induced per individual and promising preliminary host specificity results make these ephydrid flies a potentially important candidate biocontrol agent of lagarosiphon.

**Keywords:** *Lagaropsiphon major*, *Hydrellia lagarosiphon*, invasive aquatic weeds, classical biological control, host specificity testing

## **79. Assessing streamside fencing as a management option in the Milltown Lake catchment**

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Nutrient loading is one of the principal drivers in the deterioration of water quality in Ireland. Two main sources contributing to nutrient pollution in rural catchments are agricultural practices, particularly fertiliser use and slurry spreading, and single house on-site wastewater treatment systems. The aim of this study is to use a combination of monitoring and dynamic modelling to explore how changes in catchment pressures affect the export of nutrients in the Milltown Lake catchment, Co. Monaghan. Milltown catchment is 30km<sup>2</sup> and comprises of a hilly, drumlin landscape, located in a rural area. The catchment consists of a lake, supplied by three inflowing tributary streams. The lake is used as a domestic water supply for the local community and is also part of the National Source Protection Pilot Project (NSPPP). The current status of the lake is eutrophic to strongly eutrophic. An intensive monitoring programme has been established within the catchment since September 2005. As part of the requirements of the current research, gaps in data required to run the models have been identified and a sampling program been established to fulfil those needs. Further high frequency sampling is being carried out at the inflow to the lake to collect data for the validation and calibration of the models to be used. The impact of cattle exclusion measures such as fencing is also being assessed. Comparison between fenced and unfenced tributaries with similar land management practice will be compared. Fencing allows for the reestablishment of streamside vegetation which will aid in the prevention of erosion and reduce the amount of nutrient pollution from agricultural runoff entering the watercourse.

**Keywords:** Modelling, Nutrients, Agriculture

## **80. Using an environmental forensics approach to differentiate sewage and manure derived nitrate in Irish surface waters**

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Recently, there has been increasing interest in environmental forensics applications for nitrate source determination. To date, nitrate stable isotopic compositions have been used for this purpose. However, they do not successfully differentiate sewage and manure sources. Furthermore, no alternatives to the use of isotopes for this application are currently available. Nevertheless, there is considerable stakeholder interest for such techniques. This is especially in view of legislative obligations related to the Water Framework Directive (WFD) and due to health and environmental considerations linked to high nitrate concentrations. Such an approach for differentiating nitrate sources allows for more effective implementation of the WFD. Determining the sources of nitrate contamination allows for improved water body management and preservation of water quality, since remediation actions at contaminated sites can be targeted to the actual source, making them more efficient, thus reducing public health and environmental considerations related to elevated nitrate concentrations and reducing costs for implementing remediation actions. In addition the ‘polluter pays principle’ could be applied more effectively in the context of nitrate contamination, since the inputs can be identified. The use of co-occurring discriminators of sewage and manure is a potential way to disentangle the source. A suite of human and veterinary derived chemical markers has been identified for this purpose, with an additional advantage of providing further characterisation of the source. An SPE-LC-MS/MS method has been developed and validated for the suite of chemical markers at detection limits of up to 5 pg/L. Additionally, this project is investigating the advantages offered by the novel application of techniques, such as  $\delta^{13}\text{C}$  and NMR, to achieve differentiation, in comparison to standard chromatographic methods, in order to facilitate sample processing and analysis. Results from method development and the application of these techniques will be presented, together with results from monitoring sites within Ireland.

**Keywords:** nitrate, source determination, sewage, manure, chemical markers, isotopes, pharmaceuticals

## 81. Stormwater monitoring of an urban residential catchment

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The implementation of the Water Framework Directive has highlighted the issue of diffuse urban pollution. Stormwater discharges have been linked to receiving water degradation due to the presence of suspended solids, hydrocarbons, nutrients, heavy metals and other toxic constituents in the runoff. Suspended solids are a key parameter as many pollutants are associated with the solid fraction. Future regulation of stormwater drainage discharges will require detailed monitoring data to support the setting of pollutant discharge limits and the design of stormwater treatment measures. Of particular importance is the size distribution of particles generated in response to rainfall on the catchment, which determines the potential treatment efficiency of sedimentation, particle separation or filtration processes. Monitoring of a conventional surface water drainage system in south Dublin has been conducted to investigate the sediment and pollutant yield of an urban residential catchment. Rainfall and flow were continuously recorded, and automatic sampling equipment facilitated high-resolution sampling of each storm event at the outlet of the drainage system. Samples were analysed for suspended solids concentration, volatile suspended solids, particle size distribution, phosphorus and heavy metals. For all events monitored, the suspended solids concentration varied in proportion to the flow rate, and there was a strong correlation between suspended solids and the heavy metals and nutrients. The majority of particles contained in the runoff were less than 100 microns in size, with larger particles retained by the gullies or deposited upstream in the pipe drainage network. The research suggests that stormwater treatment systems should target fine particles, particularly for end-of-pipe solutions for conventional drainage networks. Further research will focus on the fractionation of pollutants by associated particle size ranges, and monitoring of long term accumulation of sediments in the gully pots.

**Keywords:** Heavy metals, particle size distribution, stormwater, suspended solids

## **82. Remediating hexavalent chromium with polymer modified membranes**

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Chromium is a naturally occurring metal which exists primarily in its trivalent state, Cr(III). However, hexavalent chromium Cr(VI), a known carcinogen and mutagen, is released into the environment as a waste product of industrial processes such as chrome plating, pigment manufacture and leather tanning. The wide spread industrial use of chromium often leads to contamination of ground water supplies, and this reveals two exposure pathways: dermal contact with, and ingestion of contaminated water. A common form of Cr(VI) is the chromate form,  $\text{CrO}_4^{2-}$ , which can enter the blood stream through skin lesions, causing destruction of red blood cells. We have developed a conducting membrane modified with polymer nanofibres which, when placed in a solution of acidified Cr(VI), will remove up to 99% of the Cr(VI) within 48 hours, with up to 25% removal occurring in the first 90 minutes. The formation of nanofibres greatly increases the polymer surface area and thus its efficacy. The polymer can be successfully recycled and reused for further Cr(VI) removal. We are currently investigating the mechanism by which this removal occurs, by forming the conducting polymer nanofibres on an electrode surface. This method has been successfully scaled up for use on the 25 mm diameter nylon membranes, and we believe it could be further scaled up in future for use in water treatment.

**Keywords:** chromium, membrane, water, polymer

### **83. Reclaimed asphalt; environmental assessment of a valuable resource**

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Asphalt removed during the repair of roads in Europe is not currently re-used to its full potential. The majority of it is used in low level recycling applications or simply disposed of in landfills. More efficiency in the use of this material, reclaimed asphalt (RA) can be achieved by re-incorporating it into road surface layers (i.e. reusing it for the purposes for which it was originally designed). This ensures the greatest exploitation of the engineering properties of the original material. Increased use of RA for surface layering also reduces both the demand for virgin aggregates and for landfill space, two increasingly scarce resources. There are, however, two sources of contaminants in RA, those associated with all bituminous materials, such as hydrocarbons in the binder and those deposited during the previous service life of the material. Once re-incorporated into a road surface layer, there is potential for contaminant leaching. To assess the leaching potential of RA, a percolation test was performed on materials from a range of sources including an Irish RA and a Swedish tar-containing RA. A 0.1% CaCl<sub>2</sub> solution was pumped continuously through columns of RA at a constant linear velocity of 15±2 cm/day until a terminal liquid/solid (L/S) ratio of 10 l/kg was achieved. Seven samples were taken from each column at prescribed L/S ratios during the tests which were approximately one month in duration. Samples were analyzed for a range of typical water quality parameters including pH, conductivity, turbidity, DOC and redox potential, and also for the 16 EPA priority polycyclic aromatic hydrocarbons and a selection of heavy metals. Results from the percolation test enable the determination of the important leaching mechanisms associated with each contaminant and parameter studied and their release over time and can aid the development of guidelines for the safe re-use of RA.

**Keywords:** Reclaimed asphalt, leaching, water quality

## **84. A real-time bathing water quality prediction system for Bray, Co. Wicklow**

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The Bathing Water Quality Directive 2006/7/EC will be implemented in 2014 bringing changes to bathing water quality sampling criteria and a more stringent classification system for bathing water status, making it more difficult for designated bathing areas to maintain their Blue Flag status. However, discounting of non-compliant samples will be allowed when bathing waters are subject to short term pollution from certain events such as heavy rainfall. This will only be permitted if integrated catchment and coastal management systems facilitating real-time bathing water quality forecasts are in place to provide beach managers with sufficient notice of poor quality bathing water, enabling mitigation actions including, warnings to the general public of the possible risk of exposure to contaminants or prohibition of bathing during the pollution event. This paper presents the interim findings of an Interreg funded research project that is developing a prediction system for Bray beach, Co. Wicklow. A numerical approach that involves integrated catchment and coastal models of the Dargle and the nearshore Irish Sea area off Bray is being adopted. The catchment model (using Mike 11) is being developed and will be calibrated with rainfall and river flow data collected at 17 recently instrumented telemetric sites within the catchment. Water quality sample collection at these sites is ongoing and this data ensures that the catchment model simulates accurately the faecal bacterial levels in the river and its tributaries. The catchment model forms a boundary to the coastal model, through which, inputs of appropriate levels of faecal bacteria for specified rainfall events in the catchment are simulated. The hydrodynamic coastal model, calibrated with depth, current and water quality data that is being compiled through data collection that commenced in Summer 2011, determines the impact of all microbial discharges in the model domain at the compliance point on Bray beach.

**Keywords:** bathing water quality, coastal modelling, catchment modelling, rainfall-runoff



The logo for 'environ 2012' features a green leaf icon to the left of the word 'environ' in a lowercase, sans-serif font, followed by '2012' in a larger, bold, sans-serif font.



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## **POSTER PRESENTATION ABSTRACTS**

**(Listed by Theme)**

- Biodiversity & Ecosystems (BE)
- Climate Change (CC)
- Energy (EN)
- Environment & Health (EH)
- Environmental Management (EM)
- Environmental Technologies (ET)
- Marine & Coastal Research (MCR)
- Water Quality (WQ)

**Poster BE1. Seed dormancy in rowan and its implications for nursery operations and natural regeneration**

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Although not commercially valuable, rowan (*Sorbus aucuparia*) is an important species in Irish forestry, mainly because it is native and is considered important in creating and maintaining diverse plantations (i.e. biodiversity). For this reason, there is a considerable demand for rowan planting stock in Irish nurseries. However, nursery germination tends to be low and unreliable, thus greatly affecting the economics of the operation. Rowan seeds have a profound dormancy, which should be broken before sowing. The standard pre-treatment used in operational practice (three weeks warmth followed by 18 weeks chilling in a medium of peat, sand and perlite) may not be optimal. In an attempt to address this problem, rowan seeds in this study were subjected to combinations of warm and cold treatments and then allowed to germinate at 15°C or 20°C (dark)/ 30°C (light). Some seeds were also given the standard treatment. The response to treatment was similar at both germination temperatures. The presence of the medium and short periods of warmth or no warm treatment prior to chilling resulted in a large proportion of prematurely germinated seeds. Prematurely germinated seeds usually die prior to sowing or during sowing operations. In contrast to the standard treatment, six weeks warmth followed by 20 to 26 weeks chilling greatly increased germination, with few seeds germinating prematurely. The implementation of this treatment in operational practice will improve seedling yields in the nursery. However, the results also have implications for naturally regenerated forests in Ireland. The results suggest that climate change may favour the regeneration of species that have lower chilling requirements (e.g. *Alnus* and *Betula* sp.) than rowan.

**Keywords:** germination, pre-treatment, stratification, pre-treatment, dormancy

**Poster BE2. Ecohydrological characterisation of wetlands in the border region**

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Wetlands are areas that are periodically or permanently inundated by surface or groundwater and are consequently sensitive to changes in both surface and groundwater supplies. Similar to other aquatic ecosystems, they are under multiple pressures owing to intensive agricultural land use and land management practices, water abstraction, peat extraction, pollution from industry, and waste from households, and are considered to be among the most highly threatened ecosystems on the planet. In Ireland, there is a lack of baseline data for the full range of Irish wetlands and limited understanding of the environmental supporting conditions required to maintain wetlands in a good ecological state. As part of the EU funded Tellus Border project which is undertaking state-of-the-art geoscience surveys of the border counties of Ireland, the water quality and water delivery mechanisms of a range of different types of wetlands in this region (e.g. peatlands, salt marshes, dune slacks and transition mires etc.) will be investigated. Emphasis will be placed on developing an understanding of the relationships between the hydrology, hydrogeology, water quality and ecology of different wetland types, in order to examine the environmental supporting conditions required to maintain or enhance their ecosystem health. An initial desk-study will provide baseline data describing the extent and locations of wetlands across the border counties of Ireland. A set of wetlands, will then be chosen for detailed site-specific research. By drawing on the data collected throughout the Tellus Border project and other spatial geoscientific information, the influence of geological, geochemical, hydrological and hydrogeological factors on the location and development of wetland habitats in the region will be examined. Tellus Border is supported by the EU INTERREG IVA programme, which is managed by the Special EU Programmes Body.

**Keywords:** Tellus Border, wetlands, ecohydrology

**Poster BE3. Pollinator diversity and abundance on fixed dunes in Ireland from a conservation perspective**

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Coastal dunes provide excellent habitats for a wide range of invertebrates. Fixed dunes are priority habitat under the EU Habitat Directive (92/43/EEC) supporting important plant and invertebrate communities and the ecosystem services they deliver. They are threatened by a wide range of factors; biological invasions; development; tourism and recreation; changes in hydrology and poor beach management; agriculture and afforestation and atmospheric nutrient deposition. There is global and national concern regarding insect pollinator decline, yet fixed dunes have been shown to support some of the rarer pollinator species. However it is not clear which properties of fixed dune systems promote pollinator diversity and so this project aims to assess the association between size of protected area, pollinator diversity/abundance, and assemblage structure. The effect of microsite complexity on pollinator diversity and abundance was also investigated. Fieldwork was carried out on eight fixed dune sites representing different sizes (1.6 to 238.6 ha) of protected area on the Southern and Eastern coasts of Ireland. All sites in the study have been designated as candidate special areas of conservation (cSACs) or proposed natural heritage areas (pNHAs). In order to establish whether the size of the protected area had an effect on pollinator diversity, plant diversity, and plant-insect network structure, insects and plants were sampled using transect walks and pan-trapping at each site during summer 2011. Floral richness and abundance were also sampled at each site. Microsite features are defined as physical features detectable to the human eye, which can act as surrogates for insect microhabitats. A range of features were selected, based upon the literature, and recorded for each of two 5 m<sup>2</sup> quadrats per transect. The preliminary results of this research will be presented and discussed with respect to pollinator conservation, with particular focus on how this research can improve habitat quality assessment, and potentially influence national policy and legislation.

**Keywords:** Fixed dune, pollinators, conservation, priority habitat

## **Poster BE4. Population Genetics and Management of Pike (*Esox lucius*) in Ireland**

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Throughout the northern hemisphere, northern pike (*Esox lucius*) is of particular socio-economic value for recreational and commercial fishing, and Ireland is no exception, where revenue from the angling industry is estimated at circa €50 million per annum. Pike have long been thought to be non-native to Ireland, although a lack of direct evidence for this leads it to be a contentious issue between various stakeholder groups. It is not known how pike were originally introduced into Irish waterways, nor where they came from. Despite this, historical management of this species has been based upon this assumption, leading to controversial policies such as an intensive removal of pike during predator control operations, primarily in the 1950s and 60s, aimed at protecting native brown trout (*Salmo trutta*) populations. In Ireland pike occurs in most freshwater systems, but until now no real attempt has been made to investigate relatedness and connectivity among populations. One previous Europe-wide study found one population from the River Shannon to be monomorphic at six microsatellite loci. However, pike in other regions have been shown to exhibit genetic structuring, suggesting small founding local populations and natal-site and spawning site fidelity. Here we present the first Ireland-wide population genetic investigation using a suite of six polymorphic microsatellite markers and illustrate the nature of population connectivity in pike inhabiting Irish lakes, rivers and canals. This study provides the first piece of evidence which will better inform pike management in Ireland, and attempt to reconcile the various and often conflicting needs of an important socio-economic sector.

**Keywords:** Population genetics, management, pike, *Esox lucius*, microsatellites

**Poster BE5. The impact of forestry management practices on the distribution of the Kerry Slug *Geomalacus maculosus* Allman and the investigation of other possible factors limiting its occurrence**

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The Kerry Slug *Geomalacus maculosus* is listed as a protected species in the European Habitats Directive and has further protection under Irish legislation. The slugs' distribution was believed to be limited to northern Iberia and to south-west Ireland, where it inhabits oak-dominated or mixed deciduous woodland as well as open moor or blanket bog. However the species has recently been found for the first time outside of counties Kerry and Cork, in a Coillte conifer plantation near Oughterard, Co Galway. To date, presence/absence surveys have been carried out in 42 potentially suitable habitats around counties Galway, Clare, Limerick and Kerry, without finding the species, so their migration from the south-west to Galway seems quite unlikely. We are currently looking into the spatial distribution and habitat requirements of the Kerry Slug in the Co Galway plantation and are investigating possible correlations between the occurrence of the species and management practices (e.g. planting and clearfelling), the age of the plantation, the dominant tree species within parts of the plantation and the availability of suitable food-items. This research involves hand-searching, live-trapping and feeding experiments in the laboratory as well as measuring habitat factors such as humidity, soil acidity and light intensity. The results of this research will help to provide some of the necessary range, population and habitat data to inform the next EU Habitats Directive Article 17 report and set a baseline for future assessments. The results will also inform the National Parks and Wildlife Service on the impact of forest operations on the species and lead to the provision of scientifically-based advice to the Forest Service and Coillte.

**Keywords:** Kerry Slug, protected species, conservation, Irish distribution

**Poster BE6. Within season dynamics of insect-flower interactions: The impacts of mass-flowering invasive plants**

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Invasive alien species can occur at high abundances in exotic habitats and flowering invasive plants that are visited by native pollinators have the potential to disrupt native plant-pollinator interactions. For example, they can integrate into native plant-pollinator networks and significantly affect network structure. The limited research accounting for temporal variation in plant-pollinator networks shows that they exhibit strong variation both between and within flowering seasons, but trends in invaded communities have not been investigated. The copious rewards offered by mass-flowering invasive plants could cause within season variation in plant-pollinator network structure as floral abundance varies over the flowering season. We used two sets of highly resolved insect-flower interaction networks from woodland communities in Ireland invaded by *Rhododendron ponticum* (Ericaceae) to investigate the impacts of a mass-flowering event on network structure. We employed fully quantitative network parameters to compare network structure during and after the flowering of invasive *R. ponticum*. Quantitative connectance significantly increased at our sites after the conclusion of *R. ponticum* flowering but there were no significant differences in interaction evenness, interaction strength asymmetry, or generality. Our results indicate that although communities become more generalised after flowering of the invasive species concludes, their overall structure is tolerant to variation in floral abundance over the flowering season. The stability of three out of four quantitative parameters illustrates that networks invaded by mass-flowering *R. ponticum* experience little within season perturbation. Generalist pollinators may reduce within season dynamics in network structure that might be expected in communities invaded by mass-flowering plants.

**Keywords:** plant invasion, plant-pollinator interaction networks, connectance, generality, interaction evenness, interaction strength asymmetry, *Rhododendron ponticum*

## **Poster BE7. Microbial biodiversity in the rhizosphere: Agriculture and environment**

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Increasing food demands for a growing world population now requires improvements in resource (e.g. fertiliser and chemical) management and efficiency. The excessive use of artificial fertilizers is harmful to beneficial soil microorganisms and the environment. Chemical control of plant diseases that reduce crop yields significantly cannot provide a long term sustainable solution. While microbial biodiversity has received some attention over the years it is now a topic of global concern. Microbes are a key component of any agricultural system and play an important role in soil structure maintenance, soil borne disease control and plant growth promotion activities. An ideal agricultural system is sustainable if it maintains and improves human health, produces enough food for an increasing world population while maintaining and/or enhancing the environmental quality and conserving natural resources such as soil and water both now and in the immediate future. The presence of rhizobacteria in the rhizosphere can have either beneficial or detrimental effects on plant growth. Beneficial free living soil bacteria that aggressively colonize the root surfaces of plants are usually referred to as Plant Growth Promoting Rhizobacteria [PGPRs]. Nowadays, emphasis is placed on rhizosphere micro-organisms which play a central role in promoting plant growth and health. Rhizosphere micro-organisms can greatly enhance yield and quality, especially through growth promotion and/or the control of plant pests and diseases without a negative impact on the environment unlike that caused by pesticides and chemicals. PGPRs have the capacity to increase plant growth directly or indirectly and have the potential to contribute to the development of sustainable agriculture systems. Our current research project aims at exploring the large biodiversity of existing soil micro-organisms for their ability to antagonise, promote growth and protect against disease in Andean traditional agriculture which could help to reduce excessive use of agrochemicals and support sustainable agriculture and environmental protection.

**Keywords:** Agriculture, diversity, environment, microbial, rhizosphere

**Poster BE8. What is the impact of afforestation on the carbon stocks of Irish mineral soils?**

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Soils contain approximately two-thirds of the carbon (C) stored within the forest ecosystem. The residence time of stable fractions of soil organic carbon (SOC) can be > 1000 years making it a much more stable sink than living plant biomass. It is therefore vital to measure the change in SOC stocks following afforestation and to determine the mechanisms involved in controlling SOC dynamics. The change in soil C following afforestation is controlled by a number of factors: previous land use (grasslands, cropland etc); tree species; soil cultivation method; soil properties (clay content); stand age; site management; topography; climatic zone and methodological approaches. The objectives of this paired plot study were: (1) to quantify the carbon stored in the forest floor and soil (0-30 cm) of 21 forest sites and their adjacent non-forest site on same soils; and (2) to assess the impacts of afforestation on soil carbon stocks using the paired plot method. Analysis shows that carbon is not sequestered at a higher rate in forest soils compared to non forest soils, but that there are expected differences between soil and forest types in terms of the overall carbon content of the soils. Beyond these, the inclusion of factors such as soil texture, growth increments, age of forest, rainfall and temperature do not appear to add significantly to our understanding of the differences.

**Keywords:** Carbon, Soil, forestry

## **Poster CC1. The impacts of climate change and land use on sediment fluxes in Irish Rivers**

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River sediment is a natural and dynamic component of the river/catchment system, which is transported as bedload and/or suspended load, depending on the relationship between flow conditions and the supply, structure, density, size and shape of the sediment. Excessive sediments can reduce light levels in the water column and permeate into the channel substrate, compromising spawning habitats, deoxygenating the water and leading to an overall ecological deterioration of the river system. The sediment fluxes and transport/storage pathways are influenced by changing land uses and by climatic variations and understanding these in the context of sediment budgets is therefore of critical importance for the effective management of river systems. This paper introduces the Environmental Protection Agency (EPA) funded SILTFLUX project that has recently commenced and is studying how changes in land use and climate in Irish catchments affect the suspended sediment yields in rivers. The project comprises field investigation of Type A, B, C and E rivers (from Rosgen) in which sediment yields from pasture, tillage, and forestry land uses will be compared to reference values. The methodology necessitates the validation of a measurement method for determining suspended sediment concentrations and for this continuously recorded turbidity records at sites will be correlated with sediment concentrations measured from water samples collected from automated samplers, triggered for a range of river discharges. The data collected will facilitate an enhanced understanding of both the temporal and spatial variations in sediment fluxes and together with an ecological assessment of the sites, will enable an assessment of their impacts. The data set will be used to validate and assess the performance of computational catchment models as predictors of sediment yields with a view to equipping river basin managers with information that will improve the environmental sustainability of our rivers.

**Key Words:** sediment, river basin, land use, Irish

## **Poster CC2. Utilization of microalgae to sequester carbon dioxide and improve soil conditions at Edenderry Power Station**

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At present, there is 10% wood chip and 90% peat co-firing at Edenderry power station. With 80% peat and 20% co-firing of wood chip, the carbon dioxide emissions would be 724,618 t/yr, but the licensed mass emissions are: 632,319 t/yr. Directing 12% of flue gases (92,299 t/yr) to the algae farm would result in a drop of emissions to 632,319 t/yr. As 1kg of dry algal biomass utilizes 1.83 kg of CO<sub>2</sub>; 92,299 t CO<sub>2</sub>/1.83 gives 50,436 t of dry algal biomass. If the whole area is cultivated with GWP photo-bioreactors, 50,436 t /80t/Ha/yr gives 630 Ha. Again 38% of the algae farm would be used for the production of *Chlorella vulgaris* and *Haematococcus pluvialis* and 62% of the algae farm would be used for the production of *Botryococcus braunii* in closed photo-bioreactors. All species would be subject to nitrogen limiting procedures to increase lipid content for biodiesel production. As the GWP photo-bioreactor is quite a crude model compared to more sophisticated photo-bioreactors, CO<sub>2</sub> would escape from the tubing and the microalgae solution would drip on to the cut-away bog beneath. In the presence of carbon dioxide from the algae farm, plants would grow more quickly. Plants require carbon dioxide to conduct photosynthesis and CO<sub>2</sub> can also be used as a means of controlling pH of the soil. The carbon skeletons produced by photosynthesis are variously used to form other organic compounds, such as the building material cellulose, as precursors for lipid and amino acid biosynthesis or as a fuel in cellular respiration. Chlorophyll is present in *chlorella vulgaris* and it is possible that this pigment can help produce green leaves on the plants by forming chloroplasts made from chlorophyll and other pigments. The arid wasteland around Edenderry could turn into a tropical forest by positioning the photo-bioreactors for a year in one place of 630Ha and continue moving the algae farm across the bog. The biogas plant would remain in the same place. After 10 years the area could be harvested if necessary and re-planted with conventional crops. 29,056,000 l/year of biofuel and approx. 700-1,000 t/yr of health products, cosmetics and pharmaceuticals would pay for the cost of the algae farm, the increase to 20% wood chip co-firing and generate some profit.

**Keywords:** soil conditions, air quality

### **Poster CC3. Development of amine solids for the capture of CO<sub>2</sub> from gas streams**

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Carbon dioxide (CO<sub>2</sub>) is a green-house gas which is known to contribute to global climate change. Anthropogenic sources of CO<sub>2</sub> emissions have increased significantly in the atmosphere. It is believed that the burning of fossil fuels in electric power generation plants, where CO<sub>2</sub> is released in the flue gas, is one of the main contributors. It is believed that human dependence on fossil fuels will continue long into the future. Due to this, much research has been conducted into the separation and capture of CO<sub>2</sub> from such flue gases. This project involves the preparation of amines immobilised onto porous solids. The solids used in this project were SBA-15 and other mesoporous silicas. The amines used were tetraethylenepentamine (TEPA) and (3-Aminopropyl) triethoxysilane (APTES). The adsorbents were prepared by wet impregnation and grafting. A number of samples were analysed using FTIR and TGA. FTIR showed the presence of N-H functional groups and TGA allowed investigation into the actual amine loadings of the samples. The prepared solids were tested for CO<sub>2</sub> adsorption and desorption using an on-line gas rig with mass spectrometry detection. In this way, desorption of CO<sub>2</sub> was recorded with temperature. The amount of CO<sub>2</sub> adsorbed by each solid was calculated and a comparison of the results was tabulated. The research showed that the amine-modified SBA-15 samples were capable of adsorbing and desorbing CO<sub>2</sub> at relatively low temperatures. It was also found that the solids were stable over extended adsorption/desorption cycles. It is hoped from this research to propose ideas for future CO<sub>2</sub> capture technology systems, particularly in power-generation plants.

**Keywords:** CO<sub>2</sub> capture, mesoporous solids

## **Poster CC4. Climate change and financial markets: Agreeing to disagree on standards?**

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This study illustrates the current state of regulation regarding commercial environmental information and the financial markets. It forms part of the overall thesis entitled “Regulating Commercial Environmental Information on Climate Change”. The primary research question of this study was to ascertain to what extent a commercial entity can protect commercial information on the basis of commercial confidentiality while also facilitating consumers, investors and other parties that wish to verify environmental claims. This is an important issue as with a greater awareness of the issue of climate change and a corresponding increase in commercial entities making environmental claims as to their products and/or practices, there is an increased risk of the ‘greenwashing’ of products and services with no actual *bona fide* environmental benefits. If this was permitted to occur, it could gradually lead to a loss of consumer or investor confidence thus eventually undermining the evolving climate change mitigation regime. This would in turn lead to the virtual disappearance of a market for and thus investment in research to develop more ecologically sustainable products and services. The research is primarily of a doctrinal nature, complimented with case studies where appropriate. Over the course of the research it was discovered that commercial environmental information is overseen by a broad spectrum of regulatory structures. There can be seen certain *lacunae* and overlapping with regard to how certain categories of information should be dealt with. This is especially so with regard to the nascent financial markets relating to climate change e.g. the EU Emissions Trading Scheme (EU ETS). Within the framework of the EU ETS there is a lack of consistency in carbon accounting with both the UK based International Accounting Standards Board (IASB) and US based Financial Accounting Standards Board (FASB) yet to agree consistent guidelines on accounting for emissions.

**Keywords:** Climate Change, Regulation, Legislation, Financial Markets

**Poster EN1. Is the organic fraction of municipal solid waste a bioenergy resource or an environmental hazard?**

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The effective management of municipal solid waste (MSW) has become an important consideration at European and national and level in recent years. In Ireland over three million tonnes of MSW is generated annually, with over two thirds considered to be biodegradable. Waste infrastructure in Ireland is dominated by landfill, which is considered as the least favourable option in the waste management hierarchy. By 2016 Ireland will be legally obliged to divert up to 65% of biodegradable waste from landfill, relative to 1995 levels. Alternative waste treatment infrastructure is required to effectively manage up to 1 million tonnes of biodegradable municipal waste which is mainly comprised of food and garden waste. Movement towards more advanced waste treatment technologies has been slow in Ireland and is currently being hampered by a lack of certainty in the implementing waste management policy. In many EU countries, anaerobic digestion (AD) is effectively used to treat biowaste and harness the stored energy in biomass through the production of biogas which consists of approximately 60% methane gas. Biogas can be upgraded to biomethane using available technologies and can be used in the same manner as natural gas. A series of biochemical methane potential (BMP) tests were carried out to determine the upper limit of biomethane potential from source separated food waste (SSFW). An upper limit of  $469.1 \pm 29.9$  L CH<sub>4</sub>/ kg volatile solids added was achieved, indicating that SSFW food waste has a relatively large biomethane potential per kg of dry organic matter. The paper indicates that the organic fraction of municipal solid waste (OFMSW) presents a significant bioresource potential when utilised in an anaerobic digestion process to generate biomethane. It is estimated that biomethane produced from OFMSW could meet over 3% renewable energy in transport when used as a transportation fuel in compressed natural gas vehicles.

**Keywords:** bioenergy, biofuel, biogas, biomethane, biowaste, OFMSW

## **Poster EN2. Impact of Turlough Hill outage on electricity costs in the Single Electricity Market**

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The Single Electricity Market (SEM) established in November 2007, is the mechanism through which electricity on the island of Ireland is bought and sold. Pumped storage plays an important role in the context of the SEM as it is used to provide operating reserve and act as a grid balancing tool. Scheduling pumping during the periods of least demand and minimum SMP ensures that the lowest available cost generator is used to supply energy for pumping. Scheduling pumped storage to dispatch when the SMP is highest removes the most costly conventional generators from the system at times of high demand. Turlough Hill in the Wicklow Mountains is the only pumped storage plant on the island of Ireland and has a MEC of 272MW. In July 2010, the four reversible turbines housed at Turlough Hill were taken offline and have remained so for over a year. This study focused on the impact of this prolonged outage on electricity costs in the SEM. Publicly available data from the SEM was analysed using statistical techniques and the results are presented in this paper. It was found that the absence of Turlough Hill turbines had a significant impact on electricity costs in the SEM.

**Keywords:** Pumped Storage, Renewable Energy, Electricity

**Poster EN3. Microfluidic devices for enzymatic biofuel cell applications –  
Fabrication, characterisation and modelling studies**

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The ever-growing demand for miniaturized energy sources has triggered research on harvesting energy from the surrounding environment. Microfluidic biofuel cells are a very promising solution for miniaturised green energy sources. Implementation of selective enzymes in the channels of such devices takes advantage of the laminar flow to enable efficient energy conversion without the use of a membrane, which simplifies device fabrication. The design and manufacture, via microfabrication technologies, of a new generation of polymer-based microfluidic chips for energy bioconversion were the subject of this study. Fluid and mass transports incorporating a variety of different microfluidic designs were examined using numerical simulation techniques. Steady-state analytical solutions of enzymatic reactions at the surface of electrodes, in the presence of a mediator immobilized conductive polymer, have been obtained for the system and analysed in detail (including the influence of substrate and enzyme limiting concentrations). Surface modification of gold electrodes has been performed via a deposition of a 3D scaffold of nanoporous gold structures (NPG). Significant porosity and increased surface areas of modified anodes has been confirmed by high resolution SEM measurements. Electrochemical characterization of NPG electrodes has been carried out in static conditions, in buffer solutions containing glucose. The influence of mediated electron transfer and the presence of an enzyme, glucose oxidase, have been studied and improved electrocatalytic activity of NPG anodes in terms of glucose oxidation, have been corroborated as compared to the plane gold. First prototypes of non-porous microfluidic biofuel cells working in flowing conditions, in the presence of enzyme containing glucose and oxygen saturated buffer solutions, have been accomplished and characterized, confirming operability of the cells in a membrane free environment.

**Keywords:** enzyme, biofuel cell, microfluidics, nanostructure, modelling

**Poster EN4. Assessing the potential of biomethane production from macro algae available around Irish coastlines and estuaries**

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The potential to convert marine algae, a mineral rich, natural occurring biomass, which is in plentiful supply around the island of Ireland, into biomethane is being investigated. Both green and brown macro algae are commonly washed up on Irish beaches and shore lines. This abundant bioresource is often not utilised and is allowed to decompose along the shoreline causing bad odour and nuisance to the public. Such biomass could have many uses in biorefinery concepts, as a source of biofuel or as a co-feedstock in an anaerobic digestion process producing biogas. The island of Ireland has a coastline of roughly 7,500km, which allows for a large area of potential biomass to collect. In addition to this biomass there are particularly shallow estuaries which are prone to intense eutrophication and algal growth such as *Ulva Lactuca* blooms. In Ireland the concept of biogas production from a particular brown (Kelp *Laminaria* spp) and Green (*Ulva Lactuca*) algae species has not been fully investigated. Initial results from small scale biochemical methane potential (BMP) tests of the former, gave yields of 201 ml CH<sub>4</sub> g<sup>-1</sup> VS ( $\pm$  9.61) for a wilted, washed green algae. The Argideen estuary, in south west Cork, where biomass samples were collected, is currently rated as eutrophic by the EPA and is in need of a sustainable waste management strategy to deal with the mass deposition of green algae biomass commonly known as sea lettuce. Developing an economically and environmentally sustainable strategy such as treating algae both in an anaerobic co-digestion process could lead to a solution for the current sea lettuce pollution along the coastlines of south west Ireland.

**Keywords:** Methane potential, bioresource, Ulva, Kelp, anaerobic digestion, sustainable

**Poster EN5. Screening of selected microorganisms for thermo(acido)philic enzymes of potential use in the production of second-generation bioethanol**

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Combating climate change is a challenging global priority and a reduction in greenhouse gas emissions is necessary to limit global warming and avoid the most serious impacts of climate change. Initiatives taken by the EU to achieve this include mandating increased use of renewable transport fuels such as biofuels. Second-generation bioethanol can be produced from lignocellulosic feedstocks by a biochemical process involving the enzymatic hydrolysis of pretreated lignocellulosic material with subsequent fermentation of the resulting sugars to ethanol. Lignocellulosic enzymes active at high temperature are of interest in this process. Incorporation of thermoacidophilic enzymes in dilute-acid pretreatment could potentially reduce the acid concentration and temperature required for pre-treatment thereby reducing the severity and environmental impact of the process. Thermoactive enzymes are also of interest for the partial prehydrolysis (liquefaction) of pretreated material at high temperatures with the aim of reducing viscosity and improving mixing properties prior to enzymatic hydrolysis at lower temperatures. Alternatively, the enzymatic hydrolysis step could be undertaken at high temperature using such thermoactive enzymes. In the present study, selected microorganisms were screened for ability to produce appropriate thermo(acido)philic enzymes of potential use in the production of bioethanol. Several strains were found to produce endo-1,4- $\beta$ -glucanase, endo-1,4- $\beta$ -xylanase,  $\beta$ -D-glucosidase, 1,4- $\beta$ -D-xylosidase,  $\alpha$ -L-arabinofuranosidase and acetyl xylan esterase activities with activity at 70°C and pH 3. Three strains were also found to produce ferulic acid esterase activity with activity at 60°C and pH 4. Application relevant assessment studies undertaken on the crude enzymes produced by some of these strains show their ability to release reducing sugars from the lignocellulosic feedstock straw at 70°C. The results indicate the potential suitability of these enzymes in the production of bioethanol.

**Keywords:** second-generation bioethanol, lignocellulose, enzymes

**Poster EN6. Anaerobic digestion of food waste in Ireland: Microbial community and dynamics analysis during a long term operation of a two-phase system**

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In Europe, food waste constitutes a large proportion of bio-waste, accounting for 30-45% of municipal solid waste. Ireland produces over 100,000 tonnes annually, the majority of which is landfilled. To comply with EU regulations, disposal alternatives need to be developed. One alternative technology is anaerobic digestion (AD). AD is a naturally occurring process whereby complex substrates are converted to biogas (biofuel) via the concerted activities of anaerobic mixed microbial consortia. It comprises several steps: Hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Different microorganisms underpin these steps and work in sequence with the product of one group being the substrate for the other group. When applied to food waste the main issues encountered during AD are known to be the limiting rate of hydrolysis (solids destruction) as well as process failure when reactors are operated for extended periods of time (>1 year). This work aims to enhance and stabilise reactor performance during the AD of food waste by dividing the bioprocess into two distinct phases: i) hydrolysis and acidification and ii) methanogenesis, which were designed to take place in sequential, but separate reactors. In order to provide data to develop this AD process, batch anaerobic tests performed at 37°C were used to establish the biodegradability, intermediate formation and methane yield of the food waste collected from the canteen of the National University of Ireland Galway, over a period of one week. The specific methane activity (SMA) of the granular sludge used to seed reactors was studied. Molecular techniques were employed to monitor microbial population dynamics and to help control the process. This paper presents seed biomass activity, methane yield, concentration of intermediates and solids destruction data from mixed food waste.

**Keywords:** Anaerobic digestion, Food waste, two-phase system, methane yield molecular techniques

## **Poster EH1. Drinking Water Quality in Ireland**

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The European Communities (Drinking Water) No. 2, Regulations, 2007 assign the Environmental Protection Agency (EPA) the role of supervisory authority over public drinking water supplies and provides powers of enforcement to ensure actions are taken where the quality of public drinking water is deficient. The EPA gathers monitoring data on all drinking water supplies and produces an annual report on drinking water quality and on the enforcement of public water supplies. Local authorities must notify the EPA of any exceedances of the limits set in the legislation. The EPA applies a risk based enforcement approach and applies strategic initiatives to address specific gaps in the management of supplies. Audits of public supplies are conducted and the EPA can direct a local authority to take action to improve a supply. Enforcement of the legislation by the EPA has brought about improvements in the quality of public supplies and the management of supplies by local authorities. This paper demonstrates these improvements in drinking water quality in Ireland's drinking water.

**Keywords:** drinking water, enforcement, quality, exceedances

## **Poster EH2. The health of Irish buildings, their occupants, and the Technical Guidance Documents**

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The TGD's, are a set of documents providing guidance on building in accordance with the Building Regulations. When a residential development was evacuated last year due to the health and safety risks posed by the buildings, the media coverage brought building regulation into the public eye. Incompliance with regulations puts people at risk from unsound structures, exposure to hazards such as fire or toxic chemicals. The environment is put at risk from excessive water, energy and resource consumption. While the health risks of incompliance with TGD B are obvious, as it relates to fire safety, there are risks associated with other TGD's also. Sustainable Energy Authority Ireland (SEAI) reports on Building Energy Ratings (BER) show that ratings achieved are often below the minimum requirements on energy consumption of TGD L. High energy buildings, coupled with an increase in fuel poverty can lead to more cold related deaths, particularly in the elderly and infirm. Composite management of the TGD's is important. When a building achieves high levels of insulation and air tightness according to TGD L, adequate ventilation becomes critical. TGD F deals with ventilation, but has not been updated as often as TGD L. Inadequate ventilation increases indoor air pollution, condensation and mould (increasing respiratory illness such as asthma). Toxic chemicals and gases also build up, such as radon, increasing the risk of cancer, or carbon monoxide, which can be lethal, or Formaldehyde and Volatile Organic Compounds, (VOC's) which are carcinogenic, and are released from fixtures, fittings and finishes such as paint, plywood or carpet. These are known as the symptoms of Sick Building Syndrome (SBS). Buildings contribute to the health of humans and the environment. To address this, an overhaul of building regulation is required, through better enforcement, balance between the TGD's and incorporation of sustainability.

**Keywords:** Technical Guidance Documents, Sick Building Syndrome, building regulation, health and safety, environment, sustainability

**Poster EH3. Changes in the production of phytochemical compounds in red lettuce in response to supplemental blue light**

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This research was carried out to investigate the hypothesis that blue (440 nm) light can be used to increase the production of antioxidant phytochemicals in red leaf lettuce cv. Outredgeous. Lettuce was grown in controlled environment growth chambers in the newly implemented CELLS research laboratory at LIT. Four light treatments were applied with light emitting diode (LED) arrays at  $300 \mu\text{mol m}^{-2} \text{s}^{-1}$  of photosynthetically active radiation with an 18 h-light/6 h-dark photoperiod for 28 days. Two treatments applied blue light during either early or late stage of development. The treatments were: (a) red 640 nm ( $290 \mu\text{mol m}^{-2} \text{s}^{-1}$ ) + blue 440 nm ( $10 \mu\text{mol m}^{-2} \text{s}^{-1}$ ) with blue light removed at 21 days after planting (DAP); (b) red 640 nm light ( $300 \mu\text{mol m}^{-2} \text{s}^{-1}$ ) with blue light being added at 21 DAP. Control treatments were: (c) red and blue light for the 28 day cycle and (d) red light only for the 28 day growth cycle. Environmental conditions were maintained at 23 °C, 65% relative humidity and ambient CO<sub>2</sub> for the duration of the experiment. The phytochemical content of the leaves was determined before and after changes in blue (440 nm) light treatments using LCMS analysis of 60% methanol extracts of the leaves. Preliminary research has identified chicoric, tartaric, chlorogenic and malic acid as major components of the methanolic extracts. An increase in the concentration of cyanidin glucosides and quercetin glucosides was observed upon the introduction of blue light during the final week of growth. This suggests that spectral quality is regulating the production of these phytochemicals. Work is ongoing to identify the key steps for blue light regulation of the biosynthetic pathway resulting in the increased production of these compounds in red leaf lettuce.

**Keywords:** Controlled environment, blue light, lettuce, anthocyanin, flavonoids

## Poster EH4. Microorganisms as alternatives to animal drug testing

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One of the objectives of the recent European Union legislation governing the testing and evaluation of chemicals (REACH) is the promotion of alternatives to animal testing. The development and validation of methods to replace animal experiments with more ethical and environmental sustainable approaches has been placed firmly on the political agenda. Traditionally conducted in animal models, perfused organs or cell cultures, the study of the drug metabolism and toxicity of metabolites may be successfully performed using microbial cells. Some microorganisms, such as the zygomycete fungus *Cunninghamella* and actinomycetes bacteria, have been shown to metabolise xenobiotic compounds in an analogous fashion to mammals. Other numerous practical and economical advantages of using microorganisms are the low cost, the scale-up capability and the easier detection, isolation and identification of metabolites. In the present project, the zygomycete fungus *Cunninghamella elegans* is used as a microbial model to mimic the mammalian metabolism of several fluorinated drugs of clinical importance. The biotransformation of drugs and the determination of the metabolites was investigated using fluorine-19 nuclear magnetic resonance spectroscopy ( $^{19}\text{F}$  NMR), GC-MS and HPLC. The investigated fluorinated drugs were converted by *Cunninghamella* spp. to a variety of phase I and phase II metabolites present in several mammalian species, including man. The results strongly suggest that microbial models can mimic mammalian metabolism of fluorinated drugs so they may replace or, at least, complement the use of animals particularly for the early phases of drug development. Furthermore, the upscaling of the biotransformation may also have potential as a method of generating useful quantities of drug metabolic intermediates as analytical standards or for toxicity testing, avoiding the concerns often associated with chemical synthesis, such as the use of noxious reagents and harsh reaction conditions.

**Keywords:** drug testing, biotransformation, fluorine, *C.elegans*

**Poster EH5. Sourcing of sustainable groundwater supplies for rural water supplies: An assessment of a weathered crystalline rock aquifer system in Central Uganda**

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The important aspects in groundwater sourcing are being investigated in a crystalline basement aquifer in rural Central Uganda. Microbiological water quality in respect to faecal coliforms has been monitored at thirty-five water sources of different types over a period of seven months. The risk level based on the WHO guidelines associated with consumption of water from these sources was established and was correlated to water related illnesses in the area. In addition, the risk factors responsible for the current microbiological water quality were assessed. A model of water source contamination was developed based on the relationship between individual risk factors and levels of contamination. Furthermore, a hydrological assessment was carried out through an enhanced field monitoring regime. Analysis of temporal and spatial rainfall variations at catchment level and determination of evapotranspiration using the most recommended method enabled an accurate water balance study. Results from water quality analyses showed that shallow sources were associated with high risk and pollution sources come from simple anthropogenic, construction and environment related issues that can be controlled. Unfortunately, these shallow water sources are highly used which may explain the high prevalence of water related illnesses in the area. During the twenty-one month water balance study, the area was found to experience a bimodal weather pattern with long wet seasons of four to five months compared to dry seasons of two to three months. High evapotranspiration rates (in the range of 1000 mm/annum) are experienced while temporal and spatial rainfall variations are also high. Hydrographs plotted from piezometer data show that groundwater is affected by natural stress with an average fluctuation of one metre. The results of this study are being used to review well siting to provide rural water communities with improved supplies.

**Keywords:** Groundwater, rural water supplies, sustainability, crystalline rock aquifer

## **Poster EM1. Potable water distribution network model for quality and operations management**

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The field of water distribution network modelling is well established with numerous municipalities and operations companies across Europe and the US using them on a daily basis. The usage level in Ireland is far lower. Most Irish local authorities have Geographical Information (GIS) systems for above and below ground water services assets; however this data is rarely used to develop distribution network models. The absence of data for domestic consumption is one of the major barriers for the development and subsequent calibration and testing of network models. Furthermore, no standardised approach for network models exists for Irish local authorities. This project aims to outline a generic methodology for the creation of a GIS based water distribution network model, which will be calibrated using a genetic algorithm based approach. Collaboration with stakeholders such as a local authority is necessary for this project. Analysis of existing geospatial and operational data currently available within local authorities will provide a better understanding of the network, its condition and elements, including pipes, valves and meters. This data will be used to create and calibrate a computer based water distribution network model. Utilising this model, this project will develop operating procedures for on-going monitoring, maintenance and network improvement. This project will also model chlorine residual levels in order to assist in the development of cost effective disinfection regimes that both minimise disinfection by-product formation and maintain acceptable taste and smell typically associated with high chlorine residual levels. Successful completion of this project will address acknowledged problematic areas such as leakage and network condition monitoring in order to assist in existing leak detection procedures and operations maintenance.

**Keywords:** Water Network Model, Genetic Algorithm, Asset Management

## Poster EM2. Zequanox<sup>TM</sup> - Effectiveness in non target ecotoxicology studies

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Due to the invasion of zebra mussels in European and American waters there is a need for an environmentally friendly mussel control method to replace chlorine and other biopesticides currently in use in drinking water plants and other such infested facilities. To this end, Marrone Bio Innovations (MBI), an American company that develops natural pesticides, in co-ordination with New York State Museum, developed a product (MBI-401) commercially named Zequanox<sup>TM</sup>. This poster presents the non target studies carried out at IT Sligo to: (a) further evaluate the target specificity of Zequanox<sup>TM</sup> with respect to species in Irish water systems as well as those protected in aquatic ecosystems and (b) conduct studies and treatments with Zequanox<sup>TM</sup> on aquatic ecosystems impacted by invasive zebra mussels. The taxa chosen are widespread and fit within various functional feeding groups: mussels, *Anodonta* and *Mytilus*; water-flea, *Daphnia*, (filter feeders); mayfly, *Baetis sp.* (benthic grazers); water hog-louse, *Asellus aquaticus* and midge larva, Chironomidae (decomposers). These non target studies consist of 72 hour static renewal ecotoxicology testing, with doses ranging from low to high concentrations, 100-600 mg/l on average. MBI-401 applied at a low dose (<200 mg/l) to zebra mussels is effective in causing mortality whilst at the same time having no negative impact on the organisms tested. There was no significant mortality observed in any of the species tested at lower dose concentrations (<200 mg/l) however some of the smaller organisms tested like the mayfly suffered mortality at higher doses (>300 mg/l). The results of this study are important for gaining regulatory approval for the use of MBI-401 in European waters.

**Keywords:** Zequanox<sup>TM</sup>, static renewal ecotoxicology testing, taxa

### **Poster EM3. Monitoring of particulate matter accumulation and washoff on an urban road surface**

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Urban stormwater discharges have been recognised as a significant pollution threat to receiving waters due to the presence of suspended solids, heavy metals, hydrocarbons, nutrients and other toxic constituents in the runoff. The implementation of the Water Framework Directive will focus attention on diffuse pollution, including regulation of stormwater discharges. Therefore, an understanding of the sources and transport mechanisms of urban runoff pollutants is needed. The primary source of urban runoff pollutants are impermeable surfaces such as roads, roofs and other paved areas. These areas act as a sink for pollutants from vehicle emissions, atmospheric deposition and erosion of urban surfaces during dry weather. Subsequent rain events wash off this material into the nearest stormwater drainage system. Sampling of particulate matter was conducted on an urban residential road in south Dublin over consecutive days to investigate the accumulation and washoff patterns. The sampling area was split into zones to investigate the spatial variability and samples were retrieved using a dry-vacuuming technique. The testing consisted of total mass, particle size distribution and the concentration of heavy metals present in the solids. The results confirmed that the total sediment load increased with consecutive dry days. Variability was moderate within sampling zones, but high between zones. The mass and size distribution of the solids washed off during storm events were influenced by the rainfall intensity and duration. The highest concentrations of heavy metals were attached to the fine sediments between 63 and 150  $\mu\text{m}$ . A reliable test protocol for urban surface sampling was developed, and the testing highlighted the need to capture fine sediments in urban stormwater treatment systems.

**Keywords:** Particulate matter, stormwater, particle size distribution, heavy metals

## **Poster EM4. Preliminary Map of the Soils of Urban Dublin**

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This map of the Soils of Urban Dublin is a first attempt in Ireland to show urban land-surface materials in a way that is compatible with soil-surveys in rural agricultural lands. The classification system used is the World Reference Base for Soil Resources, including Technosols, Fluvisols, Regosols, and Arenosols. Buildings-and-pavement” (B&P in the map legend) equates to the class Ekranic Technosol in WRB. Less-specific groups of “Till-derived soil” and “Gravel-derived soil” are provisionally used where minimum criteria to identify WRB reference soil groups are not yet established. Four soil-landscapes are defined to group the soils: (1) Cut and Fill, formed of scalped surfaces in quarries, transport corridors with linear couples of excavated and deposited soil, municipal landfills, graveyards, and land reclaimed from the sea; (2) Industry (not included in (1)); (3) Settlement (ditto), including residential and commercial areas, and; (4) Urban Open, including diverse lands that are vegetation-dominated, but where much soil movement is expected to have occurred. Much work is needed before such a survey can be considered useful, including intensive field survey, soil characterisation by description and analysis, ground-truthing of indicators from remote imagery, polygon revision, and model testing. It does, however, represent the first portrayal of these soils in a way that is compatible with rural soil-surveys, and is a necessary basis for urban policies that relate to soils, such as the proposed Soil Framework Directive.

**Keywords:** urban, soil, survey, Dublin, Technosol, World Reference Base

**Poster ET1. Development of novel integrated photocatalytic adsorbents (IPCA) for organics removal from water & wastewater**

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Active pharmaceutical ingredients (APIs) are an important group of organic environmental contaminants that have the potential to cause health risks for humans as well as biota. Currently research interest is focusing on development of novel water treatment systems for their removal. Combining the adsorptive properties of activated carbons (ACs) with the photocatalytic properties of titanium dioxide (TiO<sub>2</sub>) to create composites is called integrated photocatalytic adsorbents (IPCAs). The aim of this research is to develop IPCAs that can photodegrade a range of hazardous organics in water and wastewater. IPCAs were prepared using ultrasonic impregnation of commercially available ACs and TiO<sub>2</sub>. The use of calcination (heat treatment) in IPCA preparation and its effect on photocatalytic performance was investigated and found to be negative. The surface morphology of the IPCAs was characterised using SEM/EDX and FESEM, which confirmed uniform deposition of TiO<sub>2</sub> nanoparticles across the AC surface. The physical and chemical properties of the IPCAs were investigated using XRD and FTIR. For adsorption and photodegradation studies two medium molecular weight APIs: famotidine and solifenacin succinate were chosen as model pollutants. UV irradiation from a 125 W medium pressure mercury lamp was used to demonstrate the removal of famotidine and solifenacin from aqueous solutions using IPCAs. These studies indicated that IPCAs can remove more solifenacin from deionised water solutions than either TiO<sub>2</sub> or AC separately; however for famotidine removal the IPCAs show no improvement compared to AC or TiO<sub>2</sub> in both deionised water and wastewater matrixes. The adsorption of famotidine onto IPCAs is pH dependant and is highest at pH8 while solifenacin adsorption demonstrates no trend with increasing pH. The IPCAs adsorbed more famotidine (0.276 mmol/g) than solifenacin (0.128 mmol/g) at equilibrium and the reasons for this are explored.

**Keywords:** Activated carbon, titanium dioxide, famotidine, solifenacin succinate, IPCA

## **Poster ET2. Water technologies for deployment in Cork City and County**

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Managing Irish water services is a constant and demanding task for the country's local authorities; so a technological hub to aid the councils is a timely and innovative resource. Several small-scale research projects for the benefit of Cork City and Cork County Councils have been conducted, alongside novel instrumentation development in collaboration with Irish SMEs. Relevant, real-world research projects provide useful solutions for local authorities to implement according to need. Initially, the focus is on Remote Supervision of Multiple Small Sites; Viable Technologies for Treatment of FOGs; Workflow Management Systems; and Centralised Information Acquisition Solutions for DMAs. Additionally, instrumentation is being developed for aquaculture and horticulture industries. Future work includes harnessing expertise across multi-disciplinary groups to create a sound foundation for water quality and delivery research.

**Keywords:** Water quality, FOGs, DMAs, remote monitoring, innovation centre

**Poster ET3. Development of an immunoassay for determination of polycyclic aromatic hydrocarbons in water**

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PAHs are organic compounds formed from incomplete combustion processes, consisting two or more fused aromatic rings. They are very harmful because of their carcinogenic and mutagenic content. Monitoring PAHs in water is important because of its highly mobile state and transportation capability. This project is based on developing a portable immunosensor biochip for screening of PAHs in water. This sensor provides sensitive and specific output as it detects specific PAHs using an immunological reaction. The biochip consists of a three electrode system with gold as the working electrode sensor. A hapten conjugation of bovine serum albumin and phenanthrene (BSA-PHE) has been synthesised as the immobilised receptor biomolecule for indirect enzyme-linked immunosorbent assay (ELISA) with PAH antibodies and free PAH analytes. A modified Ag/AgCl reference electrode was employed to enhance the stability of the immunosensors. A competitive ELISA was carried out within the electrode using alkaline phosphatase (AP) as the labelled-enzyme. The limit of detection (LOD) for this sensor is in the range of 1 - 100 ng l<sup>-1</sup> in aqueous sample. Modification of the gold surface was done to enhance the excellent binding of antibody towards the antigen, thus the response is increased. Proof of concept has been established for the microsensor, future developments will focus on new sensor design and fabrication. Validation of the electrochemical immunosensor was achieved by comparing results obtained with chromatographic techniques.

**Keywords:** Biosensors, PAHs, immunosensors, monitoring

**Poster ET4. Associations between spatial patterns and sources of Pb in urban soils at different spatial scales in Ireland**

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One of the main challenges in urban soil studies is to identify the sources of pollutants. This study investigates the associations between spatial patterns and sources of Pb in urban soils at different spatial scales in Ireland: the national scale, a regional scale of Galway City, site scales of green areas of a roadside sports ground, a historical rubbish dumping site, a bonfire site and an urban park. At the national scale, the spatial patterns of elevated concentrations of Pb in soils are in line with the locations of major urban areas, mining sites, and Pb-containing rocks, affected by the sources of urbanization, mining activities and underlying geology. At the regional scale of Galway City, elevated concentrations of Pb is found in the city centre areas with a high density of road network, implying the source of historical traffic emissions. Elevated Pb concentrations along the roadsides of a sportsground and an urban park also showed the sources of historical traffic emissions. The bonfire associated elevated Pb concentrations were found as scattered spatial outliers, and the rubbish dumping associated elevated Pb concentrations were located at areas where the rubbish was exposed in the air or the top soil cover was thin. Spatial patterns at large spatial scales are helpful for the identification of sources at large scales, and *vice versa*. Such associations between spatial patterns and sources of pollutants help to improve our knowledge of urban soil pollution processes and pollution management.

**Keywords:** Spatial analysis, Spatial distribution, Sources, GIS, Pb, Soil

## Poster MCR1. Algal-exuded organic ligands as modulators of metal bioavailability in seawater

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This work describes species-specific ligand profiles observed for three brown macroalgae (*Laminaria hyperborea*, *Fucus vesiculosus*, and *Ascophyllum nodosum*) as a function of exposure to copper or zinc over 7 days. Cathodic and anodic stripping voltammetry (CSV and ASV) were used to determine total metal concentration, metal complexing capacity of exudates, conditional stability constants of exudates, and glutathione and cysteine concentrations in the media. All species released ligands that significantly enhanced the total ligand concentration of the initial seawater. Positive covariation of metal concentration and exuded ligands supports the hypothesis that the release of extracellular ligands is modulated by metals. In direct contrast, exuded glutathione was typically highest in the control culture indicating it is not a contributor to the metal binding ligands released here. Cysteine was detected only under the highest metal treatment for *L. hyperborea*. While the composition of exudates varied with species, complex stability constants were similar in all treatments. These values are similar in magnitude to those reported for sea and estuarine waters, thus suggesting that a major fraction of ligands in seawater is derived from macroalgae. Independent of the concentration of organic material exuded, stabilities of metal-organic complexes did not change within species upon metal treatment. This suggests ligands from each seaweed species possess similar chemical characteristics. Overall, results indicate the release of extracellular ligands is a species-specific phenomenon and metals modulate the quantity and quality, but not the complexing capacity, of the released exudates. Future modelling and monitoring of trace metals in coastal waters should consider the impacts of contaminant-induced exudation on the bioavailability of trace metals.

**Keywords:** algae, metal bioavailability, organic ligands, voltammetry

**Poster MCR2. Metal speciation in estuarine waters: On-site voltammetric determination at Lough Furnace**

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As a result of the OSPAR convention (1998) and The Water Framework Directive of the European Parliament (2000/60/EC), the concentrations of metals and their inputs into seawater must be monitored by each country of the European Union. While some metals act as micronutrients for marine species, most metals are toxic at high concentrations. Metal speciation is also crucial: both bioavailability and toxicity are highly dependent on speciation. The use of anodic and cathodic stripping voltammetry can permit the determination of both the total concentration of a given metal and the concentration of uncomplexed metals. This project uses existing voltammetric methods to develop a portable and semi-autonomous voltammetry system capable of measuring multiple metals simultaneously in natural waters. Pretreatments of the samples allows for determination of the speciation of the metals studied. The instrument was deployed at a lake (Lough Furnace) in the northwest of Ireland (Co. Mayo) where both fresh and salt water are present and clearly separated. Concentrations as well as behavior of zinc, cadmium, lead and copper were studied as a function of the physicochemical properties of the water. Science Foundation Ireland (SFI) has funded this work.

**Keywords:** metals, speciation, voltammetry

## **Poster MCR3. Tracking Environmental Change Using Coastal Sediment Records**

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Coastal sediment records can be used to track Holocene environmental change; including climate change, sea level rise, freshwater discharge and recent anthropogenic changes. An understanding of past, contemporary and future coastal systems requires temporal datasets that can integrate natural conditions and subsequent human induced deviations. This project is a paleoecological study, utilising the sediment record to link spatial and temporal data for coastal ecosystems and applies their use in the Galway Bay region. A transect of the inner bay silt/clay depositional areas <1.8km from the coast was targeted for core extraction. These sediments are being examined for their physical, chemical and biological properties and their response to bay dynamics, the range of natural variability and responses to unusual events. Sediment records portray amalgamated profiles of the extent of land-based activities, along with sedimentation rates, time marker horizons, geochemical signatures and biological responses represented in fossil assemblages. These assemblages provide evidence of the aquatic system dynamics during the past centuries, thereby providing an ecological track for further assessment of contemporary and future impacts. The provision of information to help define background (reference) conditions, assess change of state and help anticipate ecosystem responses is imperative to achieve integrated coastal zone management and anticipate reaction to climate variability and to guide policy and legislation in these fields. This poster presentation represents the work completed to date: four Vibrocore samples have been examined and sedimentology, lithology and stratigraphy have been established; fourteen AMS 14C dates have been obtained, ranging from 535 to 11,699 years before present (BP). On-going investigations include fossil assemblages, biochemical properties, salinity levels and sea-level variation. Based on these investigations, past climatic conditions and environmental change during the Holocene in Galway Bay will be assessed.

**Keywords:** palaeoecology, palaeoceanography, sediment record, climate change, holocene, fossil assemblages, Galway bay, coastal ecosystems, sea level rise, environmental change

**Poster WQ1. A novel methodology for field based water sampling from groundwater wells for laboratory based multi-element analyses**

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In recovering groundwater samples for trace metal analysis, it is critical that a robust, reliable and replicable protocol be used if reliable survey data is to be generated for local authorities, government agencies and policy makers. A comprehensive methodology for preparation of sampling equipment and bottles and for recovery of water from wells is presented in this poster which ensures that the representative sample recovered is free from potential trace metal contamination from the handling process. Before sampling all of the field apparatus that come into contact with the water and the LDPE sample bottles were subjected to a rigorous cleaning procedure involving sequential soaking (for 1 week at a time) in phosphate- free detergent and trace metal grade acids; 4M HCl, 6M HNO<sub>3</sub> and 1% HNO<sub>3</sub>(Ultrapure). The fieldwork requires two people operating a 'clean hands - dirty hands' technique where the 'clean hands' person only touches the bottles and samples while the 'dirty hands' person only touches equipment. Samples are recovered using Low Flow sampling protocol (as per US EPA 1669, SESPROC-301-R1 (2007)) combined with an ultra clean (trace-metal-compatible) sample handling technique. Low Flow sampling is based on the principle that water in the open borehole is in equilibrium with water in the formation. During the pumping both drawdown and unstable parametric values are recorded (pH, temperature, conductivity (EC), redox potential (Eh), and dissolved oxygen (DO) are recorded until stabilised when a sample is then recovered). A split line incorporated onto the sampling apparatus allows for the simultaneous collection of non-filtered and filtered sample portions.

**Keywords:** groundwater, trace metals, sample recovery

## **Poster WQ2. A Miniaturised Conductivity Sensor for Marine Environmental Applications**

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In 2007, EU member states were required to adopt Directive 2005/35 into national law, which covers ship source pollution. This involves investigation of discharges of oil and other polluting substances in ports. Established methods for the detection of pollutants in waters are based on sampling and analysis of discrete water samples, which are performed in laboratories located remotely from the sampling sites, and are personnel-dependent, time-consuming and expensive. There has been growing interest in research and development of chemical sensors and biosensors which can meet the monitoring needs in polluted water at the point-of-need. SHOAL (FP7-ICT-231646) is developing a robotic fish which can detect pollution (including copper, lead, phenol derivatives) in real-time at the source through incorporation of a highly sensitive chemical sensing system. Here, one of the sensors, a miniaturised conductivity sensor (interdigitated Pt electrode array on silicon fabricated using state-of-the-art micro- and nano-technology) is described. Conductivity provides a rapid assessment of seawater quality, information on the absence/presence of pollutants, and, being a measure of the total level of dissolved salts and minerals can be used for evaluation of salinity. Determination of physical parameters including salinity, temp, pH are necessary for accurate pollutant monitoring. In this study, the design, development and characterisation of the sensor are discussed. Impedance spectroscopy was used for evaluation of the sensor behaviour in conductivity standard solutions, artificial seawater and organic contaminates. The optimal structure, equivalent circuit and the optimal sensor setting have been determined. The performance is comparable with Metrohm 712 conductometer.

**Keywords:** Conductivity, Seawater, On-chip, Interdigitated

**Poster WQ3. Evaluation of the temperature and pH effects on performance of the electrochemical sensor for detection and quantification of copper in sea water**

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This study concerns the development and characterization of electrochemical sensors for pollution monitoring in the natural waters of ports and estuaries. It reflects a surge in special emphasis on environmental problems as indicated in the European Parliament and Council Directive 2005/35/EC of 7 September 2005. The pollutant of particular interest in this work is copper, which, at high concentration, is one of the most toxic metals to aquatic organisms and ecosystems. The developed sensor is based on a three electrode micro electrochemical cell constructed on a silicon die and consisted of a platinum working microelectrode array, a platinum counter electrode and an Ag/AgCl reference electrode. The details of the sensor design, fabrication and characterisation are given in previous publications. The objective of this work is effect of pH and temperature on the sensor performance. This investigation is essential for successful sensor implementation in the real-time marine environment (e.g. based on using robotic fish for detecting pollutions). In practice these environmental factors are variable and their impact on the main sensor parameters such as signal peak value, sensitivity and limit of detection can be significant. The experiments conducted in artificial seawater in the temperature range of 10 to 25 °C and in pH range of 6.0 to 8.0 confirmed this point. Thus, it was found that the peak of the sensor current decreased by 2.5 times with the temperature decrease from 25°C to 10°C (from 27.3nA to 10.8nA at the copper concentration of 3 µM) with corresponding reduction of sensitivity of 5 times (from 5.454nA/µM to 1.12nA/µM). The peak current and sensitivity of the sensor decreased as the pH of the solution deviated from neutral value. For example, at 25 °C, the sensitivity reduced from the maximum value 5.454nA/µM taken at neutral pH 7.0 to 1.83nA/µM at pH 6.0, and 2.142nA/µM at pH 8.0.

**Keywords:** Electrochemical, Copper, Seawater, UPD-SV

**Poster WQ4. Determination of the fate of antimicrobial resistant *E. coli* in a wastewater treatment plant using Monte Carlo simulation**

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Wastewater treatment plant (WWTP) effluent has been identified as a potential source of antimicrobials and antimicrobial resistant (AMR) bacteria. Environments containing high loads of antimicrobials and bacteria are a concern because they may exert selective pressure and contribute to the dissemination of resistance. Hence, it is important to investigate the role of WWTPs in the recombination, exchange and dissemination of environmental resistance. A Monte Carlo simulation model was developed to evaluate the fate of ampicillin, streptomycin, cefoxitin, cefotaxime, tetracycline, sulphonamide and ciprofloxacin resistant *E. coli* within a WWTP. Samples were examined (n = 15) along a municipal wastewater route from a specific hospital to WWTP. Resistant and total bacteria were recorded. The quantitative data was used to create probability density distributions representing bacteria load and growth/survival factors which model the change of bacteria within the WWTP. Model predictions varied for each AMR *E. coli* complex. While overall bacterial counts reduced during WWTP processing, in some instances, the proportion of resistant strains were seen to increase. The proportion of streptomycin, cefoxitin, cefotaxime, tetracycline, sulphonamide and ciprofloxacin resistant *E. coli* increased after WWTP processing. Contrastingly, the proportion of ampicillin resistant *E. coli* decreased after WWTP processing. The greatest change in population resistance was seen in cefoxitin and cefotaxime resistant *E. coli*. The proportion of resistance strains increased from 7% and 8% resistant to 29% and 27% resistant, respectively. The model incorporates the uncertainty and variability of the quantitative data facilitating the identification of critical stages of the processing of effluent. There is a need for further investigation into the role WWTPs play on the development and maintenance of AMR strains. In particular, what affect, if any, hospital effluent containing high loads of antimicrobials and AMR determinants contributes to the development and dissemination of resistance.

**Keywords:** Wastewater treatment plant, Antimicrobial resistance, Monte Carlo simulation

**Poster WQ5. Understanding the factors influencing the formation of disinfection by-products in drinking water: Quantification and characterisation of aquatic humic substances**

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Humic acids form a significant fraction of aquatic natural organic matter (NOM). They are known to react with disinfectants during the production of drinking water. Thereby, humic acids act as major precursors to hazardous disinfection by-products (DBPs). Information on the complex chemical structures of humic acids is unresolved and the mechanism of DBP formation is unclear. This research focuses on understanding the extent of DBPs formation under different treatment and source water conditions, including the NOM character of abstraction waters. This poster will explain how humic acids, in the presence of disinfectants, can form toxic by-products such as trihalomethanes (THMs) and haloacetic acids (HAAs). The quantification of humic acids in water using a liquid-liquid extraction procedure followed by UV-Visible spectrophotometric analysis at 520 nm will be described. Humic acids will also be characterised by Infrared Spectroscopy in an effort to understand the molecular nature of NOM in source waters. The importance of characterisation and quantification of humic acids to prevent the formation of DBPs will be demonstrated in this poster. The theme of ENVIRON 2012 - "Our Environment: Integrating Today's Research with Tomorrow's Actions" – is addressed by this research in that it will provide support for the regulation of disinfectant by-products with regard to the EU Drinking Water Directive and public health issues.

**Keywords:** Disinfection by-products, natural organic matter, humic acids



**Annual Review 2011**

**CHAIRPERSON'S ADDRESS:  
From Dr. Paul Bolger**



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The Environmental Sciences Association of Ireland (ESAI) was established in 1991 to “*facilitate communication and interaction between persons interested in the environment through colloquia, seminars, workshops and publications*”. The association currently has over 500 members. Its activities are funded through an annual membership fee (€50 annually with a €25 concessionary rate for students). In attending the ENVIRON colloquium you are automatically entitled to a year’s free membership of the association. The majority of the association’s work is carried by the ESAI Council which meets 4-5 times a year. We are currently fortunate to have a hard-working, enthusiastic & committed Council who deserve credit for their efforts that they have made to sustain and develop the association over the past year. We are always looking for new members to join the ESAI Council so, if you are interested, please come along to our AGM which takes place at 1.30 PM on Thursday of the colloquium.

One of the main activities in 2011 has been the re-development of the ESAI website which received a much needed facelift. The new ESAI website was launched in December 2011 ([www.esaiweb.org](http://www.esaiweb.org)) and is a major improvement on the old website which is due in no small part to Emmet Jackson who managed the project. The new website is clean, uncluttered, easy to navigate and looks terrific. Well done Emmet! The Association has also set up an ESAI Facebook and Linkin page – we would encourage ESAI members to log in and share their thoughts and opinions on all things environmental.

The 2011 ESAI photo-competition had another record high number of entries. The theme of this year’s competition was Life in the Urban Jungle. Congratulations Gerry Sugrue for his winning entry “Ducks marching through a luxury hotel into a summers evening” and thanks to Alan Berry for his work in organising and promoting this competition. The Association has also produced two newsletters in 2011 under the skilled editorship of Dr John Wann and Mr Timothy O’Sullivan. These newsletters can be downloaded from the ESAI website.

Income is the life-blood of any organisation and we sincerely thank all ESAI members for continuing to support the association in these difficult economic times. The ESAI has put in new accounting procedures that ensure all monetary transactions are approved by two members of the ESAI Council-Administration.

In addition we have appointed an external accountant to audit the ESAI accounts on an annual basis and the Association Treasurer (currently Nuala Murphy) will present these audited accounts at the ESAI AGM.

The ESAI became a company in 2008 in order to apply for funds from the Irish Environmental Network (IEN). The Association was unsuccessful in receiving funds from the IEN and a decision was taken by ESAI Council in 2011 to dissolve the company and return to the status of Association which is more suited to the aims and decision-making structures of the organisation.

In 2012 the ESAI Council hopes to develop the following areas of the association:

- Bring more benefits and added-value to members
- Broaden the association's membership to encompass all environmental professionals
- Examine at the possibility of developing an all-Ireland database on environmental research and expertise

We would be interested in your views and inputs on the above items and would encourage you to express your views to me at [chairperson@esaiweb.org](mailto:chairperson@esaiweb.org) or else on our Facebook account.

Finally, on behalf of the ESAI, I wish to say a sincere thanks to Dr Brian Quinn for his contribution to the association who is stepping down from the ESAI Council after 5 years of service. I would also like to acknowledge the ESAI administrator, Sinead Macken, who is a repository of knowledge on the ESAI past and present, for her work, dedication and support in 2011.

Dr Paul Bolger

Paul Bolger is manager of the Environmental Research Institute at University College Cork. He has been on the ESAI Council since 2007, served as treasurer from 2008-2009, vice-chair in 2010 and was conference convenor at the 2011 ENVIRON in University College Cork.

## **ESAI GOALS AND OBJECTIVES 2011:**

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**The ESAI (Environmental Science Association of Ireland), founded in 1995, is a not for profit organisation.** The membership is drawn from all sectors and disciplines, ranging from biology and ecology to engineering, hydrology and management and from professors to amateur naturalists. The goals and objectives of the organisation are to:

- Provide a forum to facilitate exchange of specialist information and advice amongst environmental researchers, policy makers, environmental management practitioners and other stakeholders, within Ireland and elsewhere.
- Promote a fuller awareness of the role that higher-level education institutions may make in finding solutions for the urgent environmental problems confronting contemporary society.
- Provide a forum for networking amongst environment researchers both at national and international scales.
- Facilitate an annual conference aimed at providing postgraduate and other researchers with an opportunity to learn about each other's work, and for postgraduates to present and publish papers within a supportive community.
- Promote high professional standards amongst environmental researchers and professionals.
- To ensure a platform for science-based research on the environment in Ireland.
- Provide a Code of Ethics for Environmental Professionals in Ireland through its membership.
- To maintain growth in the membership base.

## **CONTACT DETAILS**

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## **MEMBERSHIP:** **Make the most of your Membership**



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### **Benefits of Membership**

By becoming a member of ESAI, you will also have access to:

- Discounted rates at Environ, Annual Irish Environmental Researchers Colloquium, one of the major activities of the Association. It is now one of the largest national scientific meetings in Ireland attracting over 300 delegates each year.
- Networking at your finger tips by featuring in a Directory of Expertise on the ESAI website.
- Access to ESAI listserver
- Reduce isolation
- Learn from others and absorb best practice
- Raise the profile of you and your business
- Stimulate new business opportunities
- Innovate and commercialise new products and services

### **Raise your Profile**

- Members of ESAI will receive free-of-charge E-Newsletters, Environews.
- Member presence in the online Directory of Expertise on [www.esaiweb.org](http://www.esaiweb.org).
- Sponsorship opportunities

### **Keeping you Informed**

The ESAI website – [www.esaiweb.org](http://www.esaiweb.org) – has now become a valuable resource for environmental professionals in Ireland. The new events area offers a snapshot of what is happening in the industry nationwide. The website is designed by AttikDesigns.

## 2011 EVENTS:

### 6<sup>th</sup>-8<sup>th</sup> April:

Environ 2011;  
21<sup>st</sup> Annual Environmental  
Researchers Colloquium hosted  
by  
University College Cork

*Venue for Environ 2011: Main  
Quadrangle: University  
College Cork.*



### 6<sup>th</sup> April:

Ocean Studies – Avenues for Employment *Workshop and Field Trip*  
Geospatial Technologies – Their Real Value for your Real World Applications  
*Workshop*  
Scientific Writing & Presentation: A Beginners Guide *Seminar*  
Environ 2011, UCC

### 8<sup>th</sup> April:

Life Coaching *Workshop*  
Environ 2011, UCC

### 23<sup>rd</sup> July:

Launch ESAI 2011 Photography Competition  
“Nature in the Urban Jungle”



*“The Energy of Water”*  
*Juliette Giannesini 2010 Winner*

### 1<sup>st</sup> December

Launch of the new look ESAI  
website

## ENVIRON 2011

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The 21st Irish Environmental Researcher's Colloquium (ENVIRON 2011) was held in University College Cork (UCC) from Wednesday, April 6th - Friday April 8<sup>th</sup>, 2011. UCC last hosted the ENVIRON colloquium in 2002 and we were delighted to have the colloquium back in Cork in 2011. We were also very pleased to have the Environmental Protection Agency as a new partner in this year's colloquium; their increased financial and organisational support was key to the success of this year's event. The colloquium was well attended with over 250 delegates over the three days and we were very fortunate to have sunny April weather throughout the three days of the conference to allow delegates to enjoy the UCC campus as they moved between the various workshops and research talks.

On the Wednesday evening of the colloquium, Professor Michael Depledge (former Chairman of the UK Science Advisory Committee on the Environment & Climate Change) delivered a thought provoking colloquium keynote address on the topic of "Health and the Value of Nature". Professor Depledge, who has recently established the European Centre for Environment and Human Health in Cornwall, talked about the importance of the natural environment to human health outlining evidence from his research that close interaction by people with their natural environment (whether it be a walk on the park, cycling in the countryside or a swim at the beach) has demonstrable beneficial health effects. Professor Depledge's talk can be viewed at the web-link below:

<http://interactive.ucc.ie/test/new/include/sciencelectures-current.html>



*Professor Michael Depledge who delivered the ENVIRON 2011 keynote address*

The colloquium was officially opened on Thursday morning by the Dr Michael Murphy, President of University College Cork. The UCC President pointed out that the environmental research being presented at ENVIRON has slowly moved from being of somewhat peripheral interest to economic, political and social centre stage as the problems of global warming, energy security and biodiversity loss has focused minds globally on how human activities impact on the environment and on the dependency of economic growth on finite resources. The official opening was followed by the colloquium's plenary session which had a number of high profile speakers who provided presentations on the colloquium theme of "Towards 2020: Environmental challenges and opportunities for the next decade". Professor John Sweeney (NUI Maynooth) spoke of the challenges for Ireland in adapting to climate change emphasising that local and global action is vital to increase resilience to future climate change impacts focusing on water resource management, biodiversity, building and construction, coastal flooding and governance. Ms. Laura Burke (EPA Director) discussed the contribution of environmental research to informing environmental policy in Ireland particularly in the areas of climate change and water protection, and emphasised the importance of maintaining capacity and investment in environmental research. John Mullins (CEO of Bord Gais) spoke about the opportunities presented by the climate change challenge in terms of the green economy and renewable energy.



*ENVIRON 2011 Plenary Panel (L-R): Dr Jerry Murphy (UCC), Mr John Mullins (Bord Gais), Ms. Laura Burke (EPA Director), Professor John Sweeney (NUI Maynooth) and Dr Michael Murphy (President, UCC).*

The colloquium research programme had over 150 oral and poster presentations presented under the themes of:

Water Quality

Energy & Climate Change

Marine and Coastal Research

Biodiversity and Ecosystems

Environmental Management

Environmental Technologies

Environment and Health

There were 96 oral presentations at the colloquium with over €2000 worth of prize-money available for both oral and poster presenters along with a number of new prize categories such as a prize for Best Environmental Technology presentation. The overall winner of the best oral presentation was Avril Challoner from Trinity College Dublin on her research “Indoor outdoor air quality relationship in an urban environment: Dublin case studies” (see article on following pages for further details). For the first time at an ENVIRON colloquium researchers presenting posters were invited to do a one-minute oral presentation on their posters at the oral presentation sessions. The feedback from this initiative was extremely positive as it allows researchers in the early stages of their research to highlight their work and it is hoped that it will become a regular feature of future ENVIRON colloquia.



*John Walsh (Lifetime Labs) presenting prize for Best Overall Oral Presentation at ENVIRON 2011 to Avril Challoner (TCD).*

ENVIRON 2011 devoted an increased emphasis on training and transferable skills for environmental scientists and engineers with the first day of the colloquium given over to workshops and training seminars. The “Ocean Studies” workshop ran for a full day and explored the possibilities around careers in education and outreach, sustainability and economics, marine transport consultancy and environmental and biodiversity protection, as well as discussions on essential life skills for work at sea and understanding the European research funding system. The “Ocean Studies” workshop was supported by the Environment Graduate Programme along the Coastal & Marine Resources Centre, UCC and the Irish Society for Ocean Studies.

A half day workshop on science communication was also held and proved very popular. The workshop was facilitated by Professor William J. Reville (UCC) and Dr Brian Quinn (GMIT). Professor Reville discussed the importance of communicating science to the public emphasising the importance of telling a story, expressing opinions and the appropriate use of humour! Dr Brian Quinn’s talk focused on how scientists and engineers can improve their communication with their peers and provided insight into the basic principles to adhere to and pitfalls to avoid when writing your first publication or when presenting scientific results.

Mr Andy Day (Compass Informatics) and Dr Fiona Cawkwell (UCC) provided two linked workshops on the use of Geographical Information Systems (GIS) and Remote Sensing (RS) for the capture, analysis and presentation of spatial data for a variety of environmental applications. The workshops showcased some real world applications within GIS and RS software and focused on Irish environmental issues with an emphasis on practical solutions using GIS and RS. Finally Ailbhe Harrington returned to ENVIRON 2011 to give her very popular workshop on Life Coaching.

The conference meal took place in the nearby River Lee Hotel and was followed by a “casino night” where the well-fed conference delegates could gamble their “fun money” at roulette or card playing. After the conference meal a presentation was made from the ESAI Council to Dr Shirley Gallagher in thanks for her work on the Council and as ESAI Chairperson for the past decade. The ENVIRON 2011 colloquium closed on Friday afternoon with a prize giving ceremony and an announcement that the 22<sup>nd</sup> Irish Environmental Researcher’s Colloquium (ENVIRON 2012) is to be held in University College Dublin on March 7<sup>th</sup>-9<sup>th</sup>, 2012 to coincide with the Dublin City of Science festival. From the ENVIRON 2011 organising committee best wishes to the ENVIRON 2012 organising committee.

## Student Prize Winners 2011

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There were 150 presentations in total made at the Environ 2011 colloquium and the ESAI ran their annual student competition, judging all student talks and presentations, making the difficult decision to find the best posters and talks. The ESAI would like to thank the many judges that assisted with the competition. The winning student presentations chosen by the ESAI were as follows:

**ESAI Best Overall Oral Presentation** (sponsored by LifeTime Lab) went to **Avril Challoner, TCD** for her talk “Indoor outdoor air quality relationship in an urban environment: Dublin case studies”.

**ESAI Best Overall Poster Presentation** was awarded to **Peter Downey of the CELLS Research Group in LIT**, with his poster entitled “Effects of growth parameters and gravity on Isoflavonoid production in etiolated soybean seedling and callus tissues”.

**Best Forestry Oral Presentation** (sponsored by Dept. Of Agriculture, Fisheries and Food, Coford Research Programme) was presented to **Joanne Finnegan, NUI Galway** for her talk on her research “Assessment of Impacts of Forest Operation on the Environment”.

**Best Forestry Poster Presentation** (sponsored by Dept. Of Agriculture, Fisheries and Food, Coford Research Programme) was given to **Rob Deady, UCC** with his poster entitled “Diptera diversity associated with debris resulting from thinning and clearfell activity in commercial Sikta spruce plantations”.

**Best Soils Presentation** (sponsored by Soil Science Society of Ireland) went to **Agnieszka Piwowarczyk, UCD** for her talk on “Adsorption isotherms of fungicide chlorothalonil in selected Irish Soils”.

Of the new awards in 2011;

**Best Environmental Technology Presentation** (sponsored by Glantreo Ltd.) was received by **Patrick Morrissey, TCD** for his talk on “The impact of on-site wastewater treatment for small community developments on groundwater quality”.

**Best Biodiversity Presentation** (sponsored by Aulino Wann & Ass.) was awarded to **Brendan Canning, NUIG** based on his talk which posed the

question “Upland commonages in Connemara: can biodiversity be used to inform sustainable agri-environmental policy?”

**Best Waste and Resource Management Presentation** (sponsored by CIWM) went to **Donall Dowd, GMIT** for his presentation entitled “Design out waste in construction”.

Our sponsorship for prizes was greatly appreciated with a record €2,000 to present to students this year. Many thanks to the continued support from our sponsors and a big welcome aboard to all our new prize sponsors!



**PHOTOGRAPHY COMPETITION 2011**  
Available online [www.esaiweb.org](http://www.esaiweb.org)

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**Winning photograph “Ducks marching through a luxury hotel into a summers evening” Gerry Sugrue.**

The theme of the 2011 ESAI Photography competition was “**Nature in the Urban Environment**”. The competition was opened to all amateur photographers on the 1<sup>st</sup> August 2011. Due to the overwhelming number of international entrants last year, this year’s competition was restricted to entrants from the island of Ireland. Photographs were judged on picture quality, composition and appropriateness of caption. The winning photograph entitled “Ducks marching through a luxury hotel into a summers evening” was taken by Gerry Sugrue from Dublin. The winning photographer received a framed copy of their photograph together with a €250 voucher for photographic equipment, kindly sponsored by the Environmental Research Institute at University College Cork. The two runners up in the competition, entitled “Starlings on my aerial” by Leon Murphy, and “Green Light” by Anna Pielach, both received a one year membership to the ESAI.

2<sup>nd</sup> Place:  
“Starlings on my  
aerial”



3<sup>rd</sup> Place:  
“Green Light”



The winning photographs will be displayed in the Photo Competition Gallery section of the ESAI website at <http://www.esaiweb.org/gallery/photo-competition>. All photographs entered to the competition can be viewed on our Facebook page at: <http://www.facebook.com/pages/ESAI-Environmental-Sciences-Association-of-Ireland/14517104891002>

## ESAI INCOME AND EXPENDITURE ACCOUNT

For the year ended 31 December 2011

<b>Opening balance as at January 1st 2011</b>		<b>432.88</b>
	€	€
<b><u>Income</u></b>		
Membership	3628.71	
Membership (Environ)	8550.00	
Environ 2011	44640.00	
Environ 2012	245.00	
<b>Total Income</b>	<b>57063.71</b>	
<b><u>Expenditure</u></b>		
Environ 2011	40525.43	
Environ 2012	3224.75	
Web Design/Software	2164.86	
Administration	5847.00	
Accomodation and Travel	448.93	
Audit and Accountancy	690.00	
Bank fees and charges	795.81	
E-zine	400.00	
General Expenses	73.66	
Other	105.50	
<b>Total expenditure</b>	<b>54275.94</b>	
		<b>2787.77</b>
<b>Balance</b>		<b>3220.65</b>
<b>Balance on 31/12/2011</b>		<b>3220.65</b>

\*The draft set of ESAI accounts for the year ending 31/12/2011 have been prepared by the ESAI treasurer and are subject to audit by an independent auditor.

## **ESAI COUNCIL MEMBERS 2011:**

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Currently Vacant

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Dr Shane Colgan

Ms Aoife Delaney

Mr Emmet Jackson

Mr Joe Noonan

Ms Clare McCambridge

Dr Mary Purcell

Dr Paul Murphy

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