MICROBIOLOGY SOCIETY

FOCUSED MEETING
2017

Microbial Resources for Agricultural and Food Security

& All Island Phosphorus Sustainability Workshop

Metropolitan Arts Centre
Belfast, Northern Ireland
21–23 June 2017

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MICROBIOLOGY SOCIETY

Advancing the understanding and impact of microbiology by connecting and empowering communities worldwide

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CONTENTS

INTRODUCTION

We are delighted to welcome you all to Belfast, and to this Irish Division meeting of the Microbiology Society, organised jointly by Queen's University Belfast and NUI-Galway. The conference is in two parts, comprising an Environmental Protection Agency of Ireland-sponsored workshop on Phosphorus Sustainability, followed by the meeting on Microbial Resources for Agricultural and Food Security.

It is historically fitting that a workshop on phosphorus sustainability should be held in Belfast, as the city has a rich historical connection to phosphorus and its use as a fertiliser. Indeed it was Belfast man James Murray, the inventor of Milk of Magnesia, who used the phosphorus by-products from his 'fluid magnesia' process to first formulate a synthetic fertiliser. Where better therefore to discuss the sustainability of phosphorus than arguably the birthplace of the fertiliser industry? No doubt Murray would have been an avid attendee and a keynote speaker at this meeting.

As micro-organisms play a pivotal role not only in phosphorus cycling, but across the agri-food sector, the conference will focus on their diverse roles in agriculture, from increasing farming efficiency to safe environmental management, and the production of value added products from agri-food and bio-based waste streams. In keynotes encompassing biogeochemistry, microbiology, crop science, modelling, and process engineering, the meeting will promote a multi-disciplinary understanding of new approaches and biotechnological possibilities to improve our ability to harness microbial processes, thereby providing more efficient and sustainable agri-food systems with better environmental stewardship.

We would like to thank the Microbiology Society for their invaluable support, both financial and administrative, in organising this meeting. We would also like to thank all of our sponsors for their financial assistance. Finally, we would like to thank everyone at the Metropolitan Arts Centre (MAC) for their help in hosting this meeting and NATIVE™ by Yellow Door for the catering.

Once again we offer a hearty Northern Irish welcome to everyone. We hope that you have a great meeting and thoroughly enjoy your visit to Belfast.

Your organising committee,

John McGrath
Queen's University Belfast, UK

Vincent O'Flaherty
National University of Ireland Galway, Ireland

Katrina Macintosh
Queen's University Belfast, UK

Jason Chin
Queen's University Belfast, UK

John Quinn
Queen's University Belfast, UK

GENERAL INFORMATION

Badges
Badges are issued by the Microbiology Society and are only to be used by the named person. For security purposes, badges must be worn at all times during the meeting.

Certificates of attendance
A certificate of attendance can be requested following the event by emailing profdev@microbiologysociety.org.

Mobile phones
Please ensure your mobile phone is switched to silent mode or off during the scientific sessions.

Meals and refreshments
Lunch and refreshments will be served in the Lab. Please see the scientific programme for specific times. The taste of local food and craft ales will take place on Thursday night at 19:00 in the Crush, level 1.

Programme changes
While every effort has been made to ensure the programme is accurate, changes are unavoidable and we will ensure updates are provided throughout the meeting.

Photography and filming at the conference
The Society may carry out filming and photography throughout the meeting. The images and videos will be used to promote the meeting and the activities of the Society. They may be used online, in Society publications, or for other PR and marketing purposes.

Recording
Only recording set up with prior permission is authorised.

Dietary requirements
All disclosed dietary requirements made at the point of registration have been shared with the catering team in advance. However, please ensure you ask for advice if required and the catering team will do their best to accommodate your needs.

Twitter
Delegates, exhibitors and speakers tweeting from the conference are invited to include the hashtag #AgriFoodSec17 in their tweets. On Twitter you can follow the Society @MicrobioSoc and Phosphorus.ie @Phosphorus_ie.

Wi-Fi
There is complimentary Wi-Fi in the venue.

Username: MACGuest

Password: themac1234

Posters
Posters will be displayed throughout the meeting and a poster abstract book will be provided in your delegate pack.

Abstract locations are identified by their board numbers and presenting authors are requested to stand by their posters when possible to present their work.

Posters must be removed by 13:00 on Friday 23 June. Neither the Society nor the venue are able to return any remaining posters after this time.

PROGRAMME

Phosphorus Sustainability Workshop

Wednesday 21 June 2017

Registration and welcome refreshments	**08:30**	
Welcome and introduction from Queen's University Belfast	**09:15**	Katrina Macintosh (Queen's University Belfast)
Overview of the workshop	**09:30**	Dana Cordell (University of Technology Sydney)

Session 1: Regulatory perspectives on phosphorus management

Chair: Richard McDowell, AgResearch & Lincoln University		
Phosphorus stewardship in Ireland within an EU regulatory perspective: challenges and opportunities	**09:45**	Kimo van Dijk (European Sustainable Phosphorus Platform)
Delivering better phosphate management using the Northern Ireland Sustainable Land Management Strategy	**10:15**	John Gilliland (Devenish Nutrition)
Coffee break and networking	**10:45**	
Panel 1	**11:00**	Raymond Smith (Environmental Protection Agency) Kieran McCavana (Northern Ireland Environment Agency's Water Management Unit) Thomas Gardiner (Northern Ireland Water) Ted O'Reilly (Irish Water) Alan Morrow (Department of Agriculture Environment and Rural Affairs) Kimo van Dijk (European Sustainable Phosphorus Platform) John Gilliland (Devenish Nutrition)
Q&A with Panel 1 and delegate table work	**11:45**	
Flash poster presentations	**12:30**	
Lunch and networking	**12:45**	

Session 2: Perspectives on phosphorus recovery, recycling and reuse

Chair: Paul Butler, Enterprise Ireland		
Circular economy – challenges and opportunities for phosphorus recovery & recycling in Europe	**13:30**	Christian Kabbe (Kompetenzzentrum Wasser Berlin, German Phosphorus Platform)
Panel 2	**14:00**	Patricia Arcenegui (Veolia) Andrea Gysin (Ostara Nutrient Recovery Technologies) Kees Langeveld (ICL Fertilizers Ltd) Fiona Brennan (Teagasc Johnstown Castle) Christian Kabbe (Kompetenzzentrum Wasser Berlin, German Phosphorus Platform)
Q&A with Panel 2 and delegate table work	**14:45**	
Coffee break and networking	**15:30**	

Session 3: Future directions for phosphorus sustainability

Chair: Phil Haygarth, Lancaster University		
Phos4You – addressing the phosphorus (P) challenge through transnational cooperation	**15:45**	Barbara Bremner (Environmental Research Institute, NHC, University of the Highlands and Islands)
Establishment of an All Island nutrient platform	**16:00**	Katrina Macintosh (Queen's University Belfast)
Feedback from delegate table leads **Open discussion on the 'Issues raised', 'Where to go from here?', 'Next steps' and 'Nutrient Platform'**	**16:15**	
Workshop wrap-up	**17:15**	Brent Jacobs (University of Technology Sydney)
Buffet dinner and drinks reception	**17:30**	

Microbial Resources for Agricultural and Food Security

Thursday 22 June 2017

Registration and welcome refreshments	**08:00**	
Opening welcome and overview	**09:00**	John McGrath (Queen's University Belfast, UK)

Session 1: Nutrients in the environment with a focus on agricultural systems

Chair: Katrina MacIntosh, Queen's University Belfast, UK		
Adapting to phosphorus vulnerability for a food secure future	**09:10**	Dana Cordell and Brent Jacobs (University of Technology Sydney, Australia)
Offered paper: Revisiting the soil microbial organic phosphorus cycle: Discovery of novel mechanisms to mobilise phosphorus in *Flavobacteria* spp.	**09:50**	Ian Lidbury (University of Warwick, UK)
Why have phosphorus concentrations in water decreased, while agricultural production in New Zealand has increased?	**10:10**	Richard McDowell (AgResearch & Lincoln University, New Zealand)
Flash poster presentations	**10:50**	
Coffee break, networking and poster viewing	**11:00**	
Phosphorus in the land–water continuum: are we ready for the future?	**11:30**	Phil Haygarth (Lancaster University, UK)
Offered paper: Impact of drainage and phosphorus status on grassland microbial communities	**12:10**	Jessica Graça (Teagasc, Environmental Research Centre, Ireland)
New ways to look at root-microbe interactions	**12:30**	Lionel Dupuy, (The James Hutton Institute, UK)
Lunch, networking and poster viewing	**13:10**	

Session 2: Microbial ecosystems and nutrient cycling

Chair: John McGrath, Queen's University Belfast, UK		
Flash poster presentations	**13:50**	
Impact of agricultural practices on the diversity and activity of key functional groups of micro-organisms in the soil nitrogen (N) and phosphorus (P) cycles	**14:00**	Kari Dunfield (University of Guelph, Canada)
Offered paper: Recycling P from sewage sludge ash with the help of Phosphate Solubilising Micro-organisms	**14:40**	Nelly Raymond (Copenhagen University, Denmark)
The fundamental role of microbial nutrient cycling in the Earth system	**15:00**	Tim Lenton (University of Exeter, UK)
Coffee break, networking and poster viewing	**15:40**	
Offered paper: Soil microbes as facilitators in restoration of post-mining substrates	**16:10**	Deepak Kumaresan (School of Biological Sciences & Institute for Global Food Security, Queen's University Belfast, UK)
Role of the soil microbiome in the nitrogen cycle	**16:30**	Penny Hirsch (Rothamsted Research, UK)
Flash poster presentations	**17:10**	
Drinks reception and poster viewing	**17:30**	
A taste of local street food and local beer & ale tasting (Crush, level 1)	**19:00**	

Friday 23 June 2017

Session 3: Harnessing microbial processes within the agri-food sector

Chair: Vincent O'Flaherty, National University of Ireland Galway, Ireland		
Microbial management for optimised biogas production from organic wastes	**09:30**	Anna Schnürer (University of Agricultural Sciences, Sweden)
Offered paper: Pathogen survival in agriculture-based anaerobic digestion compared with stored slurry	**10:10**	Stephen Nolan (Functional Environmental Microbiology Group, NUIG, Ireland)
Offered paper: Soil microbial community responses to compounded soil management and climatic disturbances	**10:30**	Camilla Thorn (National University of Ireland Galway, Ireland)
Athena SWAN at Queen's University Belfast	**10:50**	Edel Hyland (Queen's University Belfast, UK)
Coffee break, networking and poster viewing	**11:05**	
Offered paper: Optimising enrichment culture for isolation of *Clostridium difficile* from animal and environmental samples	**11:35**	Mairead Connor (Queen's University Belfast, UK)
Phosphorus cycling and capture by methanogenic archaea	**11:55**	Jason Chin (Queen's University Belfast, UK) and Fabiana Paula (National University of Ireland Galway)
Wrap-up and prizes	**12:35**	
Close	**13:00**	

INVITED SPEAKERS' BIOGRAPHIES AND ABSTRACTS

Jason Chin, Queen's University Belfast, UK, and Fabiana Paula, National University of Ireland Galway, Ireland

Jason is a Postdoctoral Research fellow at Queen's University Belfast who studied the microbial metabolism of phosphonate compounds during his PhD. Since then he has worked on a range of phosphorus issues including exploring different triggers for bacterial accumulation of phosphorus as polyphosphate and chemical phosphorus capture methods. His current research focus is the microbial community of a novel anaerobic digester design to try to understand what drives phosphorus cycling and removal within the system.

Fabiana gained her PhD in 2012 from the University of São Paulo through work on microbial groups linked to nutrient cycling in Amazon rainforest soils. In her first postdoctoral project at National University of Ireland Galway, she was an Irish Research Council fellow, working in collaboration with Monaghan Mushrooms, in an enterprise partnership program. Since Fabiana joined NUIG, she has been involved in different projects, including studies of complex communities and pure cultures. Fabiana is interested in responses of soil microbes to different nutrient inputs. She is also studying phosphorus uptake by methanogenic archaea as part of a SFI project to investigate phosphorus recovery in anaerobic reactors.

Phosphorus cycling and capture by methanogenic archaea

Phosphorus is required by all living things yet also causes significant pollution, particularly due to anthropogenic waste streams. Agricultural demand for phosphate rock combined with a critical supply risk caused the EU to designate it as a "critical raw material", driving research into the removal and recycling of phosphorus from waste. We investigated the microbial community of anaerobic digesters, which are usually poor at removing phosphorus, to explore their phosphorus cycling genes and capture potential. Bioinformatic studies revealed that many of these organisms, particularly in the genus *Methanosarcina*, possess genes for polyphosphate production, a biopolymer exploited in bacterial systems for phosphorus capture. Cultures of *Methanosarcina mazei* which underwent a period of phosphorus starvation followed by an addition of excess phosphate increased their phosphorus uptake levels and accumulated intracellular granules which appeared to be polyphosphate. These results shed light on the poorly characterised polyphosphate regulation mechanisms in methanogenic archaea, and open perspectives for studying biological phosphorus removal in anaerobic systems such as bioreactors.

Dana Cordell and Brent Jacobs, University of Technology Sydney, Australia

Dana leads and undertakes international and Australian sustainability research projects on phosphorus and food futures at the Institute for Sustainable Futures, UTS. She leads the collaborative P-FUTURES project across Australia, Vietnam, the US and Malawi which aims to identify together with local stakeholders how urban food systems can cope or transform in response to the emerging global phosphorus challenge. In 2008 Dana co-founded the Global Phosphorus Research Initiative (GPRI) to facilitate research, networking and public debate among policy-makers, industry, scientists and the public regarding the risks and opportunities for food systems associated with global phosphorus security. As a global food security expert, Dana is frequently invited to provide expert opinions and interviews, from the United Nations to BBC to Australia's Chief Scientist. Dana's research contributions have led to numerous prestigious recognitions including one of Australia's top science prizes — the Eureka Prize for Environmental Research and a position in 100 Women of Influence.

Brent is a Research Director in climate change adaptation at the Institute for Sustainable Futures, University of Technology Sydney. Brent's background is in agricultural science with broad experience in agricultural systems and eco-physiology of crops and pastures gained through teaching and research conducted at universities in Australia and in the South Pacific. Brent has a decade of experience in public sector policy and research in the areas of natural resource management, structural adjustment and development of assistance packages to accompany natural resource reforms. Brent's current research interests include transformation, vulnerability and adaptive capacity of communities to support climate change adaptation and he leads the Adaptive Communities Node of the NSW Climate Adaptation Research Hub.

Adapting to phosphorus vulnerability for a food secure future?

Plant macronutrients (NPK) are essential in fertilisers and feed for food production globally, yet too much can lead to system leakage and eutrophication, while too little can limit agricultural productivity and compromise food security. The use of fertilisers has contributed to feeding billions of people globally over the past half-century by boosting crop yields. The world's food systems are simultaneously vulnerable to scarcity and excess use of phosphorus. The security of the world's finite phosphate rock reserves is increasingly uncertain and risky. All farmers need access to phosphorus to grow crops, yet just five countries control 88% of the world's remaining phosphate rock. Morocco alone controls three-quarters. So few producers of a globally critical resource in potentially politically unstable regions creates a serious risk of disruption to supply and price fluctuations. Remaining reserves are of lower quality, harder to physically access, require more energy to mine/process and are becoming more expensive. Excess phosphorus use has led to a staggering 80% loss or wastage in the supply chain between mine, farm and fork. Much of this ends up in rivers, lakes and oceans leading to widespread nutrient pollution from China to the Great Barrier Reef. Algal blooms can damage aquatic ecosystems and pollute drinking water, costing fisheries, local communities and recreation industries heavily; estimated at US$2.2 billion in the US alone.

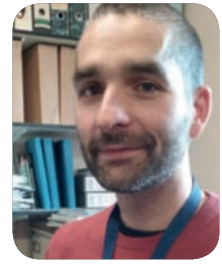
Kari Dunfield, University of Guelph, Canada

Kari is a Professor in Applied Soil Ecology in the School of Environmental Sciences, and a Tier 2 Canada Research Chair (CRC) in Environmental Microbiology of Agro-Ecosystems at the University of Guelph. A graduate of the University of Calgary, (BSc Microbiology 1995) and the University of Saskatchewan (MSc Plant Science 1999; PhD Soil Science 2002), she also did postdoctoral research at the University of Maine (2003). Kari's research program focuses on assessing anthropogenic impacts on ecosystem services, in particular focusing on the microbial communities in the soil and the soil–water interface. Kari was awarded an Ontario Ministry of Research and Innovation Early Researcher Award in 2011 for her research focused on the impact of agricultural practices on the diversity of soil microbial communities, and on source water quality. She currently serves as a co-Editor-in-Chief for the Canadian Journal of Microbiology.

Impact of agricultural practices on the diversity and activity of key functional groups of micro-organisms in the soil nitrogen (N) and phosphorus (P) cycles

Healthy and diverse communities of soil organisms influence the quantity and quality of food production and key soil ecosystem services such as carbon sequestration, water quality protection, climate regulation and nutrient cycling. Agricultural soils provide a unique system because they can be managed to facilitate the conservation of soil biodiversity and the functions it provides. A combination of quantitative-PCR and high throughput sequencing approaches were used to target selected bacterial functional genes to evaluate how agricultural practices, such as crop residue removal, tillage and shifting from annual to perennial cropping systems influence the diversity of bacterial communities associated with soil nitrogen and phosphorus cycles. Using metagenomic and metatranscriptomic analysis, the magnitude of field-scale N2O emissions were correlated with expression of the nitrification (*amo*, *crenamo*) and denitrification (*nirS*, *nosZ*) genes. Similarly, we developed primers to target bacterial non-specific acid phosphatase (NSAP) genes in soils and linked their expression to acid phosphatase activity in long-term field trials from Canada and New Zealand. Findings from this research program will inform policies that promote sustainable agricultural management practices, which ensure levels of agricultural production necessary to meet society's demands for plant biomass for food, feed, and biofuels, while minimising the impact on soil ecosystem services.

Lionel Dupuy, The James Hutton Institute, UK

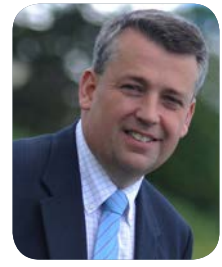


Lionel's research focuses on quantitative techniques for root soil microbe interactions. He gained his PhD in finite element modelling of root soil mechanics in 2004 (University of Bordeaux) and undertook his postdoc in cellular modelling of plant tissue morphogenesis in 2007 (University of Cambridge). Since then, he has been a researcher at the James Hutton Institute, within the Plant Systems Modelling lab.

New ways to look at root-microbe interactions

Roots and their interactions with soil and micro-organisms are important in nutrient uptake and disease transmission, but techniques for observing such interactions *in situ* are lacking. In this talk, I will present new approaches developed in my lab to observe, image and characterise roots and micro-organisms live and *in situ*. For example, we have developed a new substrate termed transparent soil that can combines complex soil-like environment and the capabilities of imaging biological processes at different scales, resolutions and throughput rates using modern microscopy techniques. I will also present new approaches to understand root and soil physical interactions, including optochemical sensors, 3D imaging, image analysis and modelling.

John Gilliland, Devenish Nutrition, UK



John, Director of Agriculture with Devenish Nutrition, is highly respected and recognised as an excellent participant and communicator in the Agri Food and Sustainable Land management Sectors. He has been an award-winning Farmer in Ireland and in the UK; an Innovator and Farm Leader; while at the same time, he has been a policy adviser for Devolved, National and European Governments. Just retired as a Non-Executive Director of the Scottish Rural College and SAC Consultancy in Edinburgh, positions he held for the last seven years, John was formerly President of the Ulster Farmers Union during the 2001 outbreak of Hoof & Mouth; Vice Chair of the UK Sustainable Development Commission; and Chair of the UK's Rural Climate Change Forum. He currently runs his family's 180ha, arable and willow farm in N. Ireland, while also being a member of the EU Commission's Expert Industry Panel on Mixed Farming Systems; and currently, chairs N. Ireland's Expert Working Group, which has just published N. Ireland's first Sustainable Land Management Strategy for the Department of Agriculture, Environment and Rural Affairs, in Belfast.

Delivering better phosphate management using the N. Ireland Sustainable Land Management Strategy

When the N. Ireland "Going for Growth" Report was published in 2013, recommendation 22 called for the creation of a Sustainable Agricultural Land Management Strategy to be created to deliver up to a 40% increase in output from the AgriFood Sector, an increase in Farm Incomes, while reducing the Industry's environmental footprint at the same time; phosphate and its impact on water quality was thrown into the spotlight. As the person chosen to chair the process to create such a strategy, my paper will layout the new Strategy. Published in October 2016, it has the ability to deliver on all of the aims asked of it, simultaneously, and was recently describe in the EU Commission's February 2017, EIP Agri Newsletter, as being inspirational.

Phil Haygarth, Lancaster University, UK

Phil is a Professor of Soil and Water Science and leads the Sustainable Catchments Research Challenge for Lancaster University, with personal research at the interface between soils and freshwaters, with a focus on phosphorus. His research involves studying the mechanisms by which soils retain phosphorus for food production, but critically defining conditions that prevent the unwanted leakage to fresh-waterways. Phil is well known for developing the phosphorus "transfer continuum" model and the practical impact of this has been to influence the UK Government, and others around the world, develop policies to optimise plant uptake of nutrients but minimise losses to water. This involves efforts to reduce runoff energy, which can have dual benefits for both diffuse pollution and flood control.

Specific current lines of research and impact include:

- Development and maintaining 'Demonstration Test Catchments' that can help provide a focal meeting point for policy-makers, farmers and researchers.
- A focus on plant types that have benefit traits, such as the potential to be efficient users of phosphorus or rooting qualities that 'soak up' runoff water.
- A consideration of what may happen to phosphorus under future climate change scenarios, which predict warmer wetter winters and hotter drier summers.

Phosphorus in the land–water continuum: are we ready for the future?

Phosphorus is crucial for our global food production, underpinning the DNA of the earth's biology, mostly relying on fertiliser coming from the geological supplies that need to be carefully managed. However, when phosphorus leaks from agricultural systems, it is considered a pollutant in the receiving rivers, lakes and estuaries. The presentation will consider phosphorus movement from terrestrial to fresh water and marine environments, with potential links to aquatic eutrophication. In considering this, understanding the forms and mobility of phosphorus in the environment is particularly challenging, because of its complexity, because it is highly prone to immobilisation in chemical complexes and/or biological material. Some discussion will focus to the role of organic phosphorus compounds in the environment. The paper will conclude with a reflection on the wider behavior of phosphorus in the land–water continuum, to consider and evaluate on the key biogeochemical processes in the face of global pressures on food production, water quality and climate change, and ask the question – are we ready for the future?

The work reflects input from many collaborators who will be acknowledged in the oral presentation.

Penny Hirsch, Rothamsted Research, UK

Penny leads a group working on soil microbiology and molecular ecology at Rothamsted Research, the longest-running agricultural research institute in the world. Research on nutrient cycling in arable systems focuses on N and P and the relationship between the soil and crop plant microbiomes, applying metagenomics and metatranscriptomics, in addition to more conventional approaches. Over the years, she has worked with fungi and bacteria, on rhizosphere interactions and other microbial activity in soil that supports plant health and productivity, including nitrogen cycling. This is combined with long experience on the extraction, amplification and bioinformatics analysis of DNA and RNA sequences derived from soil and the rhizosphere. The long-term field experiments at Rothamsted have provided valuable resource for applying these techniques to determine agronomic impacts on soil and plant microbiomes.

Role of the soil microbiome in the nitrogen cycle

The global N cycle is driven by microbial activity: only prokaryotes can reduce atmospheric nitrogen gas to form ammonia and prior to the introduction of industrial fertilisers, they were the primary route by which this essential resource was made available to plants. However, micro-organisms are also responsible for converting ammonia to nitrate which is readily lost to water bodies, and nitrate to nitrous oxide, a potent greenhouse gas. To manage soil and crops to maintain the N supply to plants whilst minimising losses, it is important to understand the diversity, abundance and activity of the micro-organisms responsible for the different steps in the terrestrial N cycle. Although the identity of many of the groups involved has been determined at the phylum level, there is little detailed knowledge of these micro-organisms, the majority of which are recalcitrant to laboratory culture. Metagenomics and metatranscriptomics provide a method for investigating the ecology of N-cycling micro-organisms *in situ* in soil, illuminating the soil microbiome "black box". In this talk, I will present the results from long-term field experiments at Rothamsted, comparing the effects of different agricultural management and fertiliser regimes over time.

Christian Kabbe, Kompetenzzentrum Wasser Berlin, German Phosphorus Platform, Germany

Christian started his professional career as Head of Laboratory and Vice Production Manager in the chemical industry in 2003. He joined the German EPA in 2008 where he promoted the development of a national strategy for sustainable P management. Being in favour of facts instead of rumors, he initiated the national sewage sludge ash monitoring campaign finally conducted between 2013/2014.

In 2011 he moved to the Berlin Centre of Competence for Water as program manager for resource recovery from waste (water) and coordinated the EU project www.p-rex.eu (2012-2015) dedicated to demonstration and assessment of P recovery and recycling routes. The spin-off P-REX Environment (2017) continues the know-how transfer into practice and builds cross-sectoral bridges between nutrient recovery and recycling. Christian is co-founder of the ESPP and DPP and member of the ifs, DWA and engaged in various European and German working groups and bodies dealing with sustainable nutrient management in a circular economy.

Circular economy – challenges and opportunities for phosphorus recovery & recycling in Europe

Circular economy for nutrients! How to transfer buzz words into solid results? So far the potential to recover and recycle phosphorus remains untapped or is just inefficiently used as in the case of sewage sludge, manure and food waste. To provide alternatives to argued traditional nutrient recycling routes, various technical solutions have been developed in recent years. They allow recovery of phosphorus minerals suitable as raw material for industries like fertiliser production or even as ready-to-use renewable or next generation fertiliser.

Still, the so-called technical nutrient recovery is missing a demand-side driven market pull for recovered (secondary) nutrients and the biggest challenge will be bridging the gap between supply (recovery) and demand (recycling). Whereas in the past, the focus of nutrient recovery technologies was laid upon high recovery rates for single nutrients, now energy efficiency, synergies and cost become more and more important.

What about value chains? We have to look for easy to implement, rather integrative solutions instead of reinventing the wheel, creating parallel (infra)-structures. Think forward, act circular!

Tim Lenton, University of Exeter, UK

Tim Lenton is Professor of Earth System Science and Climate Change at the University of Exeter. His research focuses on understanding the behaviour of the Earth as a whole system, especially through the development and use of Earth system models. He is particularly interested in how life has reshaped the planet in the past, and what lessons we can draw from this as we proceed to reshape the planet now – as described in his books *Revolutions that made the Earth* (with Andrew Watson) and *Earth System Science: A Very Short Introduction*. Tim's work identifying the tipping elements in the climate system won the Times Higher Education Award for Research Project of the Year 2008. He has also received a Philip Leverhulme Prize 2004, a European Geosciences Union Outstanding Young Scientist Award 2006, the Geological Society of London William Smith Fund 2008, and a Royal Society Wolfson Research Merit Award 2013.

The fundamental role of microbial nutrient cycling in the Earth system

Today, nearly 4 billion years after life first appeared on Earth, the planet hosts an abundance of complex life, including more than 7 billion of us humans. But we all owe our existence to the microbial biosphere and its role in establishing and regulating global nutrient, carbon and oxygen cycles. I will briefly trace the critical 'revolutions' in Earth history that have brought the planet to this point, and the role of microbial nutrient cycling in creating an oxygen-rich atmosphere and maintaining highly productive ecosystems on land and in the oceans. Interestingly, the feedbacks that connect the global microbial-driven cycles of nutrients, carbon and oxygen are not all stabilising ones. The Achilles' heel of the Earth system is the propensity for microbial nutrient cycling to amplify the de-oxygenation of aquatic systems. In this context the ongoing mining and loading of phosphate rock fertilisers on the land poses the risk, not just of triggering anoxia in freshwaters, but of triggering an ocean-wide anoxic event, equivalent to those associated with past mass extinctions. This gives yet another reason to work out how we can foster much more efficient utilisation and microbial recycling of nutrients in global agricultural and food systems.

Richard McDowell, AgResearch & Lincoln University, New Zealand

Richard is the Chief Scientist for the New Zealand Our Land and Water National Science Challenge, a Principal Scientist at AgResearch and Professor of soil and water quality at Lincoln University. He has degrees from Lincoln and Cambridge Universities. Before joining AgResearch 15 years ago he was employed by the United States Department of Agriculture – Agricultural Research Service and was involved in water quality research and aiding in policy development. He is a fellow of the New Zealand Society of Soil Science, has received a few awards, and has written a few (~300) articles on soil and water quality issues. He has a special interest in providing options and tools to mitigate water quality contamination (from a variety of land uses) while maintaining profitable primary production enterprises (and no interest in talking about rugby).

Why have phosphorus concentrations in water decreased, while agricultural production in New Zealand has increased?

Since 1995, agricultural production in New Zealand has doubled. This has been attributed to an increase in intensity and an improvement in productivity across a range of primary sectors. This has been supported by one of the highest application rates of phosphorus (P) fertilisers to land in the OECD. The resulting increases in soil Olsen P concentrations and land use change have been highlighted in regional and national reports as the main cause of an increase in the median P concentrations of the majority (~60%) of sites routinely monitored (n=557) between 1995 and 2004. However, from 2004–2013 the majority (~60%) of sites have shown decreasing concentrations of P fractions – at an average rate of 1.5% per annum. The concentrations of other water quality indicators such as nitrate, sediment and *E. coli* have continued to increase. A number of factors, such as the implementation of good management practices through voluntary or regulatory schemes, have been postulated as causing the decrease in P concentrations. I present the current evidence base for each factor and thoughts on how to decrease concentrations further.

Anna Schnürer, University of Agricultural Sciences, Sweden

Anna is a Professor and external collaboration specialist in Bioenergy at the Swedish University of Agricultural Sciences. She presently also holds a position as a guest professor at Linköping University in Sweden. Her work aims to find links between microbiology and methane production with the goal to find solutions for optimised gas production with higher yields and improved process stability. The research is accomplished in the laboratory as well as in industrial biogas processes and the work is often performed in cooperation with national and international universities, as well as with industry and branch oriented organisations. Anna is head of the biogas team at the department of microbiology and she has published around 80 per-reviewed papers in the area of biogas.

Microbial management for optimised biogas production from organic wastes

The microbiological process leading to methane production is complex and involves many different types of micro-organisms, often operating in close relationships owing to the limited amount of energy available for growth. The microbial community structure is shaped by the incoming material, but also by operating parameters and process conditions, such as process temperature, hydraulic retention time and ammonia level. Factors leading to an imbalance in the microbial community can result in process instability or even complete process failure. To ensure stable operation and an efficient process it is of critical importance to secure high activity of key microbial populations, which might vary depending on the prevailing conditions. The presentation will discuss different aspects that need to be taken into consideration in order to achieve optimal degradation and gas production, with particular focus on relationships between operation management and microbiology, including strategies for microbial steering and surveillance.

Kimo van Dijk, European Sustainable Phosphorus Platform, Belgium

Kimo works for the European Sustainable Phosphorus Platform (ESPP, www.phosphorusplatform.eu), a platform organisation working on nutrient stewardship by bringing together different stakeholders including governments, research institutes, industry, non-governmental organisations and farmers. Additionally, he participates in the Dutch Nutrient Platform and other nutrient networks. In the last years he did research on nutrient management and phosphorus (P) security at Wageningen University. He analyses the present P flows in Europe (EU-27) at the country level, develops dynamic nutrient flow models, and simulates potential future P use by scenario analyses. In the past he did scientific studies for the Dutch government about the options for sustainable P use in the Dutch, West European and European society. Furthermore, he was involved in analysing P flows and future nutrient management options at the local level in cities (Rotterdam and Wageningen).

Phosphorus stewardship in Ireland within an EU perspective: challenges and opportunities

Globally we face the Nutrient Challenge. The European food system is depending on import of P-rock for fertilisers. At the same time, the loss of nutrients still leads to eutrophication of surface waters. The European Sustainable Phosphorus Platform (ESPP, www.phosphorusplatform.eu) will present and compare the present use of P in Europe and Ireland. An overview of the European policy context will be provided, including an update of the revision of the EU Fertiliser Regulation making potentially a European market for recycled nutrients possible. The need and role of regional nutrient platforms in the transition towards sustainable use of nutrients will be discussed based on experiences of existing platforms (e.g. Netherlands and Germany). To inspire for action, success stories in nutrient stewardship will be shown as solutions to tackle the nutrient challenge.

WORKSHOP PANEL MEMBERS

Patricia Arcenegui, Veolia

Talk title: Business opportunities for Veolia's recycled fertilisers made from bio-ashes

In 2009 Patricia graduated from Pablo de Olavide University with a BSc in Environmental Sciences. Since then she had spent a year working as an Ecosystem Analyst at EGMASA, followed by three years as a Coastal and Transitional Water Project Manager at Omicron Amepro (Seville).

In 2014 Patricia graduated with a MSc in Environmental Technology at Imperial College London, developing her thesis on Veolia's recycled fertilisers (full title: "Veolia's recycled fertilizers, using nutrient recovery in Ireland: a case study approach"). Her thesis resulted in Veolia producing the first fertiliser made out of recycled phosphorus. Patricia has been a part of Veolia's team since June 2014.

Fiona Brennan, Teagasc Johnstown Castle

Talk title: Maintaining phosphorus supply for plants in Irish soils

Fiona Brennan is a Research Officer in Soil Microbiology in the Department of Environment, Soils and Land-Use in Teagasc, Johnstown Castle, Wexford, where she leads the Soil Microbiome sub-programme. She holds an adjunct Lecturer position in the National University of Ireland, Galway (NUI Galway) and is a principal investigator in the Plant and Agricultural Biosciences Centre (PABC). She completed a BSc in Environmental Biology (University College Dublin) and a PhD in Microbiology (NUI Galway) prior to holding postdoctoral research positions within Teagasc and INRA (The French National Institute for Agricultural Research). Prior to her current appointment she was a Lecturer in Microbiology in NUI Galway and a Research Scientist in the James Hutton Institute, Scotland. A key focus of her research team is on soil–plant interactions in agronomic systems, recycling of organic amendments, and on understanding the role of functional microbial communities in soil biogeochemical cycles and greenhouse gas emissions.

Thomas Gardiner, Northern Ireland Water

Talk title: P removal from wastewater in Northern Ireland

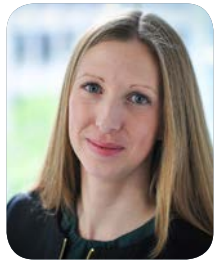
Thomas has worked in the water industry since graduation from the Queen's University of Belfast in 1996 as a civil engineer. He spent 10 years working on direct Civil Engineering projects, being involved in design, site supervision and project management on a range of Water and Sewerage projects.

Shortly after NI Water was formed in April 2007 Thomas transferred to the Regulation team and was responsible for capital investment reporting and supporting the opex efficiency assessment team deriving special factors etc. as well as pioneering energy benchmarking within the business.

In November 2016 Thomas took up the role in Asset Management and is currently the Head of Asset Lifecycle planning managing a team setting strategic direction of the company including developing a new Sludge Strategy for NI Water.

Andrea Gysin, Ostara Nutrient Recovery Technologies

Talk title: Experiences of recovering high value phosphorus fertiliser from wastewater



Andrea has over 17 years of experience in the water industry, both in consulting firms and technology start-ups. Prior to joining Ostara in April 2016, Andrea led the innovation agenda for a high-growth professional services firm. In 2005, Andrea set-up a platform known as TAG – the Technology Approval Group – to accelerate routes to market for start-up companies in the water sector. Andrea has held management and business development roles in several start-up businesses focused on the development of biosolids and organic waste treatment projects.

Kees Langeveld, ICL Fertilizers Ltd

Talk title: Sustainability at ICL

Kees is Vice President Business Development at ICL. From 2003–2006, he was the Managing Director of Amsterdam Fertilizers, then from 2006–2012 he was President and CEO of ICL Fertilizers Europe, heading a group of 2,500 on sites for fertiliser, feed phosphate and potash production in Europe. Kees currently heads the global M&A strategy group for phosphates, preparing JVs, exploring new mines, and developing strategic projects.

Kieran McCavana, Northern Ireland Environment Agency's Water Management Unit

Talk title: Agricultural phosphorus management in Northern Ireland – An environmental problem or a potential opportunity?

Kieran is a Senior Scientific Officer with the Water Management Unit of the Northern Ireland Environment Agency (NIEA) which is part of the Department of Agriculture, Environment and Rural Affairs (DAERA). He graduated from the University of Ulster in 1989 in Environmental Science and also in 2005 with an MSc in Environmental Management. Since then he has worked in a number of government departments, specialising in agricultural regulation and environmental management. He has been closely involved in the development and implementation of the Nitrates Action Programme Regulations and the Phosphorus Regulations in Northern Ireland with particular interests in promoting the efficient use of nutrients by the agricultural industry to achieve environmental, economic and social outcomes.

Alan Morrow, Department of Agriculture, Environment and Rural Affairs

Talk title: Phosphorus – a little goes a long way or does it?

Alan is a Senior Countryside Management Adviser within the Department of Agriculture, Environment and Rural Affairs (DAERA). He has almost 20 years' experience in providing environmental management advice to farmers and others allied to the agriculture industry.

Throughout his career Alan has had a particular interest in issues affecting water quality on farms. He has had lead role in developing a number of training programmes for farmers and advisers in connection with improved farm nutrient management and pollution control. Alan co-chaired the Nitrates Guidance Group in connection with the current Nitrates Action programme. As lead author, he was responsible for producing the most recent DARD '*Code of Good Agricultural Practice for the prevention of pollution of Water, Air and Soil.*' Alan has also worked outside the UK as an EU 'Short Term Expert' in Poland on a water resources protection project – *Water Resources Protection vis-à-vis agricultural impacts*.

Ted O'Reilly, Irish Water

Talk title: Phosphorus removal in a regulated environment

Working in Asset Planning in Asset Management, Ted has responsibility for the direction Irish Water takes in terms of wastewater treatment, including the development of asset standards and policies, and incorporating innovative technological advances into the asset base. Key to this is the development of wastewater investment requirements to meet national priorities for the provision of wastewater services. Prior to joining Irish Water, Ted was involved in the establishment of Irish Water through the Irish Water Programme. Before that, he worked on a number of technology development projects in water and wastewater treatment, as well as lecturing and postgraduate supervision.

A chartered engineer, his background is in wastewater treatment and technology development and has completed BE, MEngSc and PhD degrees in civil and environmental engineering.

Raymond Smith, Environmental Protection Agency

Talk title: Phosphorus reduction in rivers & lakes – progress made and future challenges

Raymond is a graduate of the Royal Society of Chemistry. He spent five years working as a laboratory analyst in Eclipse Scientific in the UK before taking up a new role as Chemist with the Environmental Protection Agency in the Castlebar Regional Inspectorate in 1996. His initial role was as analyst with responsibility for the implementation of laboratory accreditation in accordance with ISO 17025. In 2005, Raymond took up the role of Regional Chemist with responsibility for the management of the Castlebar laboratory team before taking up a similar role in the EPA's Monaghan Regional Inspectorate in 2011. He has extensive experience working with and managing teams involved in the monitoring of surface waters, groundwaters, industrial effluents, wastewater discharges etc for a range of physico-chemical and microbiological parameters. He has responsibility for the assessment and reporting of data in accordance with various requirements including the Water Framework Directive.

Barbara Bremner, Environmental Research Institute, NHC, University of the Highlands and Islands

Talk title: Phos4You – addressing the phosphorus (P) challenge through transnational cooperation

Barbara is a project manager within the Environmental Research Institute, part of the UHI-North Highland College. The ERI undertakes high quality, vibrant research that seeks to address emerging issues related to improving understanding of the natural environment. With a background in marine ecology, Barbara has extensive experience in wildlife conservation, regulation and land use, as well as managing EU funded projects. Joining the ERI in 2011, she has contributed to research, knowledge exchange and commercial activity. This has included responsibility for outreach activity and for delivery of TURNKEY project (Atlantic Areas Programme 2007-2013) as Lead Partner. Currently Barbara is managing ERI's contribution to Phos4You project and sits on the Partner steering group.

Katrina Macintosh, Queen's University Belfast

Talk title: Establishment of an All Island Nutrient platform

Katrina is a Postdoctoral Research Fellow at Queen's University Belfast working on an EPA funded project investigating phosphorus recovery from wastewater in terms of novel technologies for advanced treatment and re-use. She is also involved in the NERC funded SLURRY-MAX project investigating the networks of policy, decision support tools and practices that inform livestock manure management within the UK, and how these can best be integrated into farm-level practices. Katrina gained her PhD from the University of Ulster researching the distribution and dynamics of iron in streams and its effects on aquatic ecology. At Ulster, she worked as a Postdoctoral Researcher developing targeted ecosystem modelling tools for lake resource management and validated the use of flow-proportional passive sensors for phosphorus and nitrogen in Irish rivers.

Katrina has been the driving force behind the 'Phosphorus Sustainability Workshop' and works closely with the European Sustainable Phosphorus Platform (http://www.phosphorusplatform.eu/), the American Sustainable Phosphorus Alliance (https://phosphorusalliance.org/) and associated stakeholders in relation to sustainable phosphorus management.

OFFERED PAPERS

Thursday 22 June

Session 1: Nutrients in the environment with a focus on agricultural systems

09:50

Revisiting the soil microbial organic phosphorus cycle: Discovery of novel mechanisms to mobilise phosphorus in *Flavobacteria* spp.

In soil, phosphorus (P) exists in numerous organic and inorganic forms. However, plants can only acquire inorganic orthophosphate (Pi), meaning global crop production is frequently limited by P availability. To overcome this problem, rock phosphate fertilisers are heavily applied, often with negative environmental and socio-economic consequences. Despite knowing microbes can facilitate P mobilisation, the precise mechanisms and key players facilitating this process remain unknown, thus inhibiting our ability to increase microbial-driven P mobilisation in the field. To determine the molecular mechanisms employed to mobilise P, a multidisciplinary approach combining multi-level 'omics' techniques with classical microbial genetics was utilised. Exoproteomics revealed that *Pseudomonas* spp. show a high intra-genus variability in their response to Pi depletion secreting numerous previously characterised and novel enzymes related to phosphatases, putative glycerolphosphodiesterases and nucleotidases. In contrast, *Flavobacteria* spp. secreted a wide range of uncharacterised enzymes in response to Pi depletion. Comparative genomic analysis revealed that these organisms lack the majority of classical P mobilisation enzymes associated with traditional laboratory strains, e.g. *Pseudomonas* spp., *Bacillus* spp. and *Escherichia* spp.. Furthermore, unlike these traditional lab strains, *Flavobacteria* spp. exhibited constitutive phosphatase activity via a novel unidentified phosphatase(s). *Flavobacteria* spp. also grew on a range on organic P substrates confirming the presence of a promiscuous novel phosphatase. Several candidate Flavobacteria genes were expressed in a phosphatase-lacking *Pseudomonas* strain leading to the identification of novel phosphatases. In conclusion, *Flavobacteria*, frequently enriched in various crop rhizospheres displays a distinct ability to mobilise P and thus are potential targets for bioagronomy.

Authors: Ian Lidbury[1,2], Andrew Murphy[1], Tandra Fraser[2], Andrew Goodall[2], Gary Bending[1], John Hammond[2], David Scanlan[1], Elizabeth Wellington[0]

[1]University of Warwick, Coventry, UK, [2]University of Reading, Coventry, UK

12:10

Impact of drainage and phosphorus status on grassland microbial communities

Soil microbes play a central role in the biological phosphorus (P) cycling, acting as sink and source of P, but microbial responses to changes in grassland P status remain elusive. Intensification of grass production systems is often characterized by high nutrient loading (NPK), soil drainage and plant monoculture. We hypothesised that intensive grasslands will sustain distinctive belowground microbial communities when compared to extensive, low P index grasslands. Twenty grassland soils were selected, based on drainage class (well or poorly drained) and available P content (high and low P, determined though Morgan's P extraction), and four soil groups (n=5). Bacterial and fungal communities were assessed though denaturing gradient gel electrophoresis (DGGE) and next generation sequencing (NGS). Bacterial communities were affected by soil drainage ($p<0.05$). Relatively higher proportions of Acidobacteria were detected in poorly drained soils. NGS identified Ascomycota, Zygomycota and Basidiomycota as the dominant fungi phyla. In soil with low P status the proportion of the latter phylum increases in comparison with high P status grasslands, regardless of the drainage class. Distinct AM fungi (e.g Glomeroceae) profiles as shown by DGGE were found in poorly drained soils with low P status ($p<0.05$). This difference was potentially related to acid phosphatase activity ($p<0.001$) and soil pH ($p<0.01$). Intensification of grass based systems appears to affect specific groups in grassland microbial communities. Drainage only impacted bacteria communities and P status seems to affect fungi communities. Soil pH is likely driving changes in belowground communities, however further analysis needs to be conducted.

Authors: Jessica Graça[1,2], Karen Daly[1], Giulia Bondi[1], Rachel Creamer[3], Fiona Crispie[4], Raul Cabrera-Rubio[4], Paul Cotter[4], Achim Schmalenberger[2]

[1]Teagasc, Environmental Research Centre, Johnstown Castle, Co. Wexford, Ireland, [2]University of Limerick, Department of Biological Sciences, Castletroy, Co. Limerick, Ireland, [3]Wageningen University and Research, Soil Biology and Biological Soil Quality, Wageningen, The Netherlands, [4]Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, Ireland

Session 2: Microbial ecosystems and nutrient cycling

14:40

Recycling P from sewage sludge ash with the help of Phosphate Solubilising Micro-organisms

Ashes from thermally converted sewage sludge are rich in phosphorus (P) but often P availability for plants remains low. The aim of this study was to explore the ability of different phosphate solubilising micro-organisms (PSM) to solubilize P from different ashes in order to elaborate a biofertilizer.

Six different PSM strains were grown on three types of sewage sludge ashes amended with nutrients. After incubation water-extractable P and pH were measured.

In order to improve the P-solubilisation activity, several combinations and amounts of C and N sources were tested with selected PSM/ash combinations.

The most promising combination was tested in a pot trial with spring wheat using a semi-sterile low-P soil. At harvest shoot biomass, P concentration and PSM survival were determined.

In the first step *Penicillium bilaiae* DBS-5 and Aspergillus niger ATCC 9142 showed the highest P-solubilisation potential on sewage sludge incineration ash (FB-I) and were selected for further investigations.

The addition of fructose+NH4+ and fructose+(NH4+)+(NO3-) improved the P-solubilisation activity for *P. bilaiae* and *A. niger*, respectively.

In the pot trial, the application of *P. bilaiae* did not increase the plant biomass and the P-shoot concentration. However, *P. bilaiae* tended to increase water-extractable soil P close to the ash application zone and the fungus persisted in soil until the end of the experiment.

PSM could improve P-availability from sewage sludge ashes in vitro, especially when specific C and N sources were added to the ash. However, future experiments should investigate how the high in vitro solubilisation can be reliably transferred to soil/plant systems.

Authors: Nelly Raymond, Dorette Müller-Stöver, Lars Stoumann Jensen

Copenhagen University, Copenhagen, Denmark

16:10

Soil microbes as facilitators in restoration of post-mining substrates

Mining of mineral resources generate substantial volumes of wastes (i.e. post-mining substrates) that are characterised by poor physical structure and hydrology, unstable geochemistry, and potentially toxic chemical conditions. Restored landscapes using these post-mining substrates possess significant abiotic constraints for both plants and microbial communities. Little is known regarding the complexity and functions of microbial communities present in post-mining substrates, and more critically, how they may be used in novel ways to shape the above-ground outcome of post-mining ecosystem restoration. Whilst previous researches have focused on soil fungal communities in a restoration scenario, our knowledge on the role of bacterial and archaeal communities in facilitating restoration of degraded landscapes is limited. Here, we will present out work that used both marker gene and shotgun metagenome sequencing, to show that topsoil storage and the blending of soil and mine waste substrates to form suitable substrates for plant establishment gives rise to variable bacterial and archaeal phylogenetic composition but a high degree of broader scale metabolic conservation at the community metagenome. Abundance and phylogeny of metabolic genes involved in nutrient cycling (e.g. amoA - ammonia oxidation or nirS/nirK - denitrification) were also compared with sequences recovered from the community metagenome using specific hidden markov models (HMM) models. We also discuss the impact of soil amendments (inorganic nitrogen vs "off-the-shelf" microbial inoculum) on "native" soil microbial community and the growth and establishment of a native plant, Acacia ancistrocarpa in the context of restoration ecology.

Authors: Deepak Kumaresan[1,2], Benjamin Moreira-Grez[1], Adam Cross[3,4], Miriam Muñoz-Rojas[5,6], Jason Stevens[4], Paul Nevill[3,4], Kingsley Dixon[3,4], Andrew Whiteley[1]

[1]UWA School of Agriculture and Environment, University of Western Australia, Perth, WA, Australia, [2]School of Biological Sciences, Queens University Belfast, Belfast, NI, UK, [3]Department for Environmental and Agriculture, Curtin University, Perth, WA, Australia, [4]King's Park and Botanic Garden, Perth, WA, Australia, [5]School of Biological Sciences, University of Western Australia, Perth, WA, Australia, [6]School of Biological, Earth & Environmental Sciences, University of New South Wales, Sydney, NSW, Australia

Friday 23 June

Session 3: Harnessing microbial processes within the agri-food sector

10:10

Pathogen survival in agriculture-based anaerobic digestion compared with stored slurry

Slurry and manure typically contain a range of bacterial, viral and parasitic pathogens. These organic fertilisers are commonly stored overwinter and managed by direct land application without treatment, potentially posing a risk to human and animal health through inhalation of bioaerosols and pathogen contamination of plants, soil and watercourses. Agriculture-based anaerobic digestion (AD) harnesses micro-organisms to produce renewable energy, increasing farm efficiency, whilst utilising additional waste streams as feedstocks and reducing greenhouse gas emissions.

This work examined survival of pathogen indicators in stored slurry compared with slurry processed in AD. Three 10 L continuously stirred tank reactors (CSTRs) were operated at 37°C, batch-fed slurry augmented with fats, oils and grease (FOG). Faecal coliforms, *E. coli* and enterococci numbers were monitored as indicators of pathogen fate throughout the trial, as were physico-chemical parameters including pH, chemical oxygen demand, ammonia, volatile solids and biogas.

Results indicated significantly higher pathogen indicator survival in stored slurry than in AD. After 7 days, faecal coliform and *E. coli* numbers declined by 3-$\log_{10}$ in AD, and 0.35-$\log_{10}$ in stored slurry. After 7 days enterococci numbers decreased by 1.4-$\log_{10}$ in AD and increased slightly in stored slurry. After two months of storage, indicators in stored slurry were still above the 1000 cfu g^{-1} threshold required for digestate, underlining the potential for agriculture-based AD to reduce pathogen load to the environment.

Future work will use simulated rainfall in controlled field trials to determine comparative risk from spreading digestate and unprocessed slurry. This research will inform Irish AD policy.

Authors: Stephen Nolan[1,2], Fiona Brennan[2], Owen Fenton[2], Karl Richards[2], Vincent O'Flaherty[1], Florence Abram[1]

[1]Functional Environmental Microbiology Group, NUIG, Galway, Ireland, [2]Teagasc, Johnstown Castle Research Centre, Wexford, Ireland

10:30

Soil microbial community responses to compounded soil management and climatic disturbances

In order to understand how climate shifts will affect soil ecosystem services, significant research has been undertaken into the stability of soil microbial communities. However, biological pulse disturbances and disturbance combinations require further investigation. To this end, we investigated soil microbiome responses to a compounded disturbance consisting of slurry application preceding an extreme precipitation event. We hypothesised that the influx of nutrients and biomass from slurry would alter resistance and/or resilience to flooding. To test this, both microbial community composition and functional potential were monitored. Slurry application resulted in transiently increased rates of basal respiration, litter decomposition and altered carbon utilisation profiles (CUP). Upon flooding, slurry improved microbiome resistance to waterlogging, considering basal respiration and litter decomposition. Flooding reduced *in-situ* nitrification in both slurry-amended and non-amended soils, as evidenced by significant NH4 accumulation. However, despite 21 days of waterlogging, potential nitrification rates for slurry-amended soils remained at least double that of the non-slurry controls. Once moisture content had returned to that of the unflooded controls, resilience was observed for all measured assays. Recovery of *in-situ* nitrification was observed by depletion of accumulated NH4 to similar levels as unflooded controls, with NH4 consumption occurring more rapidly in slurry-amended vs non-amended soils. This, in conjunction with potential nitrification data, suggests slurry amendment conferred a benefit to the nitrifying community in the face of flooding. Despite evident resilience, CUPs of microcosms subjected to flooding remained distinct to unflooded microcosms throughout the recovery period, suggesting an alternative stable state of the disturbed microbial community.

Authors: Camilla Thorn[1], Fiona Brennan[2], Florence Abram[1]

[1]National University of Ireland Galway, Galway, Ireland, [2]Teagasc, Johnstown Castle, Ireland

11:35

Optimising enrichment culture for isolation of *Clostridium difficile* from animal and environmental samples

Clostridium difficile infection (CDI) is the main cause of infectious diarrhoea in hospitalised patients. *C. difficile* produces highly resistant and infectious spores which promote nosocomial spread in healthcare settings. CDI is increasingly reported in community patients with no history of healthcare contact, there is evidence suggesting that CDI caused by ribotype 078 may potentially be a zoonotic disease. Ribotype 078 strains are the most common cause of CDI in N. Ireland.

Using a previously characterised reference strain, M120, we evaluated enrichment media for isolating *C. difficile* from animal and environmental sources. Growth of *C. difficile* from spores in several media; brain heart infusion broth, cycloserine cefoxitin fructose broth, *Clostridium difficile Brucella* broth with thioglycolic acid and L-cystine, and cooked meat broth, using several supplements (D-cycloserine / cefoxitin; moxolactam / norfloxacin; sodium taucholate; horse blood) was investigated. The highest growth rate (0.465 hour-1) and shortest lag times (~14 hours) were seen using Brain Heart Infusion broth supplemented with moxalactam, norfloxacin and sodium taurocholate. This optimised enrichment medium is now being used to build an isolate collection from animal and environmental samples. *C. difficile* isolates are being characterised using PCR ribotyping, PCR detection of toxin genes, and Multi-Locus Variable Number Tandem Repeat Analysis (MLVA). Furthermore, we have been investigating effective decontamination techniques including Cold Atmospheric Plasma.

Comparative data on enrichment media will be presented, along with results from *C. difficile* isolation work, MLVA typing data from both clinical and animal *C. difficile* isolates, and assessment of a novel plasma based decontamination technique.

Authors: Mairead Connor[1], Derek Fairley[2], Nikki Marks[1], John McGrath[1]

[1]Queen's University, Belfast, Belfast, UK, [2]Department of Microbiology, Belfast health & Social Care Trust, Belfast, UK

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