3rd SUSTAINABLE PHOSPHORUS SUMMIT

Developing a Blueprint for Global Phosphorus Security

29th February - 2 March 2012

PROGRAM

Institute for Sustainable Futures

UNIVERSITY OF TECHNOLOGY SYDNEY

GLOBAL PHOSPHORUS RESEARCH INITIATIVE

P SUMMIT WEB 'APP'

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http://guide.sustainablepsummit.net/

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tweet about the moment you realised the urgency of the world's P Crisis! #PLightbulb

INTRODUCTION

The 3rd Sustainable Phosphorus Summit will bring together key international science, policy and industry stakeholders from different parts of the food production and consumption chain concerned about the role of phosphorus availability and accessibility in global food security, about protecting the environment, and about supporting rural and urban livelihoods. Themes include:

- Sustainable food systems
- Global phosphate rock production and reserves
- Phosphorus use efficiency in mining, agriculture, food processing
- Phosphorus recovery and reuse
- Phosphorus pollution and waste
- Sustainable phosphorus strategies and global governance

The format of the Summit will ensure a high level of interactivity, multi-stakeholder participation, creativity and be outcomes-oriented.

KEYNOTE SPEAKERS

Ms Elizabeth Tilley

Water & Sanitation in Developing Countries, Swiss Federal Institute of Aquatic Science & Technology (EAWAG), Switzerland

An environmental engineer by training, Elizabeth became interested in nutrient recovery and non-sewered sanitation after constructing urine-diverting dry toilets in an arid part of Mexico. She continued her studies under Prof. Don Mavinic at the University of British Columbia and was fortunate enough to work with his group of pioneering struvite-researchers. For four years, she was a Project Officer at the Department of Water and Sanitation in Developing Countries (Sandec) at Eawag, during which time she had the opportunity to work extensively around the world, researching and piloting appropriate technologies and planning strategies. Currently, she is a PhD student studying development economics at Centre for Development and Cooperation (NADEL) at the ETH in Zurich. As part of a Bill and Melinda Gates-funded research project focusing on nutrient recovery from urine, she is researching novel incentive mechanisms for sanitation uptake and use in Durban, South Africa.

KEYNOTE SPEAKERS

Mr Chris Thornton

Coordinator, Global Phosphate Forum, France

Chris Thornton coordinates research and communications for a number of industry associations, in particular the Global Phosphate Forum, which brings together manufacturers of phosphates for detergents worldwide. Over the last decade, he has coordinated the phosphate industry's support of R&D for phosphate recovery and recycling, including research into the chemistry of phosphate precipitation (as struvite or as calcium phosphate), P-recovery reactor design, fertiliser value and agronomic testing of recycled phosphates and economic analyses of of P-recovery. Industry has also contributed to communicating developments in P-recovery, in particular through several international conferences on P-recovery and recycling. He is editor of the "SCOPE Newsletter" which summarises scientific information concerning phosphates and the environment. Alongside his professional activities, he is an active environmental campaigner in local and regional environment NGOs in France.

KEYNOTE SPEAKERS

Mr Andrew Drummond

CEO, Minemakers Australia

Andrew Drummond is the Executive Chairman of Minemakers Limited which is listed on the Australian, Toronto and Namibian Stock Exchanges. He is also a Director of Namibian Marine Phosphates Pty Ltd, the JV company which owns the Namibian project.

Andrew is a geologist and has been involved in the mining business for 40 years in exploration, acquisition, evaluation, feasibility, development and mining. His experience covers a wide variety of commodities, including phosphate, gold, tin and tungsten, copper, uranium and energy.

He has worked in Australia, New Zealand, Russia, China, the Philippines and Namibia.

KEYNOTE SPEAKERS

Prof Mateete Bekunda

General Manager, AGRIDEC Permier Seed (U) Ltd, Kampala, Uganda (Formerly Dean, Faculty of Agriculture, Makerere University, Uganda)

Professor Mateete Bekunda is a Ugandan agricultural scientist, with thirty three years experience of working on land management, particularly on soil and nutrient management for sustainable smallholder farming systems of Africa. He has spent most of his working years in university- and research institute-related projects and partnerships in several countries with extended periods at the Tropical Soil Biology and Fertility Programme of CIAT and IAEA's Seibersdorf Laboratory. His Masters and PhD theses were on phosphorus measurement using malachite green, and on its characterization in Australia's forest soils, respectively. He has held senior administrative positions at Makerere University, up to Faculty Dean, and has been a Full Professor since 2003. Iowa State University recognized him as its College of Agriculture and Life Sciences World Professor in 2008. He has published over seventy scientific papers and books chapters. He currently coordinates the African Nitrogen Centre and the African Platform of the Global Partnership on Nutrient Management.

KEYNOTE SPEAKERS

Mr David Eyre

General Manager, Research & Development, NSW Farmers Federation

David Eyre is General Manager, Research & Development with NSW Farmers' Association where he is leading innovation projects in areas including carbon farming, market based instruments, renewable energy, precision agriculture and sustainable natural resource management. He was previously a Director of the Commonwealth Research & Development Corporation, Land and Water Australia and held senior policy and science roles in NSW Government.

KEYNOTE SPEAKERS

Dr David Lansley

Senior Economist, World Vision Australia

David started with World Vision Australia in April 2008, working in the areas of food security, economic development and climate change. He is currently Senior Economist and Senior Advisor in the Advocacy and Policy Research group, with a continuing focus on climate change, economic development and food security.

Prior to commencing with WVA, David was a senior fellow at the Australian and New Zealand School of Government. Between 2003 and 2007 he undertook a PhD at the University of Melbourne and taught economics, Australian and European political science and business strategy there.

Between 1989 and 2003 he worked in the financial sector in senior economic positions with the HongKongBank, McIntosh Securities and the National Australia Bank. He also completed a Master of International Business at Melbourne University. David has also worked for Shell Australia and the Australian Council of Trade Unions, the Australian Treasury and the Australian Bureau of Statistics, and has taught at Monash University, the Australian National University and the University of Sydney.

KEYNOTE INTERVIEW

Prof Paul J Crutzen

Winner of the 1995 Nobel Prize in Chemistry, Max Planck Institute for Chemistry, Germany

Paul J. Crutzen (born in 1933) succeeded Christian Junge as Director of the Atmospheric Chemistry Department in 1980. This department performs laboratory experiments to determine the absorption of UV and infrared radiation by atmospheric trace elements, as well as the speed at which elements react in the atmosphere. In order to better understand the formation of holes in the ozone layer above the Arctic and Antarctic, processes were simulated on stratospheric particles in the laboratory. The department also performs measurements of the trace elements present in our atmosphere around the world. Mathematical models, into which the data recorded is input, are being developed to describe meteorological, climatic and chemical processes. These models can be used to estimate the possible climatic consequences of a nuclear war and the influence of human activities on the ozone and climate. Paul Crutzen was awarded the Nobel Prize for Chemistry in 1995 together with M. Molina and F. S. Rowland. Paul Crutzen retired in the year 2000.

ORGANISING COMMITTEE

Prof Stuart White

Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Professor Stuart White is Director of the Institute for Sustainable Futures where he leads a team of researchers who create change towards sustainable futures through independent, project-based research. With over twenty years experience in sustainability research, Professor White's work focuses on achieving sustainability outcomes at least cost for a range of government, industry and community clients across Australia and internationally. This includes both the design and evaluation of programs for improving resource use efficiency and an assessment of their impact. Professor White has written and presented widely on sustainable futures and is a regular commentator on sustainability issues in the media.

ORGANISING COMMITTEE

Dr Dana Cordell

Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Dr Dana Cordell recently completed her doctoral research on 'the sustainability implications of global phosphorus scarcity for food security' which she undertook jointly at the Institute for Sustainable Futures at the University of Technology Sydney, in Australia, and, Linköping University's Department for Water and Environmental Studies in Sweden. As an outcome of her research on sustainable phosphorus futures, Dana co-founded the Global Phosphorus Research Initiative. Dana is currently a core member of the international consortium of researchers working on theSustainable Use of Phosphorus project for the EU (D.G. Environment), in addition to Securing the Phosphorus Future of Australia collaborative project with CSIRO. She also has 10 years of sustainability research experience leading and undertaking interdisciplinary sustainable water, sanitation and waste management projects many of which involved high-level stakeholder engagement.

ORGANISING COMMITTEE

Mr Dustin Moore

Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Dustin joined the Institute for Sustainable Futures in 2010 as an environmental planner under the Institute's graduate program. Prior to this, Dustin contributed to the investigation of water quality issues for the Cradle Coast Regional Planning Initiative in Tasmania, and volunteered as a Sustainable Agriculture Extension Agent in rural Panama working in conjunction with community members and agency partners focusing on sustainable uses and development of available natural resources, concentrating most efforts within small coffee farms. Dustin's research focuses on the sustainable built environment, peak (P)hosphorus and its implications for food security, and green roofs/walls and their capability to help the urban area prepare for climate change. Dustin is a member of the Planning Institute of Australia (PIA), and nearing completion of the requirements to become a PIA Certified Practicing Planner.

ORGANISING COMMITTEE

Dr Tim Prior

Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Tim Prior is a Senior Researcher with the Risk and Resilience Group within the Centre for Security Studies. He has completed a Doctorate in Social and Environmental Psychology from the University of Tasmania (Australia), a Master's degree in Environmental Science from James Cook University (Australia), and completed his undergraduate studies in quantitative ecology. Before joining the CSS, Tim was a Research Principal at the Institute for Sustainable Futures at the University of Technology, Sydney.

Tim's research has focussed on risk and decision making under uncertainty, particularly in relation to individual, community and organisational preparation and response to environmental risk. His most recent work has included foresighting research on natural resource security in Australia, as well as exploring new mechanisms for risk communication with respect to natural hazards like wildfire.

ORGANISING COMMITTEE

Dr Tina Schmid Neset

Department of Thematic Studies – Water & Environmental, & Centre for Climate Science and Policy Research, Linköping University, SWEDEN

Dr Tina Schmid Neset is an assistant professor at the Centre for Climate Science and Policy Research (CSPR) & Department of Water and Environmental Studies at Linköping University. Her research areas include Material and Substance Flow Analysis studies with a particular focus on resource flows linked to food production and consumption. Within the Nordic Centre of Excellence for Strategic Climate Adaptation Research NORD-STAR, she leads the research on visualization for decision support and data analysis regarding land-use issues and risk assessment in the Nordic Countries. Tina is currently the head of Climate Visualization at CSPR and co-founder of the Global Phosphorus Research Initiative.

ORGANISING COMMITTEE

Prof Paul J Crutzen

Nobel Prize laureate, Max-Planck-Institute for Chemistry, GERMANY

Paul J. Crutzen (born in 1933) succeeded Christian Junge as Director of the Atmospheric Chemistry Department in 1980. This department performs laboratory experiments to determine the absorption of UV and infrared radiation by atmospheric trace elements, as well as the speed at which elements react in the atmosphere. In order to better understand the formation of holes in the ozone layer above the Arctic and Antarctic, processes were simulated on stratospheric particles in the laboratory. The department also performs measurements of the trace elements present in our atmosphere around the world. Mathematical models, into which the data recorded is input, are being developed to describe meteorological, climatic and chemical processes. These models can be used to estimate the possible climatic consequences of a nuclear war and the influence of human activities on the ozone and climate. Paul Crutzen was awarded the Nobel Prize for Chemistry in 1995 together with M. Molina and F. S. Rowland. Paul Crutzen retired in the year 2000.

ORGANISING COMMITTEE

Prof Bjorn-Ola Linner

Department of Thematic Studies – Water & Environmental, & Centre for Climate Science and Policy Research, Linköping University, SWEDEN

Björn-Ola Linnér is professor in Water and Environmental Studies and at the Centre for Climate Science and Policy Research at Linköping University, Sweden, where he was theprevious director (2006-2010). Currently he is a visiting fellow at the Institute for Science, Innovation and Society (InSIS) at University of Oxford. His research focuses on international policy-making on environment and development. His recent publications analyse integration ofpolicies on climate change, food security, sustainable development and low-carbon energy technologies as well as transnational governance in climate science and policy. Published books include among others The Return of Malthus: Environmentalism and Postwar Population–Resource Crises. As a researcher he has been actively involved in the international climate negotiations for several years. He was member of the Swedish delegation at the Adaptation and Approval of the fourth Assessment Synthesis Report of the Intergovernmental Panel on Climate Change, Valencia, Spain 2007. He is currently leading a research program on non-state actors in the new landscape of international climate cooperation and he is also one of the co-leaders of the Centre for Excellence Nordic Strategic Adaptation Research (NORD-STAR).

SCIENTIFIC COMMITTEE

Prof Stuart White, Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Dr Dana Cordell, Institute for Sustainable Futures, University of Technology, Sydney, AUSTRALIA

Dr Tina Schmid Neset, Department of Thematic Studies – Water & Environmental, & Centre for Climate Science and Policy Research, Linköping University, SWEDEN

Prof Bjorn-Ola Linner, Department of Thematic Studies – Water & Environmental, & Centre for Climate Science and Policy Research, Linköping University, SWEDEN

Dr Jaap Schröder, Plant Research International, Wageningen University, THE NETHERLANDS

Dr Jan-Olof Drangert, Department of Thematic Studies – Water & Environmental, Linköping University, SWEDEN

Dr Arno Rosemarin, Stockholm Environment Institute, SWEDEN

Ms Andrea Ulrich, Institute for Environmental Decisions, ETH Zurich, SWITZERLAND

Dr Mike Wong, Land and Water - Commonwealth Scientific and Industrial Research Organisation, AUSTRALIA

Dr Kazi Parvez Fattah, Department of Civil Engineering, American University of Sharjah, UAE

Mr S.Vishwanath, Advisor, Arghyam Foundation, INDIA

Dr Bert Smit, Plant Research International, Wageningen University, THE NETHERLANDS

SUSTAINABILITY POLICY

The 3rd Sustainable Phosphorus Summit Organising Committee is dedicated to further minimising the environmental impact of the Summit and has identified several opportunities for best practice sustainability solutions.

In line with the Summit themes, the following principles have been developed to guide the sustainability initiatives for the Summit:

- **sustainable food systems**: provide low impact and locally sourced food
- **resource efficiency**: aim to minimise our use of resources such as materials, energy and water
- **pollution and waste**: minimise waste and aspire to a paperless conference by avoiding using paper for the program, advertising and conference papers
- **sustainable people strategies and global governance**: build a community committed to social sustainability

The applied initiatives the Summit has undertaken include:

Sustainable Food Systems:

- entirely vegetarian menus for Summit catering – research shows that it takes two to three times less phosphorus to produce a plant based diet than a meat based diet, and where else better to demonstrate this than with the food we serve to the delegates;
- locally sourced food to reduce food miles and wastage during transport;
- locally produced organic wine to minimise environmental damage and greenhouse gas emissions; and,
- a Banquet Dinner menu specifically designed for the P Summit that is locally sourced, ethical, organic, non-GM and seasonal wherever possible.

Resource Efficiency:

- The total phosphorus consumed and excreted by Summit participants will be tracked and measured in support of a ‘P footprint’ analysis (see below for details).

Pollution and waste:

- As a part of the UTS Sustainability Strategy, the University of Technology, Sydney is dedicated to increasing recycling rates and using more recycled water, paper and other products. For more information, visit: http://www.green.uts.edu.au/about/sustainability-strategy/UTS-Sustainability- Strategy_Draft-for-consultation.pdf;
- in addition to food being locally sourced, any food waste will be composted where possible by the catering venues;
- reducing the paper wastage that often occurs during conferences has been managed with the development of a web-based P Summit app for all delegates to use during the Summit on their smart phones and personal computers - the app will allow access to the P Summit program and be available through free WiFi; and,
- avoid, minimise, re-use and recycle materials like plastic and paper wherever possible - creative reuse of materials for lanyards, and plantable paper name tags impregnated with seeds.

Sustainable people strategies and global governance:

- to highlight to companies that sustainability matters, caters have been specifically chosen for their very own sustainable food initiatives and recognised for it;
- a program has been designed that creates an interactive environment that facilitates substantial mutual learning and encourages take home actions; and,
- to reduce delegate greenhouse emissions and encourage multidimensional sustainability, hotels within walking distance have been chosen and delegates encouraged to use public transport – the Aerial Function centre is located 5 to 10 minutes walk from Central Station and bus stops are located on the main road directly outside of the venue.

At the conclusion of the Summit, an evaluation will be undertaken of how well we maintained our principles and implemented these initiatives.

Developing a Phosphorus Footprint Framework: A case study of the 3rd Sustainable Phosphorus Summit

An intern from the United States, Sarah Griffith, will be using the P Summit as a case study for her research into developing a phosphorus footprint framework.

Developing and applying carbon footprints for events, buildings, and cities is becoming nearly second nature with the global concerns around climate change and energy scarcity now in the main stream. Phosphorus scarcity on the other hand is still only a blip on the radar of public consciousness. However, concerns are increasing and there is now a need to similarly understand 'phosphorus footprints'. This project will use the event, the 3rd Sustainable Phosphorus Summit, Sydney, Australia, as a case study to develop a phosphorus footprint framework. This framework will be applied to the Summit to determine:

- the total phosphorus consumed by participants of the Summit via food and beverages;
- the total amount of phosphorus generated (and hence potentially recoverable) by the Summit participants in a) excreta, b) food waste; and,
- the total phosphorus demand associated with the Summit (including up the chain to phosphate rock and the food production chain).

The project will involve an eight-week internship with the Global Phosphorus Research Initiative in Sydney, under the supervision of Dr Dana Cordell. The developed framework will be applied to the Summit to determine the phosphorus demand and consumption of participants, as well as the total generated, thus potentially recoverable. A final report including methodology, analysis and conclusions will be delivered and made publicly available via the Sustainable P Summit website, Global Phosphorus Network and other possible platforms.

PROGRAM

DAY ONE - WEDNESDAY 29th FEBRUARY 2012

08:00 - 09:00	***Registration and Coffee***
09:00 - 09:30	**Welcome Address**
09:30 - 10:30	**Expert Panel: Phosphorus in the Food System:** Mr David Lansley *(World Vision Australia)* Mr Andrew Drummond *(Minemakers Australia)* Prof Mateete Bekunda *(AGRIDEC Premier Seed , Uganda)* Mr David Eyre *(NSW Farmers Association, Australia)* Mr Chris Thornton *(Global Phosphate Forum, France)* Ms Elizabeth Tilley *(EAWAG and NADEL, Switzerland)* Moderator: Dr Dana Cordell *(Institute for Sustainable Futures)*
10:30 - 10:50	*Morning Tea*
10:50 - 12:00	**Expert Panel Discussion: Phosphorus Challenges and Opportunities**
12:00 - 12:40	**Soapbox Sessions** 1. Global P Production & Reserves/Pollution & Waste 2. Sustainable Food Systems 3. Phosphorus Recovery and Reuse I 4. P Use Efficiency: Mining/Agriculture/Food processing I
12:40 - 13:00	**Plenary: Toolbox of Sustainable P Measures** Moderators: Prof Stuart White *(Institute for Sustainble Futures)* and Dr Tina Schmid-Neset *(Linköping University, Sweden)*
13:00 - 13:10	**Introduction to Workshop Sessions**
13:10 - 14:30	*Lunch*
14:30 - 15:20	**Workshop Sessions – Future P Scenarios**
15:20 - 15:40	*Afternoon Tea*
15:40 - 17:00	**Workshop Sessions - Future P Scenarios (ct'd)**

PROGRAM

DAY TWO - THURSDAY 1st MARCH 2012

08:30 - 09:00	***Late Registration and Coffee***
09:00 - 09:50	**Soapbox Sessions:** 1. Sustainable P Strategies & Global Governance 2. P Recovery and Reuse II 3. P Recovery and Reuse III 4. P Use Efficiency: Mining/Agriculture/Food Processing II
09:50 - 10:10	**Plenary:** Key challenges to implementing sustainable P use: Interviews Moderators: Jessica Corman and Karl Wyant *(Arizona State University)*
10:10 - 10:30	*Morning Tea*
10:30 - 11:00	*Summit Group Photo*
11:00 - 12:40	**Workshop Sessions:** Building a Blueprint for P Security
12:40 - 14:00	*Lunch*
14:00 - 14:30	**Keynote Interview:** Prof Paul Crutzen
14:30 - 15:20	**Workshop Sessions:** Building a Blueprint Ct'd
15:20 - 15:40	*Afternoon Tea*
15:40 - 17:00	**Workshop Sessions:** Building a Blueprint Ct'd
17:00 - 17:30	Drinks and Nibbles in the Aerial Foyer
17:30 - 18:30	**Ideas Bazaar**

PROGRAM

DAY THREE - FRIDAY 2nd MARCH 2012

08:30 - 09:20	***Late Registration and Coffee***
09:20 - 10:30	**Plenary: Feedback Summary from Workshops**
10:30 - 10:50	*Morning Tea*
10:50 - 12:40	**Plenary: Showcasing Sustainable Phosphorus Platforms** Moderators: Andrea Ulrich *(Institute for Environmental Decisions, Switzerland)* and Dr Dana Cordell *(Institute for Sustainable Futures)*
12:40 - 14:00	*Lunch*
14:00 - 15:30	**Plenary: Blueprint Preparation** Moderators: Dr Tina Schmid-Neset *(Linköping University, Sweden)* and Prof Stuart White *(Institute for Sustainble Futures)*
15:30 - 15:50	*Afternoon Tea*
15:50 - 17:00	**Plenary: Synthesis and Closing Ceremony**
18:30	**Jurassic Safari Dinner (Banquet Dinner)** *Australian Museum - cnr Park & College St, Sydney* To wind-up the Summit in style, the banquet dinner will be a night of exploration and roving amongst the dinosaurs and fellow phosphorus enthusiasts. The Summit Jurassic Safari Dinner will give delegates the chance to experience a museum like never before - after hours and with drink in hand. The Australian Museum will be our host, and a menu designed by celebrity chef Sean Connolly will ensure that your tastebuds are fully satisfied.

SESSION INFORMATION

EXPERT PANEL

A high-level Expert Panel will set the scene for the Sustainable P Summit on Day 1 to highlight and trigger discussion on the key sustainability issues surrounding the global phosphorus challenge. Following the morning tea break there will be an extensive and stimulating discussion between the Panelists and the audience. Our Expert Panel represents the following sectors: phosphate mining, agriculture, nutrient management in agriculture, food security, the phosphorus recovery industry and low-cost sustainable sanitation. These span Australian, African, European and North American perspectives.

Time: 9:30 - 12:00 DAY 1 (Wednesday)

SOAPBOX SESSIONS (PARALLEL SESSIONS)

The Soapbox Sessions are an opportunity for accepted presenters 'to get up on your soapbox' and present new phosphorus ideas and research to fellow phosphorus colleagues. The Soapbox sessions combine traditional conference presentations with the idea of the public arena soapboxes. Two sets of parallel themed Soapbox Sessions on Day 1 and Day 2 of the Summit will address the themes listed overleaf.

Each parallel session will be chaired yet highly dynamic and made up of fast-paced presentations. Speakers will have at least 3-4 minutes in their designated session speaking slot and their very own soapbox to stand on to promote their work. While there will be traditional digital presentation technologies available to all speakers, we hope to continue the dynamism of the Summit and rely on the zeal and passion of speakers to showcase their works in an energetic and engaging forum.

Exchange of details and questions relating to soapboxes will occur during the Ideas Bazaar (17:30-18:30 Day 2) and organically throughout the Summit.

Time: 12:00 - 12:40 DAY 1 (Wednesday)
9:00 - 9:50 DAY 2 (Thursday)

WORKSHOPS

The parallel workshops on Day 1 and 2 are at the core of the Summit. Summit workshops will serve as a platform for planning, thinking and debating phosphorus futures and what a possible Blueprint could look like. These facilitated workshops will drive discussions on the long-term future for phosphorus from general and sector-specific perspectives and will also showcase and explore a new interactive global phosphorus scenario tool. Day 2 will address general and sector-specific challenges, forming the basis for developing the Blueprint for Global Phosphorus Security on Day 3. All delegates have the opportunity to be an author of the Blueprint.

Time: 14:30 - 15:20 and 15:40 - 17:00 DAY 1 (Wednesday)
11:00 - 12:40, 14:30 - 15:20 and 15:40 - 17:00 DAY 2 (Thursday)

IDEAS BAZAAR

Following on from the Soapbox Sessions, the Ideas Bazaar is a creative space for delegates to connect with those ideas and speakers that captured their attention during the Soapbox presentations on Day 1 and 2. Hosted by comedian Dave Bloustien, the Ideas Bazaar will also feature the book launch of the outcomes of the 2nd Sustainable Phosphorus Summit held in Arizona in 2011, and will give delegates the opportunity to communicate their P Lightbulb moment – that moment that bought them to (P)hosphorus – through the (P)hotobooth and roaming Twitter platform. Drinks and nibbles will also be provided.

Time: 17:30 - 18:30 DAY 2 (Thursday)

BLUEPRINT FOR GLOBAL PHOSPHORUS SECURITY

The Blueprint for Global Phosphorus Security is a key Summit output and will outline steps to providing a more sustainable global phosphorus future. Designed and authored by delegates through the Day 2 workshop and Day 3 plenary, the Blueprint will outline the principles, challenges and opportunities for achieving global phosphorus security, identifying initiatives, strategies, roles and responsibilities for identified stakeholders. This document will set the tone for future research and policy action in the field of phosphorus sustainability and will bring attention to this emerging sustainability issue.

Time: 14:00 - 15:30 DAY 3 (Friday)

DAY ONE: P USE SOAPBOX PRESENTATIONS

Global P rock production & global reserves / P pollution & waste *(Plenary Room)*	Sustainable food systems *(Broadway Room)*	P recovery and reuse I *(Thomas Room)*	P use efficiency in mining, agriculture, food processing I *(Wattle Room)*
Exemplifying that increased demand and prices will always provide new sources of phosphate	City to Soil - Capturing organic waste nutrients	Value proposition for phosphorus recovery from urban wastewater	World Soil Resources and Food Security
Andrew Drummond	**Mr Gerry B Gillespie**	**Murray R Hall**	**Minh-Long Nguyen**
A Critical Assessment of the IFDC 2010 Report "World Phosphate Rock Reserves and Resources"	Sub-Sahara Africa's survival on low phosphorus agriculture	Novel and powerful phosphorus reagents - new concepts for more efficient, selective and sustainable synthetic procedures	P for two – Sharing a scarce resource : soil P in intercropping systems
Dr Arno Rosemarin	**Prof Mateete Bekunda**	**Dr Jan J Weigand**	**Philippe Hinsinger**
Estimating Phosphorus Ultimately Recoverable Resources and Future Production	Life cycle assessment of phosphorus use efficient wheat grown in Australia	The final sink for pig manure – recycling of nutrients or energy production?	Improving phosphorus use efficiency through whole farm nutrient mapping
Dr Steve Mohr	**Dr Bradley G Ridoutt**	**Prof Jan-Olof Drangert**	**Mr David M Weaver**
Phosphate from Western Sahara - the back story	The effects of changing diets on mined- and manure- P demand	Phosphate fertilizer from sewage sludge and meat and bone meal by thermochemical treatment with Cl-donors	Benefits of Combining Inorganic Phosphorus Fertilisers with Organic Soil Amendments
Mr Kamal Fadel, Mrs Cate Lewis	**Ms Genevieve S Metson**	**Christian Vogel**	**David L Gale**
Can Environmental Stress be Exploited for Biological Phosphorus Removal?	Phosphorus flows in the Netherlands	RecoPhos: Full scale production of a P-fertiliser from municipal sewage sludge ash	Efficient use of phosphate fertiliser in crop production
Mr Darragh Hobbs	**Bert Smit**	**Fred Bohndick**	**Steve P McGrath**
Biological availability of phosphorus sorbed to titanium mineral processing residues and implications for their use as agricultural soil amendments	Tracing Embodied P flows in Agriculture - a Participatory Process	Large scale P recovery in the phosphorus industry - Experiences from practice	Phosphorus chemical externalities from the US agricultural sector – The impact of internalization and reduced chemical application rates
Dr Laura A Wendling	**Ms Ramona M VanRiper**	**Christopher Thornton**	**Nikolinka G Shakhramanyan**
Increasing nitrogen fertiliser to reduce phosphorus losses	Against the grain – minimising terrestrial export of P with a low grain P trait	Enhanced Biological Phosphorus Removal in Wastewaters Using Bioelectrochemical Systems	How will more P-efficient pasture systems be achieved in southern Australia?
Miss Rosalind J Dodd	**Dr Terry J Rose**	**Dr Ka Yu Cheng**	**Dr Richard J Simpson**
A system to improve catchment water quality and improve profitability of pasture-based dairy farms			A protein kinase in the rice major QTL Pup1 enhances yield under low P conditions
Dr Rich McDowell			**Dr Sigrid Heuer**

DAY TWO: P USE SOAPBOX PRESENTATIONS

Sustainable P strategies & global governance *(Plenary Room)*	Broadway Room: P recovery & reuse II *(Broadway Room)*	P recovery & reuse III *(Thomas Room)*	P use efficiency in mining, agriculture, food processing II *(Wattle Room)*
Embodied phosphorus flow analysis based on the international trade of agricultural products and food	Phosphorus management in the UK water industry - from costly pollutant to valuable resource	Phosphorus Cycling in a Bio-Based Economy	Accounting P flows and stocks at country scale: the case of France
A/Prof Kazuyo Matsubae	**Mr James Cooper**	**Helen A Cope**	**Thomas Nesme**
Dutch value chain agreement: breakthrough in the transition towards sustainable nutrient management	Urine Diversion (UD) for P recovery: learning from experience in trialing UD at UTS	Selective Removal and Recovery of Phosphate from Wastewater Using Hybrid Anion Exchangers	Can soil organic phosphorus reduce reliance on mineral fertilisers?
Arnoud Passenier	**Prof Cynthia Mitchell**	**Nancy Y Acelas**	**Dr Charles A Shand**
Market based approaches to nutrient pollution and potential for application in the Peel-Harvey Catchment	Phosphorus fluxes and recovery options in the wastewater system of the city of Luleå, Northern Sweden	Phosphate recovery from septage - the honeysucker model from Bangalore	Improving internal P utilization efficiency (PUE) in crop plants
Ms Ophelia J Cowell	**Ms Inga Herrmann**	**Mr Vishwanath Srikantaiah**	**Dr Matthias Wissuwa**
Residual soil phosphorus as the missing piece in the global phosphorus crisis puzzle	Phosphorus recovery from animal manure; Technical opportunities and agro-economical perspectives	Wastewater is not “waste” : North America’s first nutrient recovery facility	Challenges in meeting agronomic and environmental targets for phosphorus use in acid sandy soils
Sheida Z Sattari	**Mr Oscar F Schoumans**	**Rob Baur**	**Dr Mike Wong**
Outcomes of the 2011 Sustainable Phosphorus Summit	The synergy of phosphorus recovery and optimized biogas production at wastewater treatment plants	Towards widespread phosphorus recovery: achieving the highest value return for recovered phosphorus	Soil moisture management as a method for reducing phosphorus losses and increasing phosphorus availability in agricultural soils
Jessica Corman, Karl Wyant	**Dr Pieter-Jan van Helvoort**	**Dr Tim H Muster**	**Dr Martin SA Blackwell**
	Phosphorus mining from urban wastewater treatment in Seoul	Potential for Phosphorus Recovery from Sydney’s Wastewater	Fixation of phosphorus by adding amendments to P saturated soils
	Dr Young-June Choi	**Vigi Vigneswaran**	**Sara De Bolle**
	Clean Water Technology	Use of desalinated reject water as a source of magnesium for phosphorus recovery from wastewater	Improved quantification of plant available soil organic P
	Philip O’Brien	**Dr Kazi P Fattah**	**Miss Tegan S Darch**

SOAPBOX ABSTRACTS

Global phosphate rock production and global reserves / Phosphorus pollution and waste - *Plenary Room Day One 12:00 - 12:40*

Sustainable Food Systems - *Broadway Room Day One 12:00 - 12:40*

Phosphorus recovery and reuse I - *Thomas Room Day One 12:00 - 12:40*

Phosphorus recovery and reuse II - *Broadway Room Day Two 9:00 - 9:50*

Phosphorus recovery and reuse III - *Thomas Room Day Two 9:00 - 9:50*

Phosphorus use efficiency in mining, agriculture, food processing I - *Wattle Room Day One 12:00 - 12:40*

Phosphorus use efficiency in mining, agriculture, food processing II - *Wattle Room Day Two 9:00 - 9:50*

Sustainable phosphorus strategies and global governance - *Plenary Room Day Two 9:00 - 9:50*

A100

Minemakers Limited: Exemplifying that increased Demand and Prices will Always Provide New Sources of Phosphate

Andrew Drummond, Minemakers Limited, Australia

Until the end of 2007, potential rock phosphate mine supply exceeded demand, and prices were low.

Mineralisation was known at Wonarah, with a resource of 73 million tonnes, and at several other areas in Australia's phosphatic Georgina Basin. Since that time, exploration by Minemakers has increased the resource to over 1.5 billion tonnes, and the final Wonarah resource position is likely to be several times that figure.

Extensive modern phosphate sedimentary deposition has been known on the Namibian continental shelf for some decades, but past cost prices and the limitation of dredging technology rendered them uneconomic. Work by Minemakers and its joint venture partners since 2009 has discovered over two billion tonnes of resources in the first two metres of sea floor sediments.

It is a realistic aspiration to double that resource within the joint venture tenements, and for it to be duplicated in known mineralized areas not held by us.

Extensive lower grade occurrences in both regions provide considerable potential to increase resources strongly when future prices make exploration and development economically feasible.

A101

A Critical Assessment of the IFDC 2010 Report "World Phosphate Rock Reserves and Resources"

Dr Arno Rosemarin, Stockholm Environment Institute, Sweden

IFDC (2010) reestimated the global phosphate reserves/resources spurned by growing concern around imminent peak phosphorus using USGS data (2010) and projections. The IFDC report estimated global commercially viable reserves at 60 gigatons P rock; USGS' estimate was 16 gigatons. The largest single change was Morocco's reserves, increased from 5.7 to 51 gigatons. The report reinterpreted literature data making assumptions: 2 tons/ m³ to convert deposit zones to Prock tonnage, 95% mining recovery, ore/ concentrate ratio (1.8) for upper bed Moroccan deposits requiring washing/screening and 3.3 for deeper bedrock requiring floatation. The report provides no new data on P concentration in sedimentary deposits or drill cores. Is this report definitive/conclusive? That no UN body commented the new data exemplifies a gap in global governance. Can the Report be the basis for a global strategy on sustainable use of phosphorus and all the implications surrounding fertiliser and food security? Or is there more homework to be done?

A102

Estimating Phosphorus Ultimately Recoverable Resources and Future Production

Dr Steve H Mohr, University of Technology, Sydney, Australia
Prof Geoffrey Evans, The University of Newcastle, Australia

The Ultimately Recoverable Resources (URR) for phosphorus was analysed and was estimated to most likely be 3204 Mt (P) with low and high estimates of 1523 and 4507 Mt (P) respectively. The Mohr (2010) production demand model was used to project phosphorus production for all countries. World demand is included in the model, and influences the production of phosphorus. By summing these countries productions it was determined that phosphorus production will peak between 1991 and 2029 with a best guess of 2024. These results are consistent with most projections on future phosphorus production. Based on these findings it is vital that recycling and demand reduction options be urgently investigated and implemented to ensure sufficient phosphorus is available. One potential recycling method could be to extract phosphorus (as well as nitrogen and potassium) from sewerage in treatment plants, creating a safe fertilizer to be sold to the agriculture sector.

A103

Phosphate from Western Sahara - the back story

Mr Kamal Fadel, Saharawi Representative to Australia, Australia
Mrs Cate Lewis, Australia Western Sahara Association, Western Sahara

We will show how the importation of phosphate rock from Bou Craa mine in Western Sahara is contrary to Australian and International law.

Morocco's illegal occupation of Western Sahara means it does not hold legal title to Western Saharan resources, therefore, the Moroccan state company (Office Chérifien des Phosphates), cannot contract to pass title to Australian companies.

The people of Western Sahara recognised by the International Court of Justice as the Sovereign over that territory in 1975 do not consent to or benefit from this trade.

Australia supports the UN peace process to resolve the conflict. Yet, at the same time, undermines it by allowing this phosphate trade.

Finding alternatives to superphosphate for Australian agriculture will assist Western Sahara to achieve self-determination and self-management of their natural resources.

A104

Can Environmental Stress be Exploited for Biological Phosphorus Removal?

Mr Darragh Hobbs, The Queen's University Belfast and The QUESTOR Centre, Ireland
Dr John Quinn, The Queen's University Belfast and The QUESTOR Centre, United Kingdom
Dr John McGrath, The Queen's University Belfast and The QUESTOR Centre, United Kingdom

Eutrophication is the single greatest threat to freshwater bodies globally. Elevated levels of phosphorus (P) in lakes and waterways lead to accelerated algal growth. The failure of current wastewater treatment systems to consistently meet the required standards for P removal contributes enormously to the problem.

A novel biochemical phenomenon has been identified that results in significant and consistent P removal from a defined medium. The cornerstone the process is the ability of certain microorganisms known as polyphosphate accumulating organisms (PAOs) to accumulate P naturally in the form of polyphosphate (polyP). Through the application of a specific environmental stress it has been demonstrated that the ability of PAOs to accumulate P can be enhanced. Acinetobacter calcoaceticus, Pseudomonas putida and the surrogate activated sludge culture, Polytox were subjected to periods of stress before reintroduction to complete media. Their ability to accumulate P increased by 176%, 209% and 200% respectively.

A105

Biological availability of phosphorus sorbed to titanium mineral processing residues and implications for their use as agricultural soil amendments

Laura A Wendling, CSIRO, Australia
Mr Mark Shackleton, CSIRO, Australia
Dr Zheng Yuan, CSIRO, Australia

Detailed investigations have shown that the Caand Ferich byproducts of Ti mineral processing exhibit high P sorption capacity and low environmental toxicity. These residues may be suitable for use as soil amendments to reduce P loss via surface runoff or leaching to shallow groundwater; however, the plant uptake and potential biological availability of P sorbed to Ti mineral processing residues has not been assessed. This is a significant gap to the potential use of these residues both in terms of quantifying potential benefits to plant growth under reduced fertilization regimes, and the possible rerelease of sorbed P to sensitive water bodies. We have used radio isotopic dilution techniques to quantify plant uptake and the potential biological availability of P sorbed to Ti mineral processing residues. These measures of P bioavailability have important implications related to the productive use of Ti mineral processing residues as environmental amendments for P attenuation.

A106

Increasing nitrogen fertiliser to reduce phosphorus losses

Ms Rosalind J Dodd, Agresearch Ltd, New Zealand

Long-term application of P fertiliser in excess of crop requirements has led to a buildup of phosphorus in many agricultural soils. Decline in soil phosphorus concentrations is slow and environmentally significant concentrations of P can be lost to water long after fertiliser application is halted. One potential method to accelerate the decline in soil P concentrations is to increase plant uptake by applying nitrogen. A field trial showed that application of N and P for 3 years results in lower concentrations of water soluble P (WSP) in soils, compared to P alone. This data will be presented along with the results from the 1st year of a lysimeter trial looking at P and N concentrations in leachate from 3 soil types with 3 rates of N (0, 150 and 300 kg N/ha/yr) and 2 rates of P (zero and half maintenance), combined with regular cutting and removal of biomass.

A107

Enhanced Biological Phosphorus Removal in Wastewaters Using Bioelectrochemical Systems

Dr Ka Yu Cheng, CSIRO Land and Water, Australia
Dr Maneesha Ginige, Australia
Dr Anna Kaksonen, Australia

Phosphorus (P) removal from municipal wastewaters is typically achieved using chemical precipitation methods. A more sustainable approach is via enhanced biological phosphorus removal (EBPR). Typically, in EBPR a unique group of microorganisms called polyphosphate accumulating organisms (PAOs), are exposed to alternating anaerobic and aerobic conditions, under which they can take up excess P from the wastewater. This study aimed to explore the possibility of using bioelectrochemical systems (BES) to facilitate EBPR without the need of aeration. We examined whether PAOs could use graphite electrodes (potentiostatically poised at +/200 mV/Ag/AgCl) as electron acceptors to enable P removal from wastewater (Figure 1). This concept could potentially reduce the aeration (energy) demand and favor the control of the EBPR process. The results indicate that aerobically enriched PAOs preferred oxygen instead of an anode for P uptake. Ongoing studies are in progress to explore applications of BES for sustainable P removal from wastewaters.

A108

A system to improve catchment water quality and improve profitability of pasture-based dairy farms

Dr Rich McDowell, New Zealand

The loss of phosphorus (P) from dairy farms impairs profit and water quality. Splitting mixed ryegrass-white clover swards into monocultures can increase milk solids. The low P requirement of ryegrass also means that it can be placed in areas that contribute runoff, and little P applied. This was hypothesized to decrease P loss. A paired catchment trial was conducted of stream-flow and pasture yield over 5 years. During the first 3 years, both catchments were treated the same, but afterwards, 40% of one catchment, near the stream was cultivated and ryegrass planted, while the rest of the catchment was direct drilled in clover and chicory. Pasture yield and modeling suggested profitability increased by $46/ha over a mixed sward. Stream losses of algal available P and total P decreased by 45 and 24%, respectively. This indicates considerable potential to improve profitability and water quality in an intensive dairy system.

B100

City to Soil - Capturing organic waste nutrients

Mr Gerry B Gillespie, Office and Environment and Heritage, Australia

City to Soil: A cost effective system for capturing P and other nutrients from organic waste streams and increasing soil carbon.

Over the past four years the Groundswell Project has refined the City to Soil collection system for food and garden organics and combined it with an ability to identify and reward individual households. The community engagement strategy in this program has a delivered excellent results based on providing the right tools, information and motivation to householders. Comprehensive social research has demonstrated strong community and political support and understanding in combination with high levels of participation. In depth economic analysis and has shown that City to Soil will pay for its implementation in three years and will be returning funds to council in real terms within five years. A new methodology for soil carbon sequestration measurement under the Australian Carbon Farming Initiative would mean the benefits would be further increased.

B101

Sub-Sahara Africa's survival on low phosphorus agriculture

Prof Mateete Bekunda, Faculty of Agriculture, Makerere University, Kampala, Uganda

Phosphorus (P) is one of the most limiting nutrients in agro-ecosystems of sub-Saharan Africa (SSA), a region dominated by characteristically poor smallholder farmers whose livelihoods are primarily dependent on rain-fed cropping, and use of limited amounts of nutrient inputs on soils that are inherently poor in soil fertility and other biophysical factors. Yield of crops is perennially low (<1 t/ha for staple cereals), making hunger and food insecurity significantly undermine development on the continent. SSA researchers have identified and tested potential management options and optimal exploitation of the limited P sources. Challenges on how to make this empirical knowledge work to enhance farmers' livelihoods persist. Innovative approaches among farmers, agro-service providers, development agencies and researchers are being implemented in order to make a real difference to food production in SSA. Emerging sustainable options and technologies for promoting increased and efficient P management in SSA cropping systems are discussed.

B102

Life cycle assessment of phosphorus use efficient wheat grown in Australia

Dr Bradley G Ridoutt, CSIRO Sustainable Agriculture Flagship, Australia
Dr Enli Wang, CSIRO Land and Water, Australia
Mr Peerasak Sanguansri, CSIRO Food and Nutritional Sciences, Australia
Dr Zhongkui Luo, CSIRO Land and Water, Australia

Over and above the potential to deliver economic benefits to individual farmers, new wheat varieties with phosphorus use efficiency (PUE) traits have the potential to make an important contribution to addressing major global environmental and food security challenges. One strategy being pursued is the development of wheat with enhanced organic anion release (mainly citrate) from the root system, which can solubilise soil bound P and increase the efficiency of P fertilizer uptake. Agricultural production system modeling, using a special purpose configuration of the APSIM modeling platform, was used to assess the potential long-term P fertilizer application savings for wheat grown in three agro-ecological regions of Australia with varying conceptual levels of root citrate efflux. In this presentation we explore the potential of PUE wheat to contribute to sustainable food systems and describe the environmental relevance of potential savings, in terms of avoided eutrophication and intergenerational resource depletion, using life cycle assessment.

B103

The effects of changing diets on mined- and manure- P demand

Ms Geneviève S Metson, McGill University, Canada
Dr Elena Bennett, McGill University, Canada
Dr James Elser, Arizona State University, United States

When considering human impact on P cycling and the solutions available to simultaneously reduce demand for mined P and aquatic eutrophication, diet is often considered in a non-nuanced manner, that is, we only consider vegetarian vs. meat consumption averages. However, changes in diets are much more complex, including changes in total calories, beverages, meat, fruit and vegetables. Diets vary across the globe based on cultural preferences, wealth, and food availability. Here, we consider how changes in diet in 16 countries from 1961 to 2007 translated into changes in P consumed and P footprints (mined P required to produce the consumed food). We found that as P diets change, there is a greater than proportional change in the need for mined P. We explore how diet changes have contributed to increases in demand for mined P over the past 50 years, and the role diet modulation could play in sustainable P management.

B104

Phosphorus flows in the Netherlands

A. L. Smit, The Netherlands
J.C. van Middelkoop, The Netherlands
W. van Dijk, The Netherlands
A.J. de Buck, The Netherlands
H. van Reuler, The Netherlands

For several reasons (environment, geopolitics, finiteness of reserves) a sustainable use of phosphorus is needed. Next to an efficient use of fertilizer (and manure!), recycling will be an important issue. For the Netherlands, characterized by an intensive agriculture, a systematic quantification was done of the phosphorus flows in agriculture, industry and society for the years 2005 and 2008. The national P surplus was around 50 Mkg P in 2008. Accumulation in agricultural soil was estimated at 20 Mkg, emissions to surface water at 6 Mkg. The remainder of the surplus (25 Mkg), can be considered as output from the waste industry, e.g. the P flows leaving households and retail which end up in wastewater treatment plants and landfill. This flow however was almost completely withdrawn from the food production chain, e.g. through incineration of sewage sludge. Current developments and options for recycling will be discussed.

B105

Tracing Embodied P flows in Agriculture - a Participatory Process

Ramona M VanRiper, Principia College, United States

Unsustainable mineral phosphorus dependencies in agriculture may be due, in part, to lack of farmer awareness of the sources of phosphorus in farm nutrient imports. A methodological tool was developed to identify and communicate sustainability criteria of P flows into farming systems. The tool traces embodied P flows in farm inputs, allowing representation of these flows to farm decision makers. This methodological framework classifies the source of P in products as fossil (mined), recovered (postconsumer), and displaced (temporally or spatially redistributed). The information gathering structure entails active involvement by the farm decision maker. Using this methodology, embodied P flow evaluations were implemented on five farming systems. Participating farmers engaged in productive discussions of their perspectives on global phosphorus scarcity, and the long-term financial and ecological sustainability of the farming systems. Toward sustainable P, there is a need to trace embodied P flows in agriculture and involve farm decision makers in a participatory process.

Against the grain – minimising terrestrial export of P with a low grain P trait

Dr Terry J Rose, Southern Cross University, Australia
Dr Juan PariascaTanaka, Japan International Research Center for Agricultural Science, Japan
Dr Michael Rose, Monash University, Australia
Dr Matthias Wissuwa, Japan International Research Center for Agricultural Science, Japan

Globally, around 8 million tonnes of phosphorus (P) are removed from fields in harvested cereal and legume grain each year, driving the need for continuous fertilizer application worldwide. In countries where P fertilisers are unaffordable this P removal leads to unsustainable mining of soil. The removal of P from fields in harvested grains would not be problematic if this P was recycled back to farmlands, but this is unlikely to be the case in the near future.

In light of this, we propose breeding for reduced P concentrations in cereal grains used for human consumption.

Several issues need resolving for this to become a reality. Does developing grain require high amounts of P to fulfill yield potential? Is seedling vigour impaired with a low grain P trait? How can such a trait be selected for? This paper presents some recent findings from experiments aimed to address these issues.

C100

Value proposition for phosphorus recovery from urban wastewater

Murray R Hall, CSIRO, Australia
Murray Hall, CSIRO, Australia
Anthony Priestley, CSIRO, Australia
Alan Gregory, CSIRO, Australia

A value proposition was developed for phosphorus recovery from urban wastewater which considered both pollution costs and the value of resources. The value proposition estimated the maximum available cost for resource recovery in net present value and drew upon abatement costs for pollution mitigation and price paths for resources. Sensitivity to resource values, discount rates and process design was explored. Locations with high potential for resource recovery were mapped across Australia. The effect of wastewater phosphorus recovery on the annual Australian phosphorus consumption was also considered.

C101

Novel and powerful phosphorus reagents - new concepts for more efficient, selective and sustainable synthetic procedures

Dr Jan J Weigand, WWU Münsterr, Germany
KaiOliver
Feldmann, Germany
Stephen Schulz
Antje Echterhoff

The intention of our research is to contribute to the field of synthetic phosphorus chemistry both, inorganic and organic, by identifying and developing highly reactive phosphorus reagents that can be potentially regenerated. Here we would like to present a convenient and smooth protocol for the conversion of the resistant P–O bond in phosphane oxides wastes into a reactive P–N bond of synthetically useful pyrazolylphosphonium salts by a highly charged, oxophilic phosphoruscentered trication. The reactions are successfully conducted at room temperature with quantitative yields. The protocol aims towards greener and more efficient processes for the use of waste materials such as phosphane oxides, to recover the phosphorus after its use. Using novel and powerful phosphorus reagents, new concepts for more efficient, selective and sustainable synthetic procedures will be developed.

C102

The final sink for pig manure – recycling of nutrients or energy production?

Prof em Jan-olof Drangert, Linköping University, Sweden

The load of pig manure is causing concern in many regions in Europe since nearby soils need no more phosphorus.

But, vast areas in the world require more nutrients and humus. To what extent can such imbalances be reduced?

The Danish pig industry imports large volumes of feed and exports meat. Its 12.5 million pigs excrete some 5 Mkg phosphorus with the urine and 20 Mkg with the dung (Danish municipal sludge contains potentially 4 Mkg P). If pig urine is evenly applied on the 2.3 million ha of arable and permanent cropland, the dose corresponds to 4 kg P2O5 per ha. This is below present application rate of some 20 kg. Also applying the phosphorus in the faeces would add another 16 kg P2O5 per ha. The presentation focuses on ways to recover P and organic material from the less voluminous pig faeces, and make it available for export.

C103

Phosphate fertilizer from sewage sludge and meat and bone meal by thermochemical treatment with Cl-donors

Christian Vogel, Monash University, School of Chemistry, VIC 3800 Clayton, Australia; Former: BAM Federal Institute for Materials Research & T., Germany
Christian Adam, BAM Federal Institute for Materials Research and Testing, Division 4.3, RichardWillstätterStraße

A sustainable and safe strategy for nutrient recovery from sewage sludges and meat and bone meals (MBM) was developed with thermochemical treatment as key technology. Mono-incineration of sewage sludges completely destructs organic pollutants. The resulting sewage sludge ashes (SSA) have a high phosphorus content but still contain heavy metals. Furthermore, phosphorus in the SSA has a low plant availability.

The SSAs were thermochemically treated at approx. 1000°C for about 30 min after mixing with Cl donors such as
CaCl₂, MgCl₂ and NaCl. Furthermore, Cl₂, HCl and PVC were tested as alternative Cl donors.

Heavy metals were effectively removed via the gas phase and new plant-available mineral phosphate phases were built up. The process can also be operated with addition of MBM as P and energy source at the same time. The improved P fertilization performance was ascertained by agricultural pot experiments.

C104

RecoPhos: Full scale production of a P-fertilizer from municipal sewage sludge ash

Fred Bohndick, Germany
Dr Harald Weigand, THM University of Applied Sciences, Germany
Dr Martin Bertau, Germany
Axel Bruckert, Germany

The substitution potential of sewage sludge for German primary phosphate imports has been estimated as 40 %. Yet, a marketable option for the full-scale recovery has been lacking. Here we report on a novel process for the manufacture of a P fertilizer from sewage sludge ash (SSA) adapted from the production of Triple Superphosphate.
Given (i) conformity of the input with phosphate ores mined from sedimentary deposits, (ii) comparability of the product with a commercially available P fertilizer regarding contaminant levels, P fractionation and yield effects, (iii) compliance of the output with the German Fertilizer Ordinance, and (iv) physical product characteristics suited for broadcast application by spreader disk the RecoPhos P 38 fertilizer was discharged from the waste legislation regime.

The fertilizer is currently being produced at a rate of 1,000 tonnes per month and sold at a competitive price.

C105

Phosphorus management in the UK water industry - from costly pollutant to valuable resource

Mr James Cooper, University of Birmingham, United Kingdom
Rosanna Kleemann
Dr Cynthia Carliell-Marquet, University of Birmingham, United Kingdom

In order for countries to increase phosphorus security and resilience to global scarcity, a phosphorus management strategy is required to increase resource efficiency. A major part of this strategy will be to increase the recovery and recycling of organic waste streams, which will become increasingly valuable. Within the UK, the water industry is ideally placed to recover and recycle phosphorus as a resource stream, therefore playing a major role in UK phosphorus management. However, this will require a shift from treating phosphorus as a pollutant, towards managing phosphorus as a valuable and finite resource. The research examines the external drivers for phosphorus recovery, such as global scarcity and further price rises, and assesses the implications of these drivers on the behaviour and investment strategies of the water industry in order to determine what is required for this shift from pollutant to resource to occur.

C106

Urine Diversion (UD) for P recovery: learning from experience in trialing UD at UTS

Prof Cynthia Mitchell, Institute for Sustainable Futures, University of Technology Sydney, Australia
Dr Kumi Abeysuriya, Institute for Sustainable Futures, University of Technology Sydney, Australia
Ms Dena Fam, Institute for Sustainable Futures, University of Technology Sydney, Australia

Urine diversion (UD) is increasingly seen to make sense in recovering phosphorous from sewage, making research on how sanitation systems could transition to UD critically important. A two-year project at UTS investigated the potential of UD in institutional spaces through a process of learning-by-doing involving small-scale toilet-to-field trials accompanied by social research involving users, cleaning staff and other stakeholders. It revealed current designs of urine diverting toilets as a user interface have limited potential, as they do not align adequately with cultural expectations and habits of practice of typical institutional users. Waterless urinals, in contrast, are a mature technology that can be deployed immediately. The UTS trial revealed the challenges of system change and provided the space for participating stakeholders to envisage and take steps towards what it would take to scale up UD in terms of building design guidelines and regulatory frameworks.

C107

Phosphorus fluxes and recovery options in the wastewater system of the city of Luleå, Northern Sweden

Ms Inga Herrmann, Department of Civil, Environmental and Natural Resources Engineering, Luleå University of Technology, Sweden

Phosphorus fluxes in Sweden's municipal wastewater systems are barely known today and phosphorus recovery is poor in many systems. Further, there are about one million onsite treatment facilities, of which a majority has a low phosphorus capturing potential. There is a need to identify phosphorus losses and recovery options in the systems to increase phosphorus recovery both on centralised and decentralised level. This study focuses on the municipality of Luleå, northern Sweden. Luleå's sanitary system is partly centralised (discharging to a WWTP with a moving bed biofilm reactor and chemical phosphorus precipitation) and partly decentralised (with several small-scale or onsite treatment facilities). The aim of this study is to identify and quantify phosphorus fluxes, including phosphorus recovery rates and losses, in the municipality's existing sanitary system. Furthermore, alternative and innovative sanitary systems are analysed towards their phosphorus fluxes and recovery options. The study therefore contributes to more sustainable sanitation systems.

C108

Phosphorus recovery from animal manure; Technical opportunities and agro-economical perspectives

Mr Oscar F Schoumans, Alterra, part of Wageningen UR, The Netherlands
Prof dr Wim Rulkens, The Netherlands
Mr Phillip Ehlert, The Netherlands
Prof dr Oene Oenema, The Netherlands

From a technical and cost benefit point of view, there are many opportunities for recovery of energy, phosphorus and other nutrients from animal manures via various treatment scenarios.

In this study, the options for phosphorus recovery from pig slurry are evaluated. The solid fraction of pig slurry contains most of the phosphorus and organic matter, and the liquid fraction most of the ammonia. The solid fraction can be used for bioenergy production through incineration and subsequently P recovery from ashes. Also P biochars can be produced. Regarding the liquid fraction of manure, there are perspectives to recover phosphorus at WWTP. In this way the recovered energy and nutrients can be utilized in more efficient ways, resulting in savings on the use of fossil energy and phosphorus reserves. This is especially relevant for large agglomerations of intensive livestock production.

Negotiations are currently taken place about large-scale manure processing pathways in The Netherlands.

C109

The synergy of phosphorus recovery and optimized biogas production at wastewater treatment plants

Dr Pieter-Jan van Helvoort, Grontmij, The Netherlands
Bert Geraats, Grontmij, The Netherlands

In the Netherlands, municipal wastewater treatment plants (WWTPs) have been committed to reduce their carbon footprint. Regional studies on carbon footprint have demonstrated that WWTPs can operate almost energy-neutral if they produce enough biogas through anaerobic sludge digestion. This is an important driver to centralize sludge processing at only a limited number of designated WWTPs where sludge digesting capacity and biogas yield are optimized. As a consequence of, large amounts of nutrients are released in these centralized sludge processing plants. This offers great opportunities for new technologies that are able to recover phosphorus as a premium fertilizer product from the liquid residues of digested sludge. We will describe a few examples of how phosphate recovery technology is integrated in large sludge processing plants enabling both carbon foot print reduction of the WWTP and resources recovery at the same time.

C110

Phosphorus mining from urban wastewater treatment in Seoul

Dr Young-june Choi, Waterworks Research Institute, Seoul Metropolitan Government, Korea

The population of Seoul is 10,575,000. The city has four used water reclamation centers operating. The average amount of treated used water by the 4 centers is 4,370,000 m3/day. The average concentrations of phosphorus are 3.23 and 1.20 mg/L in the influent and in the effluent, respectively. The concentration of phosphorus in effluent will be regulated by 0.5 mg/L in Seoul since 2012. Although the concentration of phosphorus has been decreased, the situation is not favorable to the city.

Although the centers installed coagulation process to meet the regulation of 0.5 mg/L in 2012, it can be related with problem of sludge disposal as disposal to ocean will be prohibited in 2012, too.

The city has to find ways to control phosphorus in effluent. The techniques include coagulation process, selective absorber, and membrane filtration.

If successful, the city can mine 2 million US$ of phosphorus from the used water in a year.

C111

Clean Water Technology

Philip O'Brien, Clean Water Technology Ltd., Ireland

Clean Water Technology Limited identified a market opportunity for a phosphorus removal process to reduce wastewater phosphorus concentrations to very low values to comply with the strict licence requirements that will result from the implementation of phosphorus discharge directives. Some preliminary research indicated that the CWTMedia had good potential for removing phosphorus to very low concentrations e.g., less than 0.03 mg/l. In 2007, a prototype of the novel technology was built and installed at a municipal wastewater treatment plant, where it was monitored and tested by Dr. Michael Rodgers BE, MSc, MEngSc, PhD, CEng, FIEI, Senior Lecturer in Civil Engineering at the National University of Ireland (NUI), Galway and his team of research engineers. The results of this testing have proven the technology to be a success. There are no waste products from this process and the phosphorus is recovered in the form of hydroxyapatite, it does not contain any metals and may be used as a fertilizer without any further treatment.

C112

Large scale P recovery in the phosphorus industry - Experiences from practice

Willem J Schipper, Thermphos International, The Netherlands

An overview will be given of results from large scale recycling of secondary phosphate materials in the production of phosphorus. An overview of suitable materials will be presented and technologies to make phosphates suitable as raw materials will be given, as well as an assessment of this recovery route compared to other technologies.

C113

Phosphorus Cycling in a Bio-Based Economy

Ms Helen A Cope, University of Edinburgh, United Kingdom
Dr Alistair Elfick, University of Edinburgh, United Kingdom

The liquid biofuel industry is growing and developing in response to dwindling fossil fuel resources, the drive to reduce carbon emissions and national need for energy security. Policies for adoption of biofuel technologies raise concerns over economic viability, real reduction in CO2 emissions and land-use decisions. True sustainability in a bio-based economy, however, requires that nutrients critical for biomass growth are returned to land.

Despite this, nutrient recycling is rarely discussed in this context. Here the opportunities and limitations for integrating current and novel phosphorus recovery technologies into varying types of bio-refinery will be discussed. Future research needs will be highlighted and the importance of including nutrient recovery and reuse in future biofuel policies will be emphasised.

C114

Selective Removal and Recovery of Phosphate from Wastewater Using Hybrid Anion Exchangers

PhD Student Nancy Y Acelas, Institute of Chemistry, University of Antioquia, A.A. 1226, Medellín, Colombia, Colombia
Dr Benjamin Martin, Cranfield Water Science Institute, Cranfield University, Cranfield, MK43 0AL, UK
Dr Diana López, Institute of Chemistry, University of Antioquia, A.A. 1226, Medellín, Colombia, Colombia
Dr Bruce Jefferson, Cranfield Water Science Institute, Cranfield University, Cranfield, MK43 0AL, UK

The current work improves upon conventional methods for phosphate removal. This was achieved using hybrid anion exchange, consisting of immobilized hydrated metal oxides of iron and zirconium within anion exchange resins. Batch adsorption experiments fitted common adsorption models and removed up to 99.4 % of the phosphate from a synthetic solution of 5 ppm P, dropping only to circa 80 % in real wastewaters containing 1 ppm P and competing ions such as sulfate at > 100 ppm. The media were designed to allow the economic recovery of the adsorbed phosphate using a single step alkaline regeneration. A small volume of weak NaOH solution (0.0001M) can be used to recover the phosphate from the hybrid material (Zr), and can yield a concentrated stream of 9000 ppm phosphate, ideal for processing into a fertilizer product. The work demonstrates a sustainable approach to the selective removal and recovery of phosphate from wastewater.

C115

Phosphate recovery from septage - the Honeysucker model from Bangalore

Mr Vishwanath Srikantaiah, Biome Environmental Solutions, India

Since almost all Indian villages and most Indian cities are not sewered, pit toilets and septic tanks are frequently used.

According to a World Bank study there were over 102 million septic tanks and 60 million latrine pit toilets in India in 2006. Large volumes of septage are therefore being generated without structured management.

Septage management guidelines are being developed with a primary focus on treatment, especially of pathogen loads, and avoiding pollution. From a nutrient recovery point of view work needs to be done.

This paper based on a case study from Bangalore indicates the presence of phosphate of up to 0.03 % in the desiccated samples. Composted septage application also shows good yield of bananas and millets.

Since India is import dependent on phosphates good management of septage provides an opportunity for recovery and reuse of phosphates.

Wastewater is not “waste”: North America’s first nutrient recovery facility

Peter J Schauer, Clean Water Services, United States
Rob Baur, Clean Water Services, United States
Nate Cullen, Clean Water Institute, United States

The first full-scale wastewater nutrient recovery installation in North America became operational in May 2009 at the Clean Water Service’s Durham Advanced Wastewater Treatment Plant in Tigard, Oregon. Recovering phosphorus from the dewatering side stream as struvite has a positive impact on plant operations, effluent quality, and recovers a limited resource. Significantly reducing the phosphorus recycle lowers the phosphorus loading on the plant, stabilizes biological phosphorus removal, reduces chemicals required to remove phosphorus, reduces both the dry tons of biosolids generated and the phosphorus content of the biosolids, and provides revenue from the sale of the struvite.

Phosphorus is recovered as struvite prills which are a desirable slowrelease fertilizer. In Spring 2011, the facility exceeded 1,000,000 pounds of struvite recovered for beneficial reuse. To increase struvite production by approximately 50% and to decrease struvite potential in the digestion system, the WASSTRIPTM process was implemented fullscale in summer 2011.

Towards widespread phosphorus recovery: achieving the highest value return for recovered phosphorus

Dr Tim H Muster, CSIRO, Australia
Johannes Jermakka, VTT, Finland
Aaron Seeber, CSIRO, Australia
Natasha Wright, CSIRO, Australia
Yesim Güzükara, CSIRO, Australia
Grant Douglas, CSIRO, Australia
Mona Arnold, VTT, Finland
Stewart Burn, CSIRO, Australia

Due to the depletion of global rock phosphate quantity and quality, there is an increasing need to recycle phosphorus to secure food production during the 21st century.

Approximately one fifth of phosphorus fertilizer demand could be potentially available in municipal wastewaters and while wastewater treatment plants are efficiently removing phosphorus from the effluent, there is limited endeavour to recover and reuse phosphorus.

Current economic assessments cannot clearly demonstrate the profitability of phosphorus recovery.

We present new information regarding the potential value of various recovered phosphorus commodities including the likely contaminants of different recycled forms and their potential usage in phosphorus markets. Experimental results compare the manufacturing of calcium- and magnesium- based phosphate commodities. X-ray diffraction confirmed the formation of seven crystalline phosphorus forms, and previously unreported steps were identified to form high purity products. Production costs and potential market values of various phosphorus commodities are critically reviewed.

C118

Potential for Phosphorus Recovery from Sydney's Wastewater

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Around 80% of the phosphorus imports into Sydney come in the form of food and detergent products into households. Once used, over 3000 tonnes of this phosphorus is discharged down the sewerage system by Sydney households every year. Phosphorus recovery in wastewater treatment plants with reduced biosolids generation could recover this important resource. With Sydney producing over 1200ML of wastewater per day, the scope of phosphorus recovery is phenomenally high and largely untapped. Using typical raw sewage concentration of 11mg/L, Sydney's wastewater system generates 13,200 Kg of phosphorus on a daily basis. This paper discusses various phosphorus recovery methods such as ion-exchange and struvite crystallisation, which promise to deliver significant gains in recovering phosphorus. With large wastewater treatment plants approaching the end of their design life in the coming decades, asset renewal of these plants provides an opportunity to incorporate suitable technology for the post peak-phosphorus world.

C119

Use of desalinated reject water as a source of magnesium for phosphorus recovery from wastewater

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The recovery of phosphorus, as struvite, from wastewater provides an environmentally sound and renewable nutrient source to the agricultural industry, as well as solving wastewater treatment plant problems. One of the primary operating costs for struvite crystallization arises from the need to provide external magnesium to the wastewater.

Given that the concentration of magnesium in desalination process reject water is nearly double the concentration in sea water, it can potentially be an abundant source of magnesium. In addition, with increased salinity problems resulting from reject water discharge, reduction of salinity by removing some magnesium will reduce the environmental impacts of the reject water discharge. Consequently, the use of magnesium derived from desalinated reject water can potentially solve two problems at the same time. This study looks into different desalination process (RO and MSF) reject waters to determine the efficiency of phosphorus removal from domestic wastewater.

P for two – Sharing a scarce resource: soil P in intercropping systems

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One promising option for increasing soil P acquisition efficiency in agro-ecosystems is to make better use of plant diversity, and especially of the positive below-ground-interactions occurring between two intercropped species. Niche complementarity occurs when two species explore distinct soil volumes or access different pools of soil resources, e.g. inorganic and organic P.

Facilitation occurs when roots of one species, or their rhizosphere microbial community, release P solubilising compounds such as protons/hydroxyls, carboxylates or phosphatases, thereby resulting in an increased availability of soil P, which ultimately benefits the intercropped species. This facilitative interactions will thus be promoted when the roots of the two intercropped species are closely intermingled. The need for close proximity roots may however be offset by mycorrhizal symbiosis, which might confer access to soil P resources at longer distances from roots. Better understanding these intimate rhizosphere processes shall help designing more P efficient intercropping systems for the future.

D101

Improving phosphorus use efficiency through whole farm nutrient mapping

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Australia's soils are renowned for phosphorus (P) infertility. However, recent soil testing programs suggests P in many southern Australian soils exceeds the critical values for yield responses. Excessive soil P represents an untapped resource, and a risk to water quality.

Whilst soil testing is a well established tool to determine crop and pasture P requirements, soil test data remains under utilised by many farmers, in part because it is difficult to interpret in traditionally presented forms. Colour coded maps developed from paddock based soil sampling and agreed soil test critical values remove the mystique from traditionally presented soil test data.

Under the auspices of Western Australia's Fertiliser Partnership, 109 farms were sampled on a paddock basis and colour coded maps prepared. The soil test data and resultant maps present challenges to the notion of P infertility and traditional fertiliser practice of 1015 kgP/ha/yr, towards more rational consideration of farm nutrient needs.

D102

Benefits of Combining Inorganic Phosphorus Fertilisers with Organic Soil Amendments

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As the world's population continues to increase so too does the demand for food. The sustainability of the required agricultural production, however, is in question if the raw inputs of many fertilisers supplying phosphorus (P) are finite.

Therefore, alternative, or simply more efficient, sources of nutrition are required. The uptake and utilisation efficacies of single and combined applications of compost and synthetic fertiliser were compared, and related to yield, in a glasshouse barley trial established to determine the potential for reduction in synthetic P fertiliser usage through partial substitution with compost. A microbial inoculant alone and in combination with compost or synthetic fertiliser was also included in the comparison undertaken. This project demonstrates that conventional synthetic, and organic, fertilisers could be used together to maintain or increase yield, whilst reducing demands on conventional, mined, synthetic P supplies through greater fertiliser efficiency.

D103

Efficient use of phosphate fertiliser in crop production

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Plant-available inorganic P in mineral soils is considered to be in four pools of decreasing accessibility but with reversible transfer of P between pools. Phosphorus in the readily plant-available and soil solution pools is most accessible and can be measured by reliable methods of routine soil analysis. The concentration of P in these two pools at which yield reaches 98% of the maximum yield is defined as the critical soil P level for that soil and farming system. Yields of arable crops and grassland in long-term field experiments at Rothamsted Research illustrate that the most efficient way of using applied P in crop production is to first raise a soil to its critical level and then maintain this level by replacing the P removed in harvested crops.

D104

Phosphorus chemical externalities from the US agricultural sector – The impact of internalization and reduced chemical application rates

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Phosphorus chemicals are essential for the modern cropping system however they affect environmental quality and human health. This study uses mathematical programming to examine alternative assumptions about regulations of external costs from Phosphorus chemicals and different crop managements in US agriculture. We find that, external cost regulation have minor effects on agricultural production in the US but reduce substantially Phosphorus chemicals use. Although the internalization of the Phosphorus chemical externalities, increase farmers' production costs theirincome effects are positive because of price adjustments and associated welfare shifts from consumers to producers.

Our results also show heterogeneous impacts on preferred chemical management intensities across major crops.

D105

How will more P-efficient pasture systems be achieved in southern Australia?

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The Pbalance efficiency (100*P_{products}/P_{fertiliser+feed}) of fertilised pastures in southern Australia is typically 11%29%

On very low P sorbing soils this is partly due to P leaching, but in most soils (moderate to high P sorption) inefficiency is associated mainly with P accumulation in soil. A pasture P balance study shows that the amount of P accumulated in paddocks is correlated positively with the plant-available P concentration at which the soil is maintained (Fig. 1). This indicates P efficiency may be improved if pastures are managed at lower available P concentrations.

Options include:
(i) avoiding fertilising soil beyond "critical" P (P needed for near maximum pasture growth); (ii) developing pastures with lower critical P requirements: e.g. legumes with extensive fine roots that explore soil more effectively; plants that can utilise "fixed P" in soil; or by using N fertilized grass pastures.
(iii) Development of fertilisers that minimize P reactions with soil.

D106

A protein kinase in the rice major QTL Pup1 enhances yield under low P conditions

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The major rice quantitative trait locus Phosphorus uptake 1 (Pup1) was identified in a germplasm screening under P deficient field conditions in Japan about a decade ago. Despite extensive efforts since then, currently known plant P responses could not be associated with Pup1. Recently, the Pup1 locus was sequenced in the donor variety Kasalath revealing a large (~90 kb) Pup1specific insertion/deletion (INDEL). One of the genes present in the INDEL codes for a Ser/Thr protein kinase and its over expression significantly enhanced grain yield under P deficient conditions as well as root growth in soil and hydroponics. Affymetrix gene expression analysis of transgenic plants revealed altered expression of genes related to root growth and delayed senescence but failed to identify specific regulation of P starvation genes. Pup1 gene-specific markers have been developed and are applied for the development of Pup1 rice varieties. First field experiments confirm the potentially high impact of the Pup1 QTL.

D107

Accounting P flows and stocks at country scale: the case of France

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The global scarcity and high consumption of P reserve call for large-scale, systemic assessment of societal P flows and stocks. We applied such systemic budgeting approach at country and regional scale by accounting for agriculture, industry, domestic, waste and environment compartments. France was considered as a study case due to its intensive agriculture and trade relationships. The method involved P flow modelling and extensive use of national and international databases. Results indicated (1) a positive country scale P budget of 300 kt P/year, yielding to +4 kg P/ha/year soil P budget in 2006; (2) a low P use efficiency of the food system: only 10% of the total soil P inflow was consumed ultimately as food in 2006; (3) high P losses to the environment through waste, wastewater disposal and soil erosion, accounting for half of the national mineral P fertiliser use. The regional agricultural P budgets strongly depended on farming systems.

Can soil organic phosphorus reduce reliance on mineral fertilisers?

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Fertiliser inputs have increased the P content of managed soils, yet much of the applied P becomes inaccessible to crops via sorption and organic complexation. By combining solution phase ³¹P Nuclear Magnetic Resonance (NMR) analysis of UK soils with examination of literature data, we show that top soils in many countries contain a substantial resource of monoester P compounds – the principal P form targeted by agronomic and biotechnological research to improve crop P acquisition. Thus, monoester P in soil has the potential to be utilised by plants to reduce current reliance on rock phosphate. Improving crop access to organic P, whilst avoiding leaching and other detrimental effects, may provide vital development time for other sustainable P strategies to be developed.

D109

Improving internal P utilization efficiency (PUE) in crop plants

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Efforts to develop P efficient crops have disproportionally focused on improving P uptake rather than on enhancing plant-internal P utilization efficiency (PUE). While efficient P uptake is needed to assure fertilizer P is taken up rather than immobilized in soil, it should be combined with higher PUE in order to gradually reduce fertilizer requirements of crops. We assessed to what extent genotypic variation for PUE is present within rice gene bank accessions. Genome wide association mapping identified loci conferring superior PUE in shoot and root tissue. Interestingly, highest PUE was detected in traditional rice varieties and landraces, indicating that modern varieties may have partly lost their ability to strive under low P conditions. Options to improve PUE in modern high yielding varieties through modern breeding methods are developed and their effect on the P cycle in agricultural systems is discussed.

D110

Challenges in meeting agronomic and environmental targets for phosphorus use in acid sandy soils

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Cost, supply and environmental concerns with phosphorus fertilisers led us to assess (1) the balance (PBE) and agronomic efficiency of P used by grains grown on sandy soils across the Mediterranean region of Western Australia, (2) compliance with environmental targets and (3) interventions likely to improve P management. The PBE of grains is 48% (% P applied recovered in grains). With over 80% of 109,000 soil samples examined exceeding critical Colwell P values for crops (CV), low agronomic efficiency approximating 0 (no yield gains with P application) in these soils is not offset by high PBE. Over 95% of these samples exceed environmental targets for dissolved reactive P (DRP) concentration and risk leaching P. DRP targets are still exceeded in soils close to their CV due to low P buffering index (PBI<140). Management options to improve P management include using crops with lower CV or managing soil to increase PBI.

D111

Soil moisture management as a method for reducing phosphorus losses and increasing phosphorus availability in agricultural soils

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The drying and rewetting of soils has long been known to result in the increased mobilisation of nutrients which potentially can transfer from the soil via leachate and contaminate surface waters. We have shown that the patterns of rewetting dried soils can affect the quantities of phosphorus potentially lost in leachate (see figure), with implications for the impact of predicted changes in patterns of rainfall as a result of climate change. These data also suggest that careful soil moisture management could not only prevent losses of phosphorus in leachate, but might also promote availability of phosphorus to plants. It is predicted that globally the area of irrigated land is likely to increase in the future, and the findings of our research suggest that it is now necessary to consider irrigation not only in terms of water management, but also with regard to optimising soil phosphorus management.

D112

Fixation of phosphorus by adding amendments to P saturated soils

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As a result of decades of excessive phosphorus fertilization, most acid sandy soils in Flanders (Belgium) and the Netherlands are phosphorus (P) saturated. This saturation entails a risk of significant P leaching to groundwater and causing environmental problems. A study was done to test several amendments to the soil in terms of their potential in retaining P in the soil, thereby decreasing the P availability and the risk of P leaching.

In this study several chemical amendments (such as CaCO₃, CaCl₂, AlCl₃, AlSO₄, FeCl₃, FeSO₄, olivine sand,..) were evaluated on their ability to fix P in an P saturated acid sandy soil, by a filtration and a leaching experiment.

Out of first results came that chemical amendments seem promising in reducing the availability of P in P saturated soils.

Improved quantification of plant available soil organic P

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As global P reserves decline, we need to increase our utilisation of other P sources, including organic P already present in the soil. Plants can access soil organic P by exuding organic acids and phosphatase enzymes, which solubilise and hydrolyse organic P into a form suitable for plant uptake. Organic P can comprise a significant proportion of total soil P (2080 %), but quantification of plant available organic P is less well defined.

Here, the determination of plant available P by using phosphatase enzymes has been developed, using citric acid as an environmentally relevant soil extractant. It has shown that within the tropical soils tested, the quantity of plant available organic P is greater than or equal to inorganic P. This method has the potential to distinguish agricultural land where selection of plants, based on their exudation of organic acids and phosphatase enzymes, may be advantageous to exploit soil organic P reserves.

E100

Embodied phosphorus flow analysis based on the international trade of agricultural products and food

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Phosphorus is indispensable for agricultural production. Hence, the consumption of imported food indirectly implies the import of phosphorus resources. For sustainable management of phosphorus resources, the global supply and demand network should be clarified.

In this study, we analyzed the international phosphorus flow related with agricultural production and food trade. The results show that the most phosphorus consuming countries are China, US, Indonesia, India and Malaysia in order. China consumed 2,002 ktP related with food and 1,176 kt of phosphorus was consumed in US. Looking at P consumption per capita in a year, France consumed 19.6 kgP, approximately 9 kg was consumed in Brazil and Spain, and 4 kgP was consumed in India and US. Finally the phosphorus flow network was visualized in this study, and the result would contribute to discuss the responsibilities of phosphorus consumption in the world.

E101

Dutch value chain agreement: breakthrough in the transition towards sustainable nutrient management

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Bert Smit, The Netherlands
Geert Notenboom, The Netherlands
Ger Pannekoek, Nutrient Platform, The Netherlands

Various important stakeholders in the Dutch nutrient value chain signed a agreement on phosphorus recycling in which parties commit themselves to the ambition to jointly contribute to creating a sustainable market, in which secondary phosphorus flows are brought back into the cycle. It has a broad set up with attention for the various phosphorus flows from the food industry, households, agriculture and the water sector, as well as for the phosphorus processing / fertilizer industry and NGO's. The emergence of this market is not just a matter of finding the right technology, but also of investments in the necessary process industry, the creation of new value chains, a sophisticated mix of market interventions by the government and a gradual growth and improvement of the market by applying developed knowledge and experiences. Basically, we are facing a 'system innovation', a radical change with many actors, interdependencies and stakes.

E102

Market based approaches to nutrient pollution and potential for application in the Peel-Harvey Catchment

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The Peel-Harvey Estuary, located in the South West of Western Australia, has long term and acute water quality problems. With its significant phosphorus load and sandy soils, periodic incidents include algal blooms and fish kills.

Previous research findings confirm that the main source of P is nutrient discharges from the catchments that feed into the estuary.

Nutrient management is essential for maintaining drinking water quality and primary industries but also aquatic ecosystem health; aquaculture; human recreation and cultural values. A range of approaches (regulatory, community education, engineering) have been applied but reducing P inputs to the 75 t/year required to protect water quality will require new approaches.

Market based approaches have been used to manage various types of pollution in other jurisdictions. This study will examine the characteristics of successful schemes and, as a case study, the potential for a market-based approach to improving water quality in the Peel-Harvey.

E103

P-recycling and a sustainable phosphate industry

Mr Christopher Thornton, Global Phosphate Forum, Belgium

Recycling phosphorus from waste streams (sewage, manure treatment, food industry …) will play an essential role in closing the P-cycle (alongside Reduce and Reuse), reducing global P resource consumption, responding to local absence of P resources, and reducing environmental impacts of P dissemination.
The phosphate industry has been promoting P recycling since the 1990's, considering that using recovered (secondary) phosphorus sources is essential for a sustainable society and for industry's future. Recycling is now operational at several sites worldwide, including using secondary sources (e.g. sewage sludge incineration ash) as raw material for industrial phosphate or fertiliser production and extracting phosphorus from sewage or other waste streams as a mineral fertiliser. However, because of the multi-stakeholder and regulation-driven context of water and waste management, public policy changes are necessary for a wider international development of P recycling to happen. The phosphate industry is engaged to provide expertise and industrial infrastructure, where possible, to support this.

E104

Residual soil phosphorus as the missing piece in the global phosphorus crisis puzzle

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Phosphorus (P) is a finite and dwindling resource. Debate focuses on current production and use of phosphate rock rather than on the amounts P required in future to feed the world.

Here, we show that historical crop P yield as a function of P inputs is well simulated with a simple two-pool soil P model for all continents and the entire globe. The key feature is the consideration of the role of residual soil P in crop production. We simulated that between 2008 and 2050 a global cumulative P application of 735 kg P ha <SUP>1</
SUP> of cropland – in total 1100 Tg P – is required to achieve crop production according to the Global Orchestration scenario of the Millennium Ecosystem Assessment.

This is 2040% less than estimates in other studies that neglected the important role of residual soil P when making projections of future P requirements in agriculture.

E105

Outcomes of the 2011 Sustainable Phosphorus Summit

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Karl Wyant, Arizona State University, United States
Dr James Elser, Arizona State University, United States

In 2010, a transdisciplinary group of experts, academics, scientists, and engineers met in Tempe, Arizona, USA, to discuss the many facets of phosphorus sustainability. Through several participant-driven workshops, attendees explored issues ranging from plant uptake of P, mining operations, to recycling human waste. This presentation will discuss one of the main outcomes of this meeting, the book, Phosphorus, Food, and Our Future, and how the multidisciplinary and multi-stakeholder perspectives involved have shed new light on phosphorus sustainability. Using the lens of sustainability science, Phosphorus, Food, and Our Future, discusses the biological and societal importance of phosphorus and how societal and cultural values have and may continue to influence its biogeochemistry and use well into the future.

E106

Global transdisciplinary processes on sustainable phosphorus management: The Global TraPs project

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Phosphorus (P) is an essential element of life and of the modern agricultural system. Today, science, policy, agroindustry and other stakeholder groups are increasingly concerned and uncertain, given the dissipative nature of P, about how to assess, evaluate, and cope with P pollution, mostly in the form of eutrophication due to P fertilizer runoff from agricultural land, and predictions of food insecurity later this century due to a potential peak in rock phosphate supply. The presentation will elaborate on the design, development, goals and cutting-edge contributions of a global transdisciplinary (i.e. theory-practice) process on the understanding of potentials and risks linked to the current mode of P use.

While taking a global and comprehensive HES (human environmental systems) view on the whole P supply chain, Global TraPs organizes and integrates multiple transdisciplinary case studies for better answering questions which inform sustainable future P use. Its major goals are to contribute to three issues central to sustainable resources management:
i) adaptive long-term management of biogeochemical cycles,
ii) the challenges of a closed loop approach
iii) and sustainability learning on a global level.

ABOUT THE GLOBAL PHOSPHORUS RESEARCH INITIATIVE (GPRI)

The Global Phosphorus Research Initiative (GPRI) is a collaboration between independent research institutes in Europe, Australia and North America. The main objective of the GPRI is to facilitate quality interdisciplinary research on global phosphorus security for future food production. In addition to research, the GPRI also facilitates networking, dialogue and awareness raising among policy makers, industry, scientists and the community on the implications of global phosphorus scarcity and possible solutions.

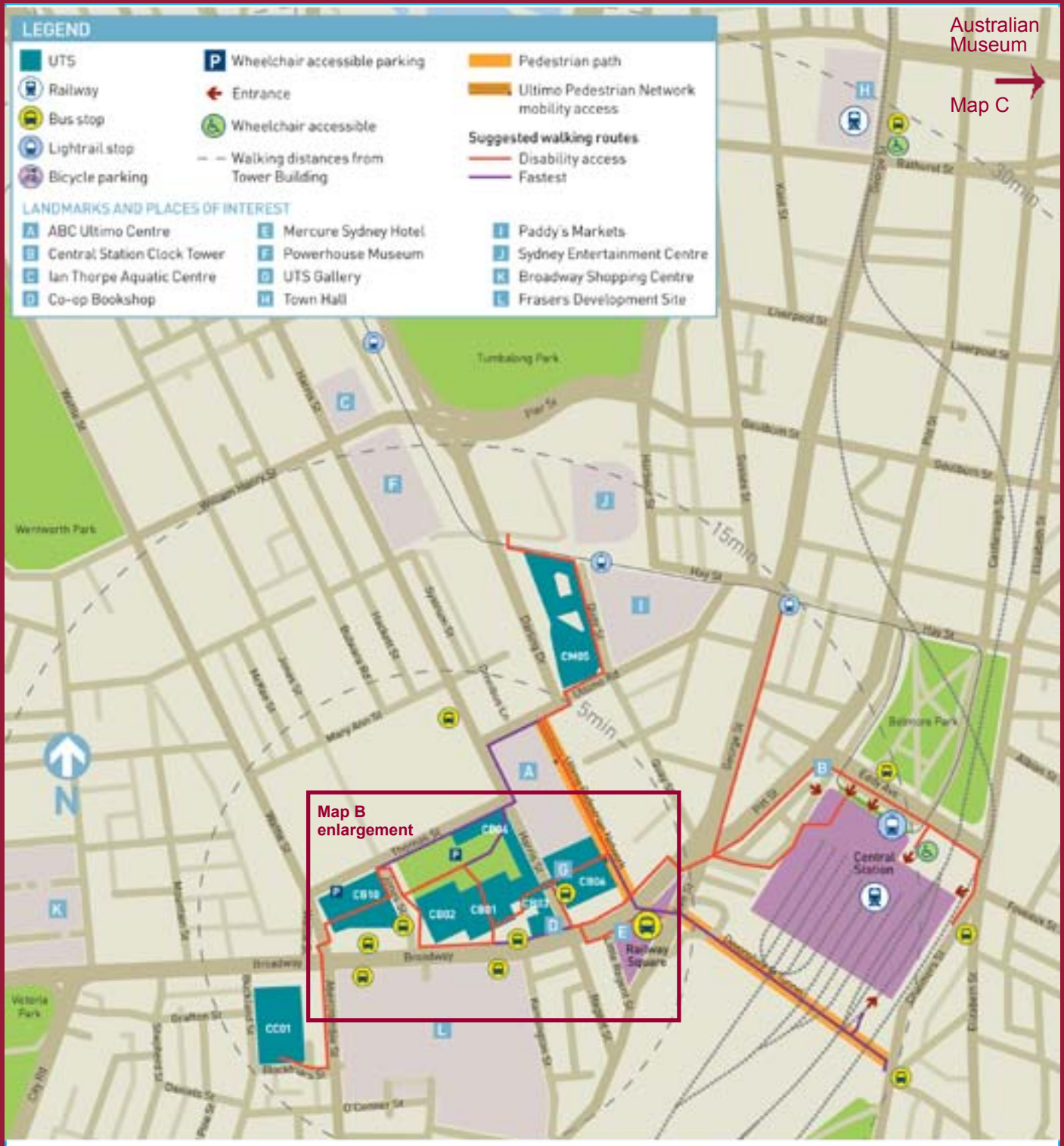
The GPRI was co-founded in early 2008 by researchers at the Institute for Sustainable Futures at the University of Technology, Sydney (UTS), and the Department of Water and Environmental Studies at Linköping University, Sweden. Today, GPRI members also include the Stockholm Environment Institute (SEI) in Sweden, the University of British Columbia (UBC) in Canada and Wageningen University in The Netherlands.

Join the Global Phosphorus Network (GPN)!

Help be part of the solution - learn, discuss, debate, act with sustainable phosphorus use scientists, innovators and policy-makers from around the world.

Visit the GPRI website for more information, and follow the link at the bottom of the homepage to join the GPN.

http://phosphorusfutures.net/



Map B

Map C

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