Issue No. 11 December 2015

Putting waste to work

A CENTRE FOR INTEGRATED BIOWASTE RESEARCH PUBLICATION

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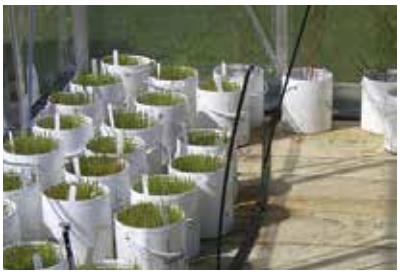

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UPDATE FROM THE PROGRAMME MANAGER

After a rather cold and miserable winter we are all very glad that summer is here – ESR in Porirua narrowly escaped flooding during one of our winter storms. On the right is a photo of the local stream that burst its banks. Luckily all our experiments survived!

It's been a busy and productive year for CIBR, we've been developing our work plans for the next phase of research and held our CIBR annual workshop. This year we teamed up with the Society for Environmental Toxicology and Chemistry (SETAC) Australasia Conference held in Nelson. CIBR hosted a session on "System approaches to sustainable biowastes management". It was really interesting to meet a different group of end-users and Virginia Baker and Jamie Ataria's key note entitled "The New Frontier: Ecotoxicology Moving from Multi-disciplinary to Transdisciplinary" went down very well and stimulated a lot of discussion!

Much of next year will be spent writing up experiments and ensuring all the information is passed onto our end-users in a way that is useful. However, the social science team will be starting a new project looking at how we can use the transdisciplinary approach more successfully. 'Wicked problems', such as biowaste management, are complex and require people from different disciplines to work together. Watch this space for more updates on how this new work stream progresses.

This year there have been several initiatives underway that will significantly influence how we manage biosolids and other organic wastes in New Zealand. Below is an update on progress: Development of the new guidelines for organic wastes is on-going. The guidelines will supersede 2003 Guidelines for the Safe Application of Biosolids to Land. Water New Zealand, WasteMINZ, CIBR and the NZLTC are collaborating on development of the guidelines. Summary reports of new scientific knowledge on pathogens, chemical contaminants and nitrogen effects have been completed and published on the WaterNZ website at: http://www.waternz.org.nz under 'Projects". You still have time to provide feedback – please contact: Nick Walmsley, Technical Manager, Water New Zealand, Tel: +64 4 472 8925, Email: nick.walmsley@waternz.org.nz

Also underway, the International Organization for Standardization (ISO) is currently developing a new standard "Sludge recovery, recycling, treatment and disposal". The new standard involves standardisation of the methods for characterising, categorising, preparing, treating, recycling and managing sludge and products, etc. Standardisation is required with a view to facilitate decisions on the choice of the treatment procedures and the use and disposal of sludge. New Zealand is not actively participating in development of the standard but are "observers". However I am representing the Australia/New Zealand Biosolids Partnership (ANZBP) on the Standards Australia committee. Thus there is an opportunity to have input into the development of the standard that may have implications for the New Zealand biosolids industry. You can find out more on the ISO website at: www.iso.org.

Over the last few months the CIBR team have been taking the "Up the Pipe" project into schools around the Wellington region! It has been a great experience for all involved; students, teachers and the CIBR scientists. "Up the Pipe" aims to increase the understanding of the risks associated with household products, by translating scientific knowledge in a way that engages students and increases the relevance of science in everyday life. Some of the awesome feedback received is below:

> *'Children who are not high achievers are confidently using terms like 'waste, pipette, samples and anti-microbials' '. . . We saw a definite impact on their understanding about science and the environment and increased their awareness of the role of scientists'*

We developed the "Up the Pipe" resource as a standalone teaching resource but the teachers have said they really want the students to meet the scientists and interact with them – so we are on the lookout for more funding to allow us to deliver this programme ourselves.

Very best wishes for the festive season and the New Year. **Jacqui Horswell**

EXPANSION OF MICROBIOLOGY CAPABILITIES

The Centre of Integrated Biowaste Research is pleased to introduce Dr Louise Weaver (Senior Scientist – ESR) and her team. Louise is leading the microbiology research area, the newest addition to the CIBR capability fold. The addition of further microbiology expertise aligns neatly and compliments the three existing research areas; soil science, social and cultural science and ecotoxicology.

Louise's research team includes collaborators from NIWA, including Rebecca Stott, Rupert Craggs and Jason Park. Louise has 15 years' experience in water and wastewater microbiology and her work is currently focusing on virus removal from wastewater (see story below). Louise is extremely excited to be joining CIBR, bringing expertise and knowledge of complex virus mechanisms and leadership to a newly developing area of research for CIBR. With the now four research areas CIBR will continue to produce practicable real-world waste minimisation solutions that broach an even broader horizon of technical and social and cultural aspects. This interdisciplinary approach to beneficial biowaste reuse is at the forefront of New Zealand science, providing a sound platform for future collaborative work. Please join us in welcoming Louise; her contact details can be found on the back of this newsletter if you would like further information on her work.

Ngā mihi,
The CIBR team.

Left: Louise Weaver working on a mesocosm experiment comparing light and dark reactions. This experiment used a column system to replicate a section of an oxidation pond.

A NEW BRANCH OF RESEARCH FOR CIBR

Louise Weaver, Rebecca Stott and Amanda Inglis

To complete the picture for biowaste research, a new group has joined the CIBR fold. The Virus Removal in Wastewater group is an ESR led research group that aims to advance knowledge of the efficacy and relative importance of processes involved in virus removal in natural wastewater systems such as oxidation ponds. The research has grown from a FRST (MBIE) funded research project granted in 2009 aimed at optimising virus removal in wastewater systems through a sustainable and low cost approach. We have expanded upon this research by focusing on enhancing the understanding of the complex mechanisms existing in wastewater that have the potential for virus (and other microbial pathogens) removal. In particular, our research is focused on those mechanisms that act independently of light (the main driver of natural virus removal).

Aesthetically pleasing oxidation pond.
Photo courtesy Mike Bourke, Christchurch City Council.

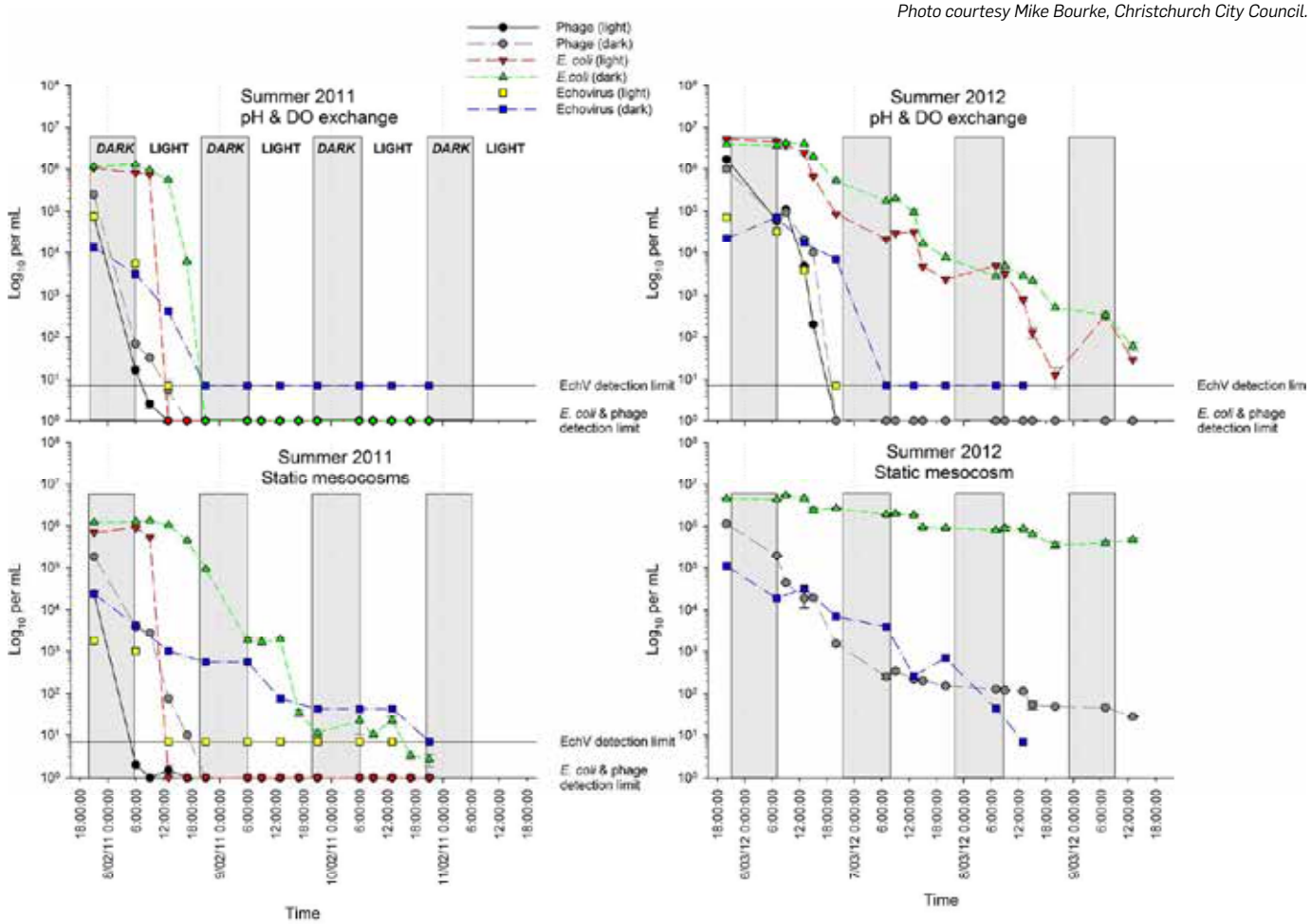

Figure 1: Mesocosm experiments with controlled pH and DO (exchange) or non-controlled (static) showing removal of indicators (E. coli and MS2 bacteriophage) and virus (Echovirus).

The behaviour of wastewater associated viruses (and other pathogens) in the absence of sunlight is not fully understood. By advancing our understanding of "dark" removal mechanisms, opportunities for optimising pathogen removal can be evaluated. We have previously shown that if the pH and dissolved oxygen (DO) in oxidation ponds is controlled, the "dark" portion of the pond is buffered to the same levels as the "light" and hence comparable removal can be achieved (figure 2). In further experiments, mesocosms containing the same oxidation pond water were spiked with high numbers of bacterial and viral indicators as well as viral pathogens and exposed either to natural sunlight or kept in the dark. Overall, microbial removal from the system over the life of the experiment (three to four days) showed that the ability to equilibrate pH and DO between the dark and light mesocosms achieved similar total removal rates in the light and dark mesocosms (within a log10 difference). For example, light and dark reduction of *E. coli* was 6 log in the summer of 2011 and 7 log during summer 2012; and 5 log reduction in MS2 phage during summer 2011 and 6 log during summer 2012 (figure 1). Echovirus 7 removal was slightly lower during both summers but still achieved high and comparable removal in light and dark mesocosms: 4 log (dark) and 5 log (light) during summer 2011 and 5 log during summer 2012 (both light and dark).

When pH and DO was increased in the dark mesocosm (without sunlight) by circulation of filtered oxidation pond water from the light mesocosm (exchange set-up), faster die off rates (k) were found for all organisms tested. For summer 2011, MS2 phage die off rate increased from -11.8 to -16.2 per day, *E. coli* increased from -4.4 to -14.0 per day, and echovirus increased from -2.4 to -9.5. For summer 2012 a similar trend was seen but to a lesser extent, and all die off rates were lower whether in sunlight or not (Figure 1), where die off rates increased from -2.9 to -13.8 per day for MS2 phage, -0.6 to -3.0 per day for *E. coli,* and -3.6 per day to -5.5 per day for echovirus.

Other removal mechanisms such as the sedimentation of particle-associated pathogens will vary depending on the properties of microbes (viruses in particular); varients such as surface characteristics, size and mobility of the microbe in question. We are currently conducting experiments to extend our knowledge of the attachment and/or aggregation and settlement behaviour of a range of viruses and other pathogens in wastewater.

The research partners with NIWA to develop a detailed model of virus removal in wastewater. The model will be used to aid management and optimisation of wastewater treatment systems for virus removal. NIWA (Dr Rebecca Stott) are also leading the research into the potential for viral grazing to occur in these systems. Protozoa naturally graze on microbes including viruses (and other particulate matter) present in wastewater. Dr Stott's research has shown that higher virus removal can be achieved in the presence of protozoa and it can be the dominant removal mechanism in the absence of light. Her research has shown 80-95% removal of bacterial and viral microbes by protozoan grazing can occur. This is an important finding as the protozoa are found in wastewater naturally and so can offer a low cost solution to viral loading issues in receiving waters.

Another part of our research aims at understanding the potential for enzymes naturally present in the wastewater to remove (inactivate) viruses. The project is led by University of Canterbury PhD student Amanda Inglis. Amanda has shown that in the presence of exo-enzymes (enzymes not attached to bacteria that produce them) enhanced virus removal can occur in laboratory experiments. (figure 2). Amanda is now working on finding out which bacteria (or other microbes) produce the most effective enzymes capable of virus removal. The ultimate aim is to identify which

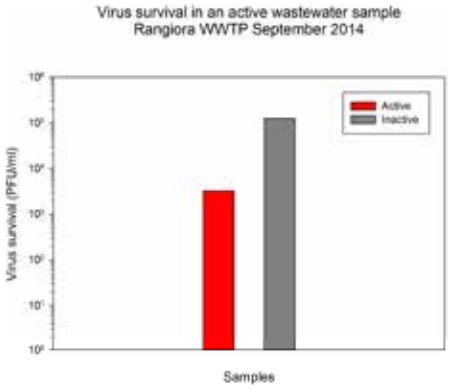

Figure 2: Increased virus (Echovirus) die-off in the presence of active exo-enzymes.

enzymes act on viruses and how the enzyme production can be optimised. It is assumed that there will be a range of enzymes that will act on viruses and so a suite of enzymes will be necessary for removal of a range of viruses present.

All of the research summarised above will add to the model for virus removal in wastewater and provide a tool for optimising the disinfection treatment performance of established wastewater systems as well as the design of new ecotechnologies.

Overall the new group will add to the existing expertise in CIBR by providing expertise in the wastewater field.

The group has expertise in wastewater pond operation (Dr Rupert Craggs and Dr Jason Park), protozoan ecology (Dr Rebecca Stott) and microbiology of wastewater (Dr Louise Weaver).

We are all excited by the new opportunities that will arise out of joining the CIBR team!

ECOTOXICOLOGY TECHNICIAN JOEL BOWATER SECURES FUNDING TO VISIT AUSTRALIAN LAB IN MELBOURNE

Joel has made great progress with the zebrafish fish embryo toxicity (FET) test and is now using it to assess the toxicity of a range of emerging contaminants. Joel recently secured funding from the Queen Elizabeth II Technicians' Study Award to visit Dr Vincent Pettigrove's ecotoxicology research team at the Centre for Aquatic Pollution Identification and Management (CAPIM) in Melbourne. CAPIM is a dynamic and well-recognised ecotoxicology centre in Australasia and their work aligns very well with our CIBR research interests. Joel will work within multidisciplinary and collaborative teams to familiarise himself with the latest monitoring approaches to assess the complicated issue of understanding the impacts of pollution on aquatic environments.

Above: Joel Bowater at an Up-the-pipe solution activity with two pupils from Clifton Terrace School.

MEET NEW ECOTOX PHD CANDIDATE MARIA CHARRY

Maria recently started a PhD project on the use of copepods to assess the toxicity of estuarine sediments at the University of Auckland (UoA) under the supervision of Louis Tremblay, Vaughan Keesing, Boffa Miskell and Mark Costello (UoA). Maria is originally from Colombia but has been in New Zealand since 2011 working in Wellington on the monitoring of storm water quality in that region. Maria is funded by a Callaghan Innovation scholarship and Boffa Miskell Limited. She is based at the Cawthron Institute in Nelson.

UPDATE FROM THE SOIL SCIENCE TEAM:
WHAT IS THE IMPACT OF LONG-TERM BIOSOLIDS APPLICATION ON SOIL MICROBIAL COMMUNITY STRUCTURE AND ENZYMATIC ACTIVITIES?

By Jianming Xue

The CIBR soils team collected soil samples of the 0-10 cm surface layer from the long-term biosolids research trial at Rabbit Island in July 2014 to investigate the influence of repeated applications of biosolids on soil microbial community structure and functions. The results showed that soil microbial communities and biochemical processes responded distinctly to the N-loading from biosolids application, which affected the soil N pool dynamics and turnover.

Biosolids, rich in organic carbon and nutrients, are commonly used as soil amendments on crop land, and preferably on forest land in New Zealand. However, the impacts and mechanisms of biosolids application on soil microbial community and functions in forest ecosystems are not well understood. Biosolids from the Nelson regional wastewater treatment plant have been applied to a 1000-ha *Pinus radiata* plantation at Rabbit Island since 1996. A research trial was established on the site in 1997 to investigate the long-term effects of biosolids application on tree nutrition and growth, and, soil and groundwater quality. The aim of this study was to examine how biosolids application influenced soil microbial community composition and enzyme activities in relation to soil nitrogen (N) availability.

Biosolids have been applied to this research trial every three years (1997, 2000, 2003, 2006, 2009 and 2012, respectively) at three application rates: 0 (Control), 300 (Standard) and 600 kg N/ha (High). Tree nutrition status and growth are monitored annually, soil properties every three years and groundwater quality quarterly. The latest soil sampling at the Rabbit Island biosolids research trial was completed in July 2014 (fig. 1). Here we update our recent findings on the impact of repeated biosolids application on soil microbial community structure and enzyme activities.

Biosolids application significantly increased the concentrations of total soil carbon (C), nitrogen (N) and phosphorus (P) in the soil (data not shown). Both the Standard and High treatments also significantly increased the pool size of dissolved organic N (DON), and appeared to increase the pool sizes of nitrate-N and total mineral N when compared with the Control (Fig. 2). Increases of dissolved organic nitrogen (DON) in biosolids amended plots could result from higher N mineralisation of biosolids-derived organic N or forest floor litter.

Phospholipid fatty acids (PLFAs) are widely accepted as biomarkers that help us to unravel the composition of soil microbial communities by indicating viable microbial biomass and providing a microbial community "fingerprint". The results showed that biosolids application reduced the abundance of Gram-negative bacteria and arbuscular mycorrhizal fungi in the soil (fig. 3).

Soil microorganisms play a critical role in various soil processes. Changes in soil microbial composition are well associated with altered soil N transformations and cycling. We assumed the increase in soil DON in biosolids-amended soils could be linked with specific soil microbial functional taxa. The functional responses of specific soil microbial fauna are represented by soil extracellular enzyme activities. We observed increases in acid phosphatase and peroxidase and a decrease in cellobiohydrolase in biosolids-amended plots when compared to the control plots (Fig. 4). These results indicate the functional changes in soil microbial community accounted for the transition of substrate preference from readily accessible to relative recalcitrant ones.

In conclusion, biosolids application changed soil microbial community composition, which in turn regulated the decomposition, mineralization and assimilation processes in plant-soil system through extracellular enzyme activities. The decrease in cellobiohydrolase activity and the opposite tendency in peroxidase may imply an imbalanced nutrient acquisition process of plant-microbial competition associated with litter and soil organic matter decomposition in winter time. Our results confirm that soil microbial communities and biochemical processes responded distinctly to the N-loading from biosolids application, which affected the soil N pool dynamics and turnover.

Fig.1. Soil samples of surface soil layer (0-10 cm) were collected from the long-term biosolids research trial at Rabbit Island in Nelson.

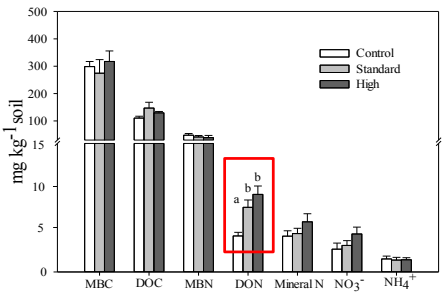

Fig. 2. Effect of biosolids application on soil microbial biomass carbon (MBC), dissolved organic carbon (DOC), microbial biomass nitrogen (MBN), dissolved organic nitrogen (DON), mineral N, nitrate-N (NO3-) and ammonium-N (NH4+).

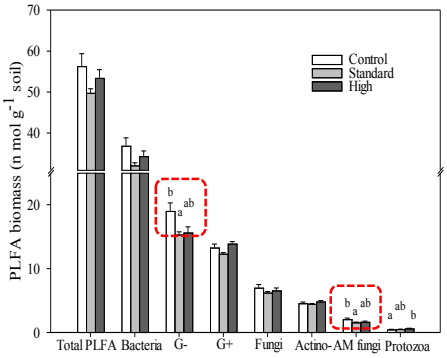

Fig. 3. Effect of biosolids application on total PLFA, total bacteria, Gram-negative bacteria (G-), Gram-positive bacteria (G+), fungi, actinomycetes (Actino), arbuscular mycorrhizal fungi (AM fungi)-) and protozoa.

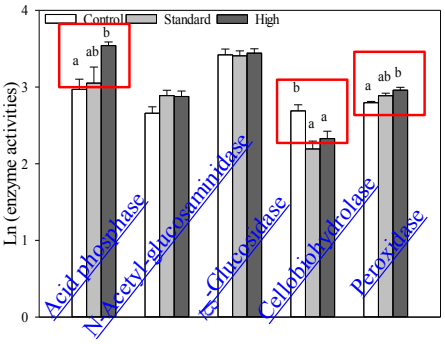

Fig. 4. Effect of biosolids application on specific soil enzyme activities.

SPECIAL INTEREST ARTICLE: BENEFICIAL USES FOR WOODY BIOWASTES IN CITIES

Robyn Simcock

What do sawdust, arborist prunings, packing cases and pine bark have in common? They're all increasingly valuable wastes that can be used to enhance degraded urban soils. Large volumes of biowaste are generated by urban vegetation maintenance, particularly tree pruning and vegetation clearance. For example, about 115,000 T/yr of biowaste from urban vegetation maintenance is managed commercially in Auckland. In Christchurch, Living Earth's organic processing plant in Bromley received nearly 50,000 tonnes of green waste and foodwaste p.a. pre- earthquakes.

Woody organic waste and composted greenwastes are used in large volumes overseas to enhance degraded soils and degraded ecosystem services typical of grassed or planted urban space[2]. The degradation is reflected in reduced infiltration, reduced rooting depth and less ability to store water[4]. Together these impact plant growth, especially growth of trees, and increase storm water runoff frequency leading to degraded surface waters. Spreading and/or incorporating minimum depths and qualities of organic materials as soil conditioners is mandated in parts of USA and Canada through rules and policies[1]. Woody organic mulches are also useful to reduce nitrogen flushes associated with use of N-leaching materials, such as biosolids, as reported in Issue 10 (Autumn 2015).

Surface-applied mulches 'work' by reducing plant stress during establishment, and initially protecting the underlying soil, then providing an organic boost as they are broken down. Table 1 lists the properties of mulches that are valued by the two largest mulch users. An under-recognised value is the capture of heavy metals, at least in the medium term, as measured at a rain garden receiving road runoff in North Shore (Figure 1)[3].

A collaborative trial with University of Auckland, Auckland Botanic Gardens and CIBR was installed in early summer 2014 to measure the effect of two wood wastes (macrocarpa sawdust and wood chip from a mulched macrocarpa hedge) on soils and lawn species. We hypothesised that adding the woody biowaste would:

- Lower plant-available nitrogen, which would in turn reduce competitiveness of grasses, especially ryegrass but increase competitiveness of herbs, including legumes.
- Reduce plant biomass, hence reduce the mowing frequency (saving money).
- Increase soil infiltration rate, and once it had broken down, the water holding capacity of the soil, hence reducing runoff.

Results will be reported in the following edition of the newsletter, when the materials have broken down.

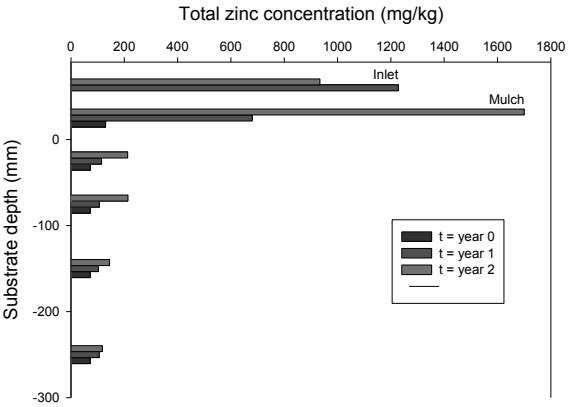

Figure: Increasing concentrations of zinc over two years in a North Shore raingarden receiving runoff from 16,000 vehicles per day.

Left: The organic mulch is capturing Zinc. 'Inlet' bars are sediment accumulated on the unplanted areas next to the black t-shaped inlets.

Table: The valued properties of organic mulches by two large users of mulch

Mulch Property +++ = highest priority, o = low priority	Landscaping	Motorways and roads
Suppress weed growth to decrease maintenance and enhance aesthetics until plants grow	+	+++
Erosion control. Maintain infiltration rate into soil by reducing crusting, blocking of the surface by fine sediment and protecting soil surface from compaction	+	++
Conserve moisture and reduce soil surface temperatures	++	+
Aesthetically attractive	++	+
Feed plants in the medium to long term	++	o/+
Absorb, immobilise or buffer contaminants: (filter, chemically bind or complex)	o	o/+ (in raingardens)
Stable against water and wind, does not float	o/+	++
Easy to spread around plants	Depends on plant spacing	+/o (usually wide spacing)

*Left: Arborist prunings and chipped trees, mulched urban wood waste such as packing cases and untreated timber, pine bark and garden green waste (**not** food waste). They usually have a high carbon content relative to nitrogen, and are initially relatively dry and relatively stable.*
Photo: Woody arborist mulch with $2 coin for scale.

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UPDATE FROM SOCIAL AND CULTURAL TEAM

Lisa Langer, Joanna Goven, Alan Leckie, Jinny Baker and Jamie Ataria

The social and cultural research team are pleased to report that their paper entitled, 'A transdisciplinary approach to local waste management in New Zealand: addressing interrelated challenges through indigenous partnership' has been accepted for publication in Futures. The team hope that their paper, which one reviewer called 'fascinating and salutary to those of us who work with indigenous communities elsewhere', will encourage more attention to the potential roles of indigenous communities and indigenous ways of 'knowing and doing' in transdisciplinary research.

The team have developed a 'Community Engagement Framework' to support local government staff, engineers and consultants in the biowaste and wastewater sector in guiding their endeavours to engage and consult with the community. Engagement with the community in Christchurch, Kaikōura, Mokai, Little River and Porirua undertaken by the team has laid the foundation to developing this framework. Helpful review comments have been received from Hamish Lowe, Lowe Environmental Impact (LEI) and Chrissie Williams, Environment Canterbury. The Australian and New Zealand Biosolids Partnership have expressed a strong interest in the Community Engagement Framework. In Australia, community engagement is a "hot topic", but little research has been undertaken across the Tasman.

From left: CIBR scientists Lisa Langer, Jinny Baker, Jamia Ataria and Alan Leckie.

Community engagement in action.

Jacqui Horswell was invited to be an international keynote speaker at the RMIT University biosolids workshop entitled 'Linking Industry and Research' held in Melbourne, September 2015. The talk, which presented the framework from 'best practice' research and field experience, was well received from the audience of researchers, regulators and water industry practitioners within Australia (e.g. Sydney Water, Victoria Water etc.). Following Jamie Ataria's excellent presentation at the CIBR workshop in Hamilton last year, the social and cultural team have produced a report on 'Tapu to noa: Māori cultural views on biosolids management'. The concepts of tapu and noa (restricted to useable) underpin many cultural practices and are a central or ruling principle of importance to Māori. The document, driven by Jamie and Jinny Baker, aims to provide some insight, language and frameworks to help non Māori gain greater confidence in asking the right questions in their conversations with local hapū and Iwi. Following revision and response to review comments, they plan to make both the 'Community Engagement Framework' and 'Tapu to noa' reports available to council staff and consultants in the next few months.

At the end of July, ESR Chief Executive, Keith McLea and Environmental General Manager, Libby Harrison, visited Scion, Rotorua where they were hosted by Scion Chief Executive Warren Parker, General Managers Elspeth McRae and Brian Richardson alongside leaders of CIBR research within Scion. Lisa Langer made a presentation highlighting Scion's CIBR research contribution and collaborations. The Scion research was well received with much interest in the potential for further collaboration between the two Crown Research Institutes. Lisa and Libby Harrison also met with CIBR collaborator, Associate Prof. Brett Robinson at Lincoln University.

NEW GREENHOUSE FACILITY AT ESR

Sarah Quaife, Staci Boyte, Jen Prosser, Jacqui Horswell

Recently, the installation of two greenhouses were added to the ESR outdoor experimental facility. Currently, these greenhouses are being utilised to fast-track the growth of native plants for an upcoming CIBR experiment in the summer of 2016. These plants are part of a pathogen survival study to further investigate potential in-situ antimicrobial properties of mānuka on microbial contamination of soil. Research conducted by the CIBR group has previously indicated that the antimicrobial properties of mānuka extracts can be linked to accelerated pathogen die-off. A pilot study further investigating the effects, observed in-situ antimicrobial properties in contaminated soil beneath growing mānuka and kānuka plants. The results of these previous findings are detailed in issue 9. of the biowaste newsletter (page 3).

The current study aims to extend this knowledge by determining whether this can be replicated in a larger trial, using two indicator organisms and a bacteriophage (a virus that infects and replicates within a bacterium). The outcome of this trial could have significance in the context of pathogen removal in biosolid-amended land.

The larger pot-trial is being conducted with mānuka seedlings, ryegrass and no plant controls which were established outdoors to replicate field conditions before their movement to the greenhouse facility. Once fully established these pots will be taken into the laboratory and dosed with *Salmonella typhimurium, E.coli,* and MS2-phage. The experiment will examine the survival of the inoculated pathogens and phage in both the soil and collected leachate under growing plants. Further details of the experiment will be provided in the autumn edition of the newsletter, 2016.

The CIBR team are looking forward to future experimental work where more stringent growth controls can be maintained.

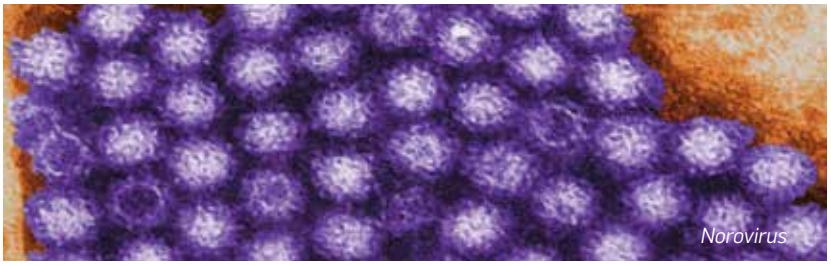
Two recently installed greenhouses at ESR.

Right: Inside the greenhouses, manuka seedlings and rye grass are watered daily with an isolated irrigation system.

IT'S ONLY A NEEDLE IN A HAYSTACK, NOT FRIGGIN' HIGGS BOSON – ENHANCED VIRUS REMOVAL IN WASTEWATER

Louise Weaver, Amanda Inglis, Judith Webber, Erin McGill, Margaret Mackenzie

The behaviour (attachment and settlement) of viruses in wastewater was presented as a poster by Louise Weaver at the annual Water NZ conference, 2015. The poster came second place as part of conference proceedings. Details of the content are described below. Globally, viruses are the greatest risk to human health as they can survive for an extended time in the environment (months, years) and are generally highly infectious organisms. For example, one virus particle (norovirus) can be infectious compared to 100's or 1,000's of bacteria cells. Data shows that a total of 1.5 billion litres of domestic wastewater is discharged daily in New Zealand (MfE 2013). It's therefore important to implement wastewater treatment systems which can remove viruses.



SO WHAT'S THE PROBLEM?
SURELY IT CAN'T BE THAT DIFFICULT?

Presently, little is known about virus behaviour in wastewater. It is unknown exactly what viruses are present in wastewater, their concentrations or whether they are present at all times. Previous research on viruses in wastewater has shown many processes are inadequate or highly variable.

Removal of viruses in wastewater may be aided by attachment to larger particles allowing settlement to occur. In other environments, viruses attach to particles and so it is assumed to occur in wastewater systems as well. Our research is currently investigating attachment and settlement of viruses in waste stabilisation ponds (oxidation ponds). Compared to the traditional bacterial indicator organisms (*E. coli*) attachment and settlement of viruses is low and highly variable. Results are significantly different to the usual indicator organisms (figures 1 – 3).

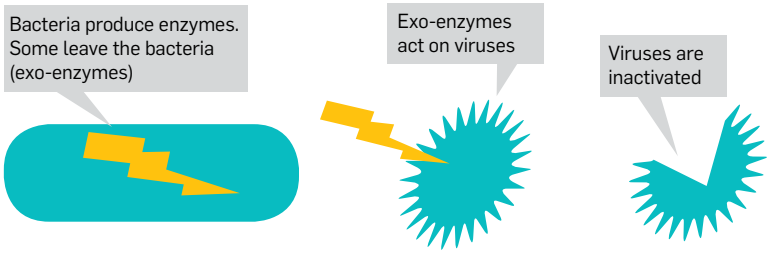
Determining the impact of this mechanism represents the first step to optimising virus removal in wastewater systems.

Aligned to this research the potential of natural populations within wastewater for virus removal (disinfection) was also presented. Within wastewater, bacteria produce enzymes for protection from other organisms and to predate other organisms. The research is investigating the potential for enzymes to inactivate (remove) viruses. Enhanced virus removal has been demonstrated to occur when enzyme activity is present (Figure 4). The majority of this is exo-enzyme activity.

Currently, the efficiency of wastewater treatment is primarily concerned with meeting regulatory levels and resource consents with less emphasis placed on pathogen removal. It is often assumed that adherence to resource consents based on indicator organisms will mean pathogen removal. But does it? If it doesn't what should we do?

The research presented is a new addition to CIBR (further information on the virus removal work found on page 2). The inclusion of wastewater to the team completes the CIBR approach to waste management and hopes to answer some of these questions on pathogen removal. The research has demonstrated that relying on indicator organisms is risky and highlights the importance of testing for viral pathogens. Further research is to enable effective treatment options

The poster came runner up in a 'Best Poster' competition - closely beaten by a poster on greywater recycling co-authored by CIBR's Alma Siggins so not too bad a loss! Overall the poster was used to emphasise the importance of virus removal research and that it is possible to both do relevant research and offer possible solutions to what is perceived as a difficult problem.



The results so far demonstrate that enzymatic activity in wastewater can be coupled with virus removal.

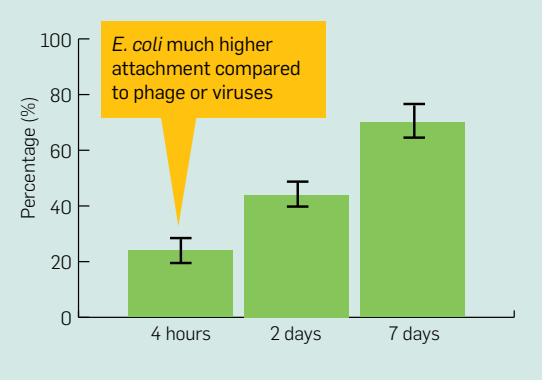


Figure 1: Attached E. coli.

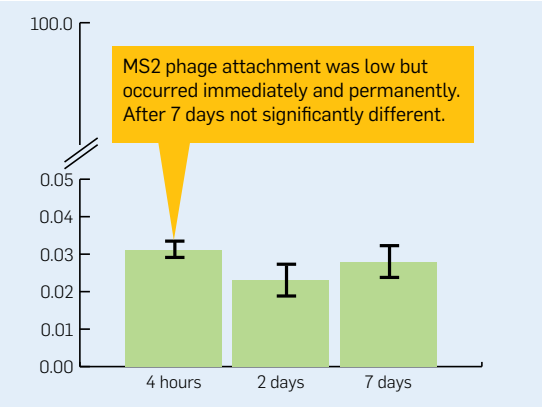


Figure 2: Attached MS2 phage.

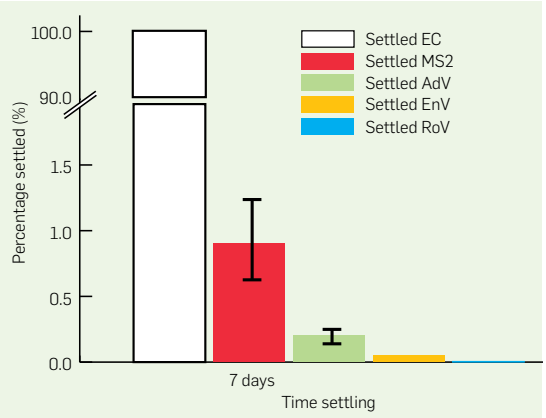


Figure 3: Percentage indicator and viruses settled. Settling experiments showed only E. coli settling. MS2 phage settled at <1% after 7 days. Viruses showed no significant settling.

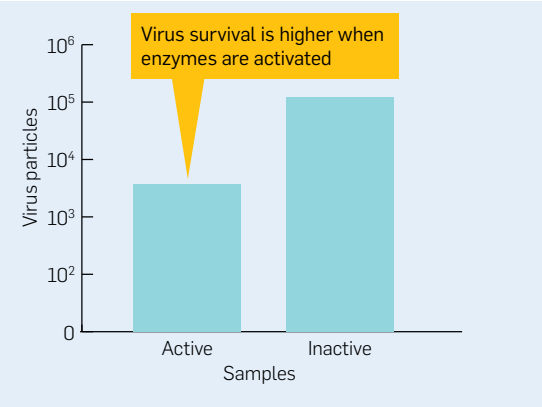


Figure 4: Enhanced virus removal occurs when enzyme activity is present.

UPDATE ON THE SETAC AUSTRALASIA 2015 CONFERENCE IN NELSON, NEW ZEALAND

Some enthusiastic delegates at the conference dinner.

Many members of CIBR contributed to make the Society of Environmental Toxicology and Chemistry (SETAC) Australasian chapter 2015 conference a success. Nearly 200 government, academia and business delegates from Australia, China, UK, USA, Malaysia, Singapore and Japan attended the Nelson conference, 25-28 August. The conference had the challenging theme 'System Approach to Environmental Management' to encourage discussions to address the growing environmental issues we are facing. There were three concurrent sessions packed with stimulating presentations and two workshops were offered. The conference programme included special sessions such as the CIBR "System approaches to sustainable biowastes management" co-chaired by our own Jacqui Horswell (ESR) and Lisa Langer (SCION Research). This was a great opportunity to hold this session at a toxicology conference as it is usually part of the Land Treatment Collective conference. Jo Cavanagh (CIBR, Landcare Research) co-chaired a special session on the management of natural resource extractions and there was a full day session covering various aspects of the revision process of the Australian and New Zealand Environment and Conservation Council (ANZECC) water quality guidelines chaired by Rick Van Dam from the Environmental Research Institute of the Supervising Scientist (ERISS) in Australia. We had excellent keynotes presentations from Alistair Boxall (University of York), Malcolm Rands (Ecostore), Gary Rielly (Methanex), Karen Lavin (NZ Parliamentary Commissioner for the Environment) and the Tony Roach Memorial Speaker Nicole Hill (University of Tasmania). Hopefully everyone found the conference useful.

Louis Tremblay, Conference Chair

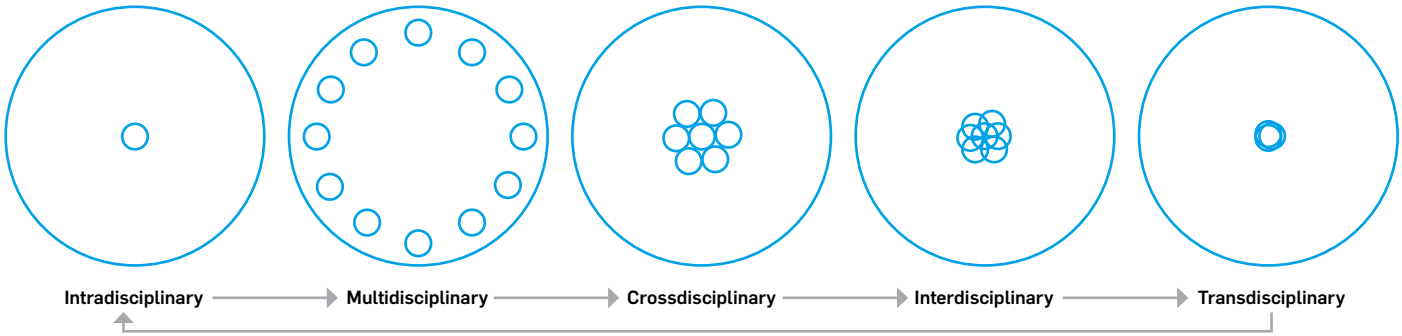
10TH ANNIVERSARY OF THE DUMONT D'URVILLE PROGRAMME

Alma Siggins

2015 marks the 10th Anniversary of the Dumont d'Urville Programme, which aims to promote and support scientific and technological co-operation between New Zealand and France. To celebrate the anniversary of this important relationship, a Symposium on Science Co-operation was held in Wellington on 19th – 20th November 2015. The Symposium was attended by members of key French and New Zealand research institutes, universities and government ministries. As part of the visit, some of the French delegates met with CIBR staff from ESR to discuss how complementarities in our research areas could be further developed. In Wellington, Alma Siggins and Jinny Baker met with Pierrick Givone, the Innovation GM of IRSTEA (National Institute of Sciences and Technologies for the Environment and Agriculture) and Georges de Noni, the Director of Research at IRD (Institute of Research for Development), New Caledonia. Louise Weaver met with representatives of IRD and INRA (National Institute for Research in Agronomy) during their visit to ESR's Christchurch site. The meetings were an enthusiastic discussion of our research topics and brainstorming of ideas for future collaborative funding opportunities.

THE NEW FRONTIER: ECOTOXICOLOGY MOVING FROM MULTI-DISCIPLINARY TO TRANSDISCIPLINARY

Virginia Baker, Jacqui Horswell, James Ataria, Lisa Langer, Alan Leckie and Joanna Goven.



What does 'good' science look like, beyond just good science methodology?

How has this changed in the last 10 or 20 years?

We posed these questions to the audience at the SETAC conference to help us reflect on how the CIBR programme and the discipline of ecotoxicology are helping shape new forms of science and environmental management that utilise multi-disciplinary and 'transdisciplinary' approaches.

The practice of science is undergoing an important paradigm shift. Previously there was a focus on 'public understanding of science', where science and policy makers adhered to a 'deficit' in public understanding. Decisions were made by experts with the expectation that with good and credible information, the public would follow expert advice. Disagreements and controversies about risk were thought to be resolved by scientists and policy makers giving factual information and educating the public to better understand the science.

Whilst these old forms of science and risk communication still persist, CIBR is building more sophisticated models of science, policy and community engagement. The new paradigms of 'public engagement in science' emphasise involvement, collaboration, partnership, co-design and two-way communication - science being responsive and informed by community knowledge and concerns. Scientists and communities can learn from each other and respect each other's different world views, knowledge and expertise.

We looked at SETAC's mission, '*to support the development of principles and practices for protection, enhancement and management of sustainable environmental quality and ecosystem integrity*', and noted that the 'development of principles and practices' was something that required ecotoxicology to move beyond the traditional science paradigms.

'Transdisciplinary' science is a very new field for biophysical and social sciences. The prescribed nature of research funding and other constraints mean that we still struggle to work at a 'cross disciplinary' and 'interdisciplinary' level, let alone 'transdisciplinary'. It is an aspirational goal and we are still working out what it means, although there is agreement that the overarching aim is the integration of knowledge, to a level that we have not yet achieved. Operating from this paradigm means that programme goals and outputs are genuinely collaborative, rather then shaped from within disciplinary confines, as the diagram above shows. (http://www.arj.no/2012/03/12/disciplinarities-2/)

In the CIBR programme, our efforts to attain a 'transdisciplinary' focus have helped us identify a number of critical success factors. These include;

- having vision and leadership within the programme,
- fostering working partnerships and co-leadership with Iwi, local government and community for shared goals (as illustrated by the far right circle in the diagram above),
- the early involvement of stakeholders,
- scientists having humility and using ordinary language, and,
- strong friendships and communication skills across research team.

We also have observed that locating the work and conversations on various marae helped to disrupt the traditional power relations and models of one-way communication and expert-driven science.

An important feature of 'transdisciplinary' approaches is that scientists work actively with communities, and that community knowledge sits alongside and actively informs the science research trajectories, design and analysis. In CIBR we have noticed a shift from the scientists producing data and focusing on the analysis of knowledge for itself (the 'know what'), to the science addressing broader 'know why' questions about why and how this knowledge is important, and to whom. This type of knowledge building requires relational and translational skill sets in working with communities and different institutional, stakeholder and professional groups. More generally these approaches help expand the scope of the science in focusing on bigger shared societal aims, and helping bring about more effective and sustainable policy and social change.

Nā tō rourou, nā taku rourou, ka or ait e iwi.
With your food basket and my food basket the people will thrive.

In society we face a number of 'wicked problems', for example waste, chemical contamination, energy and climate change, as well as chronic health issues, social inequality and poverty. These tend to be complex, layered and intersecting issues that are often symptomatic of other issues. They typically involve multiple stakeholders and power dynamics, as well as competing viewpoints and uncertainty about the right thing to do. Wicked problems are messy and changeable, but they are also very resistant to change. Often there is no one solution and they are usually never solved definitively.

Managing the impacts of human (household and industrial) waste on our environment and ecosystems is a 'wicked problem' that requires new ways of working. The shift to 'transdisciplinary' ways of working is especially important for our Treaty partnership work in Aotearoa, New Zealand where we are looking for more effective forms of environmental management that blend both western science and mātauranga Māori. These new approaches and encounters between science, policy and community will help shape the new knowledge and insights needed to build sustainable solutions that tackle the 'wicked problems' and big issues of today and tomorrow.

For more information see:

Goven, J., Langer E.R., Baker, V., Ataria, J., Leckie, A. (2015) A transdisciplinary approach to local waste management in New Zealand: addressing interrelated challenges through indigenous partnership, Futures 73: 22-36, http://dx.doi.org/10.1016/j.futures.2015.07.011

Dedicated to improving and communicating technology for the land treatment of waste products

New Zealand Land Treatment Collective

Annual Conference 2016
16th - 18th March, Gisborne.

Community Engagement and Land Treatment

How sustainable solutions can be implemented for Land based Waste Treatment, through Community consultation and engagement with key stakeholders, policy makers and advisors.

Diary dates

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Please contact Gillian Todd for criteria and further information.

Background information

The New Zealand Land treatment Collective ('the Collective') was established in 1989 to support research on treatment of waste products by land application. We provide members with the most recent information on land treatment technology, research and information, and improve communication to all stakeholders in the industry. The Collective is managed through and based at Scion, where land treatment of waste products has been researched since 1978. Many other New Zealand organisations are also involved in land treatment research, most of whom are members of the Collective.

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Email nzltc@scionresearch.com
www.scionresearch.com/nzltc

The New Zealand Land Treatment Collective is an independent non-profit organisation managed by Scion.

SCION forests · products · innovation

BIOSOLIDS – WHAT'S NEW IN EUROPE?

Jacqui Horswell

Jacqui Horswell recently attended the 20th European Biosolids and Organic Resources Conference in Manchester UK, 9 – 11 November 2015. The venue was the Manchester town hall which was built in 1877 and is absolutely beautiful inside. Right is a view down one of the many corridors.

The conference was attended by over 200 delegates from all over Europe – and two New Zealanders!

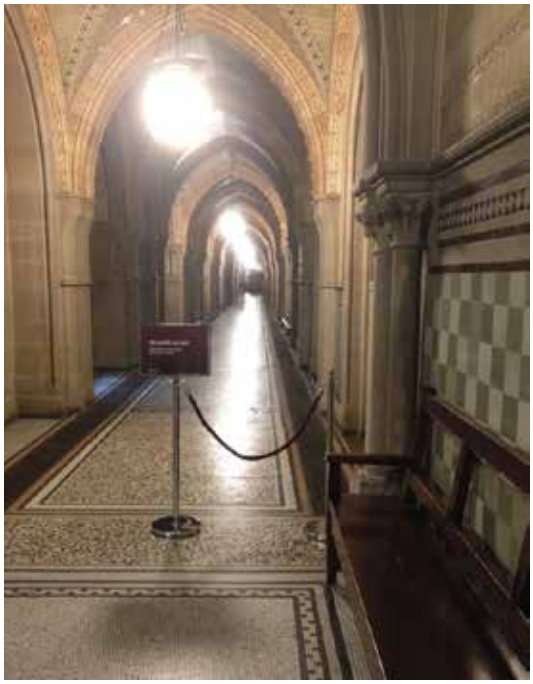
There were a lot of technical presentations on sludge treatment such as thermal hydrolysis and digestion, as well as a large focus on resource recovery. There were quite a few presentations on the value of phosphorous (P) in sludge and ways to recover it. Phosphorus is hugely important to agricultural systems and world reserves of high quality P minerals that are low in cadmium (Cd) are expected to run out within several decades. A presentation by Bengt Geraats from Eliquo Water & Energy in the Netherlands talked about a regional sludge processing hub for a number of the country's waste water treatment plant that it recovers phosphorus from the waste activated sludge by producing a high quality magnesium ammonium phosphate (MAP) fertiliser called Crystal Green.

There were a number of presentations that looked at the benefits of applying biosolids to land. Fiona Nicholson from ADAS, presented data from a 20 year field trial of biosolid application to agricultural land. The results indicated that there were increases in soil organic matter, available water capacity, water infiltration and aggregate stability, soil nutrient (nitrogen, phosphorus and sulphur) supply and, soil biological properties (earthworm numbers and weight). No negative effects on crop quality were reported following biosolid addition. Results from long-term field trials often concentrate on the negative impacts of biosolid land application so it was really interesting to see robust scientific evidence of the fertiliser benefits of biosolid addition to land.

Another interesting talk was given by Professor Ian Pepper from the Water & Energy Sustainable Technology Center (WEST). Professor Pepper is one of the BIG names in research of pathogens in biosolids along with his colleague Charles Gerba. Together they have published a huge number of papers on this topic. It was great to meet him and hear him present his research. Professor Pepper and his team have been asked to look at the survival of Ebola virus disease (EVD) in sewage during wastewater treatment. During the height of the ebola outbreak in 2014 there was a lot of concern about whether or not contaminated material could be disposed of down the toilet and ultimately into the wastewater system.Using a virus surrogate (obviously it is impossible to work with ebola directly!) Professor Pepper and his team contaminated various surfaces in a restroom and set-up bench anaerobic digesters to look at effectiveness of sewage treatment on virus survival.

Ebola virus

The research is on-going but preliminary results show that virus positive samples were collected from the restroom surfaces after a 30 minute contact time with bleach. Thus, waste discharge down the toilet is a potential route of exposure even with disinfection.



Above: Manchester town hall interior built in 1877.

The conference was celebrating its 20th year and to acknowledge this significant anniversary, three presentations were given on the history of sludge treatment. These were really interesting, especially the presentation given by Dr Bill Barber, the Technical Director of AECOM America. Bill is a brilliant speaker with great slides and anecdotes. Anaerobic digestion was invented in 1895 in order to kill pathogens – technology seems so advanced in some areas of life but we still use basically the same sewage treatment systems as those developed in the 1800's. Over the last few decades there has been a change in focus from viewing wastewater sludge as 'waste' to a potential source of valuable resources and alternative energy. This strongly aligns with the aims of CIBR –to beneficially re-use biowaste rather than disposing to landfill.

Increases in energy costs, the decline in phosphate rock production, urban expansion, population growth and scarcity of water are all factors that have increased interest in re-use and recycling of waste.

Of course the beneficial components of sludge have long been recognised – in 1866 Joseph Bazalgette oversaw the construction of sewers across London. Not everybody thought that this was a good thing:

"The Bazalgette process, as applied to London, is a total failure. It involves the utter waste of all the manurial matters in the sewage . . ." J. W. Slater, F. E. S., 1888

For more information on the conference visit the conference website: http://european-biosolids.com

If you would like further information on the programme or have any questions, please see our website www.cibr.esr.cri.nz or contact a member of the Science Leadership Team:

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