Biowastes Project

Issue No. 6

Spring 2013

Inside this issue

Up the pipe solutions – see page 5

Centre for Integrated Biowaste Research

Update from the Programme Manager

– Jacqui Horswell

Welcome to the spring 2013 newsletter. It has been a really busy year with workshops, hui and the transformation of the biowastes research programme into a virtual research centre: the Centre for Integrated Biowaste Research (CIBR).

The CIBR was launched on 9th April at a joint Australia/New Zealand Biosolids workshop in Blenheim. Over 70 delegates attended the workshop including representatives from district and regional councils, biosolids producers, the waste water industry and other interested parties, including members of the ANZBP Board. The Centre was launched by Peter Whitehouse (WaterNZ) and representatives of three of the four CIBR partners – Dr Fiona Thomson-Carter (ESR), Dr Trevor Stuthridge (Scion) and Robert Matheson (Cawthron Institute). Check out our new website on www.cibr.esr.cri.nz. A packed programme at the joint biosolids workshop brought together members of the waste water industry with researchers to discuss, understand and debate biosolids reuse. We would like to thank everybody who presented at the workshop and look forward to the next one!

Dr Fiona Thomson-Carter, GM of the Environmental Health Programme at ESR launches the CIBR

We continue our strong linkages with the NZLTC with eight scientists from the CIBR presenting their research at the annual conference in Blenheim (10th–12th April). The NZLTC conference represents an important conduit for the programme to transfer research results and engage with end-users. Gerty Gielen was awarded 'Best Technical Paper' and Morkel Zaayman was awarded a student scholarship sponsored by two industry partners (LEI and Ormiston and Associates) to attend the conference. The CIBR had a very high profile – well done everybody.

Earlier this year we also met with members of the Advisory Group: Jill McKenzie (Hutt Valley District Health Board), Kirsten Forsyth (Ministry for the Environment), Chrissie Williams (Programme Leader, Natural Environment Recovery Programme, Environment Canterbury) and Paul Bruce (Wellington Regional Council and Appropriate Technology for Living Association (ATLA). We discussed the formation of the new CIBR and the Advisory Group provided us with valuable feedback on the work plans and future directions of the research. I'd like to take this opportunity to thank all members of the Advisory Group for their continued support and expert advice.

continued over page

Update from the Programme Manager

continued from previous page

The 'Up-the-Pipe' solutions project participated in a Para Kore hui at the Poihakena Marae in Raglan (22nd–24th March). Para Kore is a marae-based initiative led by Jacqui Forbes with the goal to reach zero waste by 2020. The programme was initially based in the Waikato, but is slowly expanding to other regions so it is an excellent opportunity to align with this group as the 'Up-the-pipe' project is close to completion. The short film made to accompany the 'Up the Pipe' project is now available for free download on the ESR website (www.esr.cri.nz). The film is a humorous but informative look at what goes down your household drain, what happens in an urban waste-water treatment system, and how this can impact on natural waterways, and therefore recreational and drinking water quality.

The long, hot, dry summer at the start of the year meant water shortages across much of New Zealand, this resulted in water restrictions and careful management of household water. With a ban on watering gardens in some areas home owners looked to sources of recycled water in order to keep their gardens alive. Recycling water from the laundry and bathroom (i.e. greywater) to water plants can be an excellent way to save water. However, the greywater can contain disease-causing organisms and should be used with care. Alma Siggins, who leads our Greywater Research Programme provided advice to Regional Councils on safe re-use of greywater.

Tips for safe greywater use include:

- Only use greywater on plants that aren't going to be eaten.
- Never use water that has been in contact with human waste. For example, washing nappies.
- Use greywater immediately. Storing the water can result in the disease causing organisms to increase, especially during hot weather.
- Don't use greywater if anyone in your household is sick

The science behind these tips could form the basis for a national guideline on safe and beneficial re-use of greywater.

Jacqui

Sharing research across the Tasman

– Gregory Priest

The Australia and New Zealand Biosolids Partnership (ANZBP) was pleased to participate in the launch of the Centre for Integrated Biowaste Research (CIBR) and share in hosting the Joint Australian/New Zealand Biosolids Workshop in Blenheim, New Zealand in early April.

Australian & New Zealand Biosolids Partnership

The Australian contingency noted the event was valuable to strengthen existing relationships and develop new contacts. The range of presentations provided the visiting Australians with the opportunity to learn about current biosolids management practices in New Zealand, explore opportunities for improved biosolids regulations, and learn about innovative research activities from CIBR member researchers.

The exposure to the technical research currently underway in New Zealand will guide the ANZBP's research and communications strategies, but will also further inform research being conducted in Australian institutions.

The ANZBP will be working with a number of the workshop presenters to develop case studies which will be shared across the sector.

The ANZBP was well represented at the event, with four members of the ANZBP administrative group presenting at the workshop; Michael Naughton, Bill Barber, Gregory Priest and local Jacqui Horswell. A number of presentations were provided on past ANZBP research activities and policy efforts, which, when looked at in light of the local presentations, suggested the differences between New Zealand and Australia biosolids issues are not that great.

The ANZBP is a subscription based program, formed in 2007 by the Australian water sector, to place the beneficial use of biosolids on a sustainable footing across Australia and New Zealand. The ANZBP resides with the Australian Water Association (AWA) which has taken responsibility for implementing the program, and its agreed business plan.

ANZBP Membership enquiries are welcome and can be directed to the Project Manager at admin@biosolids.com.au, additional information regarding the ANZBP can be found on the website www.biosolids.com.au.

Pare Kore waste minimisation hui in Raglan

– Louis Tremblay and Grant Northcott

Participants at the Para Kore hui in Raglan.

Louis Tremblay, Grant Northcott and Lisa Langer participated in a waste Wananga coordinated by Para Kore held at the Poihakena Marae in Raglan on 22–24 March 2013.

Para Kore is a Tainui-based initiative striving to achieve zero waste on their marae by 2020. The Para Kore team is coordinated by Jacqui Forbes and they hold regular Wananga to educate iwi on ways to reduce waste. The Wananga are well structured with multiple hands-on activities and site visits to demonstrate practices that lead to the production of less non-recyclable waste and advise participants on ways to reuse recyclable waste. Para Kore was a perfect group to present the outcomes from the MfE Waste Minimisation Fund project 'Up-the-pipe solutions'. Louis presented the overall objective of the project which is to sensitise people to the potential implications of their daily behavioural patterns and the products that are used daily for a range of activities. The focus of the project is the various active chemicals found in household products that can potentially find their way into the environment and cause risks to exposed biota. Grant gave a presentation on the range of chemicals that are produced in large volumes and that are found in products commonly used in New Zealand households. Lisa described the process to engage communities through high school students, using the Kaikoura High School hui as an example. This was developed to provide a mechanism to inform and engage the wider community.

Overall, the project was very well received by the Para Kore Wananga participants as it showed them a waste stream that they had not considered at all. Para Kore is very good at managing and focusing on the 'visible' components of the various waste streams produced on marae, i.e. the plastic and glass containers etc. However, other sources of waste that can potentially lead to the release of contaminants into the environment are not integrated into the programme. Para Kore provides an excellent model to implement waste reduction practices as it is strongly driven by a grass root bottom-up approach.

It takes a holistic view to managing waste by offering simple solutions such as going back to basics – sourcing quality food locally and eating according to seasonal availability of produce; using reusable containers or heavy duty plastic bags that can be washed and reused at the butchers; locating farmers who will supply milk in reusable pails etc. It was very impressive to participate in the waste audit towards the end of the hui. Here the Para Kore members went through all the waste generated from the kitchen during the 3-day hui. It was a very visual and effective exercise for the participants to realise there are many ways they can substantially reduce the amount of non-recyclable waste on their marae.

Hui participants doing a waste audit at the end of the 3-day hui

Community engagement framework

– Lisa Langer, Jinny Baker, Alan Leckie and James Ataria

The CIBR social and cultural team has developed a 'fit for purpose' community-engagement framework to support local council decision-making on biowastes. The team has drawn on its extensive experience in community engagement to guide councils in designing public consultation and signposting critical decision areas. This will assist councils to achieve sustainable outcomes which are economically feasible and socially and culturally preferred with minimal environmental impacts.

The team recognises that, on one hand, biowastes, and particularly biosolids, management is a technically complex issue and that uncertainties (resource dependencies, perceptions etc.) make it high risk and costly for councils to consult with community. However, on the other hand, these factors make it equally high risk and costly not to do so.

Communities, regulators and waste managers will have opinions that vary, therefore effective two-way communication, and flexibility around decision-making, is required to achieve sustainable outcomes. A 'fit for purpose' community engagement framework has been developed that defines modes of engagement and identifies their advantages and disadvantages, with the aim of enabling councils to achieve two-way communication.

Prior to community consultation the council must be clear about its intent and enter into community engagement with the 'right spirit'. The council should know their community, mandate and scope. Each council needs to determine what it wants to get out of the community engagement process. What is the issue? What is the goal of the engagement process? How much scope, if any, is there for community participation in issue-definition and decision-making? What time, resource, or other constraints does the council face? The most important thing is to be honest with the participants and ensure that the goal matches the mode of engagement.

The team has drawn on the IAP2 public participation spectrum developed by the International Association for Public Participation and has focused on the continuum of community engagement from, inform → consult → involve → collaborate with the expectation that councils will work towards more collaborative two-way engagement in time.

One way community engagement

Inform ('status quo')

Examples – Public notices of resource consent intentions, letters to affected parties, newspaper articles, leaflets, newsletters, written reports, information on council websites, open days and school tours.

Advantages – low initial cost and low profile.

Disadvantages – lack of opportunity for community feedback means that other viable alternatives may be neglected; if information provokes concerns, it may result in: loss of trust in council, strong oppositional responses, spiraling costs and scuttling of option.

Informing communities is the usual community engagement process used in New Zealand for landfill or Resource Consent issues. Typically information is provided to those considered to be affected parties, such as individual farmers or other rural residents, with the intention of remaining 'under the radar' of the broader community.

Generally this means community engagement is only used for small-scale operations with a low profile. This presents a risk that new or better initiatives and technologies are underutilised and community concerns are left unrecognised or under-appreciated. (e.g., cultural concerns or risks to the food chain). Hence, there is a need to move away from the informing mode of one-way community engagement to engaging communities in two-way dialogue.

Two-way community engagement

Consult (pre-defined scope and parties)

Examples – Resource Consent driven, issue-specific surveys, focus groups, or community meetings with affected parties, e.g., Living Earth.

Advantages – seeks views on pre-defined approach (Option A, B or C) and fits 'business as usual' methodologies.

Disadvantages – lack of genuine dialogue or influence and therefore likely low turnout.

Involve (problem sharing)

Examples – Stakeholder workshops, working groups and interactive engagement.

Zero Waste Coordinators – good examples for inspiring/involving community (household waste reduction, recycling etc.).

Few New Zealand examples for biosolids – Marlborough Spring Creek and Grovetown wastewater community process, regular community meetings, working party etc.

Advantages – enables relationship-building, can generate local solutions and/or innovations, audiences can be selected (stakeholders, iwi, experts, affected parties, interest groups, future generations etc.), on-going and builds knowledge.

Disadvantages – can generate an expectation to influence where that possibility does not exist, on-going costs and commitment.

Collaborate (open workshop styles)

Examples – Stakeholder and community workshops, hui and long-term iwi partnerships – e.g. CBIR Kaikōura case study.

Advantages

- mobilises and integrates wider range of relevant knowledge amongst all participants;
- provides platform for raising and investigating concerns;
- raises awareness that good waste management infrastructure underpins many aspects of civic life, assets and amenities
- transparency builds trust, support for decisions and generates new ideas and robust partnerships to respond to other council issues.

Disadvantages – resource intensive, costly upfront, some 'left-field' ideas that 'don't fit', and needs good facilitation to manage more vocal people.

The draft community framework described here was presented by Jinny Baker to the Joint Australia New Zealand Biosolids workshop, Blenheim and CIBR Advisory Group meeting, Wellington. The social and cultural team seeks to further develop the framework for community engagement with councils in the future. The team welcomes feedback on this framework – please email **lisa.langer@scionresearch.com** or **virginia.baker@esr.cri.nz**.

An Up-the-pipe solutions workshop at the Clifton Terrace School

The Waste Minimisation Fund Up-the-pipe solutions project aims at reducing the level of micro-contaminants in waste by characterising the risk of active chemical ingredients found in household products.

The approach recognises the importance of engaging the community to raise awareness around the consequences of our household activities. Involving children from an early age is a priority to stimulate their curiosity and inform them about the consequences of their daily activities.

The project team has had multiple interactions with school children and the latest activity was a workshop at the Nelson Clifton Terrace School. Ian Challenger, Joel Bowater, Mariam El Orfi and Louis Tremblay spent an afternoon in Rosemary Cooke's classroom to talk about the aims of the Up-the-pipe solutions project. Students were 7 to 9 years old and were very keen to talk to scientists. Being an Enviro School, staff at Clifton Terrace were very accommodating to this type of activity.

Following introductions, the kids were split into four teams that worked two by two. The activities included looking at a range of products and assigning them to the various rooms in a house using the diagram developed by Robina Ang (ESR). The students then had to wash dirty dishes using one commercially available liquid dish soap and one homemade one.

Two students washing the dishes with Joel overseeing the process.

The Clifton Terrace classroom and Up-the-pipe solutions research team members.

At the end, the students had to vote for the soap they felt was the most effective. The homemade soap was the winner! Rosemary was very happy with the outcome. She wrote back: "The children enjoyed the activities and most importantly have become aware of some of the complexities around unquestioning consumption of common household products. It is now up to me to keep the discussion going and build on the experience you have provided."

She had the following suggestions for future activities: "Extra activities could be reading the labels of empty product bottles to see what 'nasties' they contained from a list or word find provided, maybe an activity involving mixing simple solutions and/or a worksheet activity tracing the journey through the pipe to the ocean, to keep them all meaningfully occupied."

UPDATES FROM THE SOIL AND MICRO GROUP

Worms and waste – reusing biowastes as fertiliser

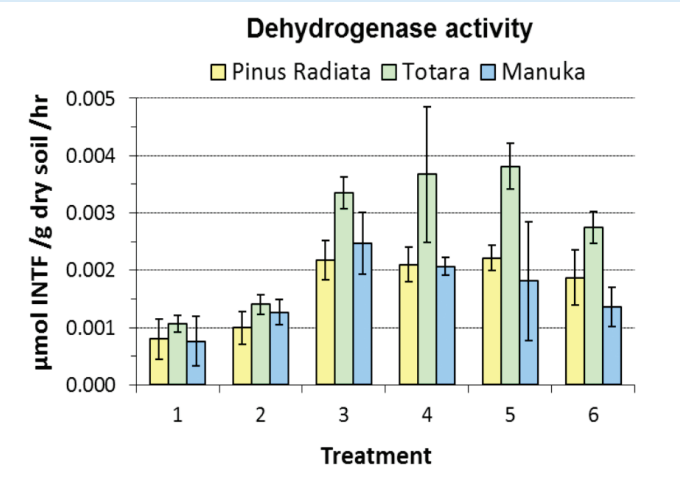
– Jianming Xue

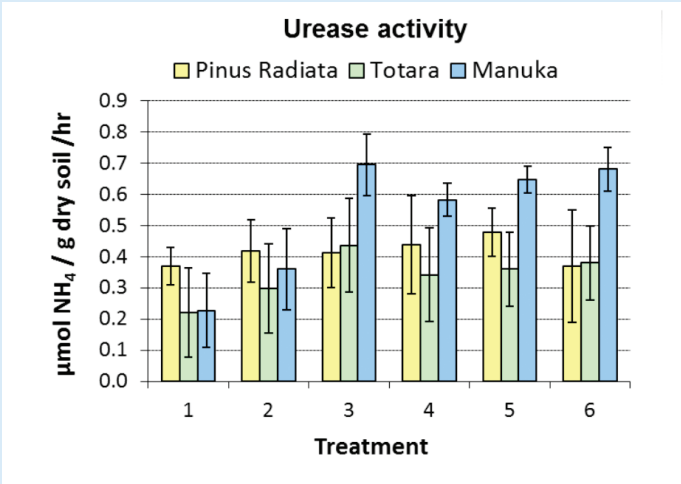
As part of the Taupo case-study the Biowastes programme soil team has been engaging with the Tuaropaki Trust to develop sustainable waste management options for the Mokai community.

The soil and micro group has so far established several experiments to examine if vermicomposting is effective in converting septic tank waste into a high-value fertilizer rich in plant nutrients, with reduced pathogen loadings, and stabilised contaminants. The 2nd glasshouse pot trial at Scion was conducted to investigate the impact of vermicomposted septic tank wastes on soil biological processes and tree growth of exotic and native species.

Soil enzyme activities are important indicators of soil biological processes and soil fertility, and are considered sensitive biological indicators of soil health. Soil dehydrogenases play a significant role in the biological oxidation of soil organic matter and are used as an indicator of overall soil microbial activity. Soil urease decomposes urea into carbon dioxide and ammonium. For all three plant species tested, application of compost (treatment 3) and vermicomposts (treatment 4–6) had greater soil dehydrogenase activity than the control (treatment 1) and chemical fertiliser (treatment 2). For both manuka and totara, compost and vermicompost treatments appeared to have greater urease activity than the control.

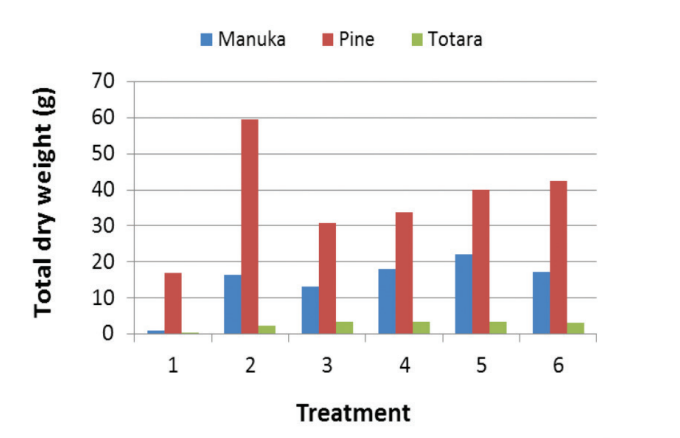
continued over page

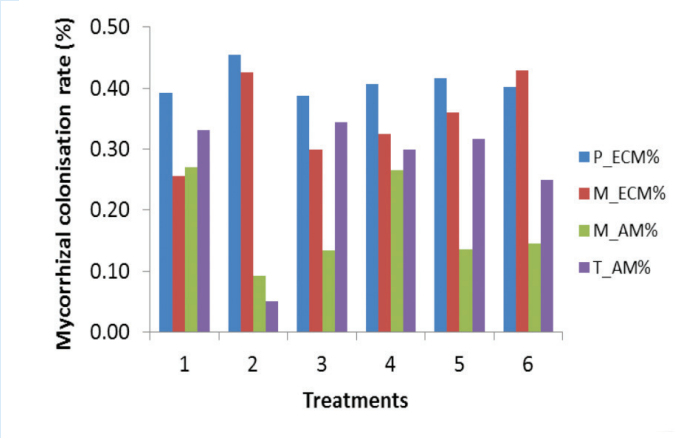




Effect of treatments on soil dehydrogenase (left) and urease (right) activities

1. *Soil only;* ***2.*** *Soil + diammonium phosphate (DAP) at 133.3 kg N/ha;* ***3.*** *Soil + 50% Septic Tank Waste + 40% Palm fibre + 10% tomato pruning – non-vermicomposted (400 kg N/ha);* ***4.*** *Soil + Same as above – vermicomposted (400 kg N/ha);* ***5.*** *Soil + 30% Septic Tank Waste + 60% Palm fibre + 10% tomato pruning – vermicomposted (400 kg N/ha);* ***6.*** *Soil + 30% Cow manure + 60% Palm fibre + 10% tomato pruning – vermicomposted (400 kg N/ha).*





Effect of treatments on seedling biomass (left) and mycorrhizal colonisation (right)

P_ECM% *– Ectomycorrhizal colonization in radiata pine;* ***M_ECM%*** *– Ectomycorrhizal colonization in manuka;* ***M_AM%*** *– Arbuscular mycorrhizal colonization in manuka;* ***T_AM%*** *– Arbuscular mycorrhizal colonization in totara.*

Application of vermi- and non-vermicomposted septic tank wastes improved the seedling growth of radiata pine, totara and manuka species when compared to the control. Vermicomposts (treatment 4–6) appeared to be better than the compost (treatment 3) in improving seedling growth. Except for radiata pine, vermicomposts were as effective as chemical fertiliser (treatment 2) in stimulating seedling growth of native species. Of all treatments, chemical fertiliser had the best effect on radiata pine growth, implying the importance of phosphorus for this species. The information on bioavailability of soil nutrients and heavy metals and their uptake by plants are currently not available and will be reported in the near future.

Different treatments had different effects on mycorrhizal colonisation rates of three species. Compared to the control, the chemical fertiliser treatment markedly reduced the colonisation rates of arbuscular mycorrhizae in both manuka and totara, but had less impact on the colonisation rates of ectomycorrhizas in both radiata pine and manuka. Application of compost (treatment 3) and vermicomposts (treatment 4–6) didn't significantly reduce the mycorrhizal colonisation rates of three species when compared to the control.

Rebuilding damaged soils with biosolids

– Dharini Paramashivam

Humanity produces approximately 27 kg dry biosolids per person each year. The disposal of biosolids is a global environmental issue. In New Zealand most biosolids end up in landfills. Biosolids are mostly organic matter and have high concentrations of plant nutrients, which when added to the soil, can improve fertility. However, biosolids have some unwanted components including pathogens and heavy metals, which need to be carefully managed.

Many soils in New Zealand and around the world have become damaged due to human activities. In New Zealand, soils that were under pine plantations have low fertility and need rebuilding to support vigorous plant growth. My greenhouse experiments revealed that the fertility of these soils can be restored by the addition of high rates of biosolids. However, such additions can lead to high nitrate leaching which can contaminate lakes, rivers and groundwater.

Certain compounds such as charcoal and lignite may have the potential to reduce nitrate leaching, The goal of my research is find a method to reduce unwanted nitrate leaching by mixing biosolids with charcoal and low grade coal. I aim to find a low-cost means of rebuilding our degraded soils.

I am using experiments at a range of scales. The coal and charcoal are first tested in the laboratory. Materials with the potential to mitigate nitrate leaching are then used in greenhouse experiments as depicted above. Finally, I am testing the system in special devices called lysimeters, which can tell us about the improvement in soil fertility and reduction in unwanted nitrate leaching over the long-term.

A key aspect of this work is that using materials such as charcoal and low grade coal are low cost. Charcoal can be made from waste material, particularly waste from forestry that results in soil degradation. The coal used in my experiments is low-grade lignite that often overlies high-value coals and hence can be considered a waste material.

My research has also delivered an unexpected outcome. When crops are grown in soils that have been rebuilt with biosolids, the plants contain elevated concentrations of essential micronutrients, particularly zinc, which can improve human and animal health.

Reapplying biosolids to land reintroduces nutrients to the soil that were ultimately taken from the soil via food production. Humanity cannot store biosolids indefinitely, and landfilling is not a long-term sustainable option. Ultimately, the loop needs to be closed and these nutrients reused.

Dharini in the greenhouse where some of her experiments are carried out.

You can read more about our research in the following publications:

Gartler J, Robinson B, Burton K, Clucas L. Carbonaceous soil amendments to biofortify crop plants with zinc. Science of the Total Environment. In press. **http://dx.doi.org/10.1016/j.scitotenv.212.10.027**

Simmler M, Ciadamidaro L, Schulin R, Madejón P, Reiser R. Clucas L, Weber P, Robinson BH. Lignite reduces the solubility and plant uptake of cadmium in pasturelands. Environmental Science and Technology in press http://pubs.acs.org/doi/abs/10.1021/es303118a

Anderson CWN, Robinson BH, West DM, Clucas L, Portmann D (2012). Zinc-enriched and zinc-biofortified feed as a possible animal remedy in pastoral agriculture: Animal health and environmental benefits. Journal of Geochemical Exploration 121, 30–35.

Knowles OA, Robinson BH, Contangelo A, Clucas L (2011). Biochar for the mitigation of nitrate leaching from soil amended with biosolids. Science of the Total Environment 409, 3206-3210.

Outputs from the Biowastes team this year

Journal papers

- Wang, H., Kimberley, M.O., Wilks, P.J. 2013. Economic analysis of a pine plantation receiving repeated applications of biosolids. PLoS One. 2013; 8(2):e57705. doi: 10.1371/journal.pone.0057705. Epub 2013 Feb 25.

Conference papers

- Cavanagh, J, Tremblay L, Northcott G, Trought K, Mitchell C. 2013. The biological response associated with biosolids. In: the proceedings for NZ Land Treatment Collective Annual Conference 2013. Water – what is it worth? Blenheim, 10–12th April.

- Cavanagh, J, Tremblay L, Northcott G, Trought K, Mitchell C. 2013. The biological response associated with biosolids. In Gielen, G., Denis, M. (ed.). Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand. p. 66–71.

- Gielen, G J H. (2013, April). Triclosan and metal effects on soil microbes. In Gielen, G., Denis, M. (ed.). Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand.

- Gielen, G J H; Dennis, M A. 2013. Edited New Zealand Land Treatment Collective – 2013 Annual conference proceedings (technical session 34): Water – What is it worth? Blenheim, 10–12 April 2013.

- Horswell, J., Baker, V., Langer, E.R., Leckie, A., Ataria, J. and Tremblay, L. 2013. 'Up the Pipe Solutions': An education intervention that engages the community via high school students. In Gielen, G., Denis, M. (ed.). Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand. p. 211–225.

- Horswell, J., Baker, V., Langer, E.R., Leckie, A., Ataria, J. and Tremblay, L. 2013. 'Up the Pipe Solutions': An education intervention that engages the community via high school students. In Gielen, G., Denis, M. (ed.). Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand. p. 211–225.

- Horswell, J., van Schaik, A., Prosser, J., Graham, D., Ross, M., Xue, J. and Booth, L. 2013. Worms and waste – Uncovering a potential partnership. In Gielen, G., Denis, M. (ed.). Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand. p. 51–65.

- Northcott, G. 2013. Emerging organic contaminants enter New Zealand's aquatic environments with wastewater treatment plant effluents. New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand.

- Siggins, A., Hewitt, J., Williamson, W., Weaver, L., Ashworth, M., van Schaik, A., Ang, R., Lowe, H., Roberts, S., Thompson, B., Robertson, J. and Horswell, J. 2013. Impact of domestic greywater diversion on the efficient functioning of a septic tank system. Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, 10–12 April 2013, Blenheim, New Zealand. P. 106–112

- Xue, J., Kimberley, M., Wilks, P. 2013. Is land application of biosolids at Rabbit Island sustainable? – evidence from a 15-year-long research trial. In Proceedings of the 2013 New Zealand Land Treatment Collective Annual Conference, Gielen, G., Denis, M. (ed.). 10–12 April, Blenheim, New Zealand.

Client reports

- Xue, J., Kimberley, M. 2012. Annual Report on the Biosolids Research Trial at Rabbit Island. Client Report No. 50611. Scion, Christchurch.

Upcoming events

CIBR members will be presenting updates of the research programme at both the WaterNZ Annual Conference 'Changing Current' in Hamilton (16–18 October 2013) and the WasteMINZ 25th Annual Conference 'Focus on the Future' in Rotorua (21–24 October 2013).

At the WasteMINZ conference, CIBR will be joining forces with WaterNZ to run a workshop on a proposed new guideline 'The beneficial use of organic waste in New Zealand – a new technical guideline for land application'.

The first call for papers for the New Zealand Land Treatment Collective (LTC) annual conference has been announced. This year's conference will be held in Hamilton on the 26–28 March 2014 with the theme – 'Managing contaminants at a catchment level – back to basics', a CIBR workshop will precede the LTC conference – dates to be confirmed.

If you would like further information on the programme or have any questions please contact a member of the Science Leadership Team:

Programme Manager
Dr Jacqui Horswell
ESR, Wellington,
PO Box 50-348, Porirua
Jacqui.Horswell@esr.cri.nz
Phone (04) 914 0684

Social and Cultural Research
Lisa Langer
Scion, Christchurch,
PO Box 29-237, Christchurch
Lisa.Langer@scionresearch.com
Phone (03) 364 2949

Soil Science
Dr Jianming Xue
Scion, Christchurch,
PO Box 29-237, Christchurch
Jianming.Xue@scionresearch.com
Phone (03) 364 2949

Ecotoxicology
Dr Louis Tremblay
Cawthron Institute, Nelson,
98 Halifax Street, Nelson
Louis.Tremblay@cawthron.org.nz
Phone (03) 548 2319