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Putting waste to work

A CENTRE FOR INTEGRATED BIOWASTE RESEARCH PUBLICATION

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Centre for Integrated Biowaste Research

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UPDATE FROM THE PROGRAMME MANAGER

Photo: Julian Thomson of GNS Science

Welcome to the final newsletter of 2016. It is hard to believe that another year is drawing to a close and what a year it has been!

Many of us felt the magnitude 7.8 (Mw) earthquake in Kaikōura that occurred two minutes after midnight on 14 November 2016. The CIBR team has a strong connection with Kaikōura as one of our case studies was based there. We spent a lot of time at Takahanga Marae and experienced the warmth and friendship of the iwi. From all the CIBR team "aroha nui" to all the whānau in Kaikōura.

The recent earthquakes highlight once again the vulnerability of sewerage systems to disruption, and the critical issue of the management of human waste. The treatment ponds and sewerage systems in Kaikōura have been badly damaged, as happened in Canterbury after the 2010 and 2011 earthquakes. Chemical toilets are being distributed throughout the region. There are some interesting issues on how to manage the chemical waste and discussions on whether alternatives, such as composting toilets are viable and safe. Next year, CIBR hopes to secure funding to look at this question. We aim to investigate the best methodology to manage human waste from 'on-site' emergency composting toilets including 'on-site' re-use/disposal options. In the aftermath of natural disasters, sustainable sanitation systems are critical to both safely remove waste and protect human health.

On the topic of composting, we have just wrapped up our co-composting trial funded by a Kapiti Coast District Council Waste Minimisation Grant. We have been researching the feasibility of vermicomposting Kapiti Coast biosolids with waste plasterboard. The results are very promising and the reuse of plasterboard positively impacts the vermicomposting process. For more information on this trial see page 3.

The Land Treatment Collective conference is now only three months away, the call for presentations has closed and the LTC Technical Committee are busy reviewing abstracts. The 2017 Conference will be held in Christchurch from 29 to 31 March. The theme of; "Resilience and Innovation" is very topical. As usual, there will be a large contingent of CIBR researchers at the conference, so come along and hear about the work and take the opportunity to pick their brains first hand!

Finally, after a very busy year I'd like to thank all our collaborators and research partners for their invaluable contribution to this research programme, and I hope that you have an enjoyable festive season.

Very best wishes for the New Year.

Jacqui Horswell

UPDATE FROM THE SOCIAL AND CULTURAL TEAM

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

"Tamaiti akona i te pā, tū ana ki te ao, tau ana.[1]"

"A child educated to be strong in their own identity stands confident in the world."

With 2017 rapidly approaching, the Social and Cultural research group have been busy exploring new biowaste research pathways that will expand existing knowledge and collective networks that they have built since the beginning of CIBR. One exciting new initiative is focussed on Te Pā o Rākaihautū (Te Pā) – a designated special character school located in Christchurch.

Te Pā is the first school of its kind in New Zealand. As a learning village it has taken traditional Māori teaching practice and cultural philosophy, and combined these with modern learning/teaching methods. This has created an innovative solution to address both educational achievement disparities and increase education choice in Christchurch. It caters for the whole whānau (family) and offers a seamless lifelong learning experience. From early childhood education, primary and secondary school compulsory sector education, right through to tertiary education, all is available on the one site.

With a key focus on restoring culture, identity and connection to the environment as a foundation to educational success and sustainability; Te Pā has both a vision and a mission: to provide place-based learning revolving around stories of environmental learning from the past. These will help create physical and spiritual wellbeing for the body, mind and environment as the curriculum will create knowledge for the student's future. This has captured the attention of CIBR, and in particular, Te Pā's approaches to create transformative behaviour change around sustainability, their aspirations for managing the biowaste streams generated, and chemical usage at their current and at their future permanent sites.

The Social and Cultural research group have visited the Te Pā and met with representatives of Te Taurinui (the Establishment Board of Trustees for Te Pā) and staff. There is excitement about the research opportunities that could assist with Te Pā's sustainability goals, providing research evidence that could guide their decision-making and assist with biowaste education and biowaste infrastructure development for their new purpose built site. It is anticipated that Te Pā will develop into a major anchor project through which other biowaste initiatives and relationships could align to build deeper cross-cultural learning and stronger models of environmental stewardship.

The CIBR team will report back on plans to work with Te Pā as discussions develop into research objectives.

Members of the Social and Cultural group inspecting one of Te Pā's purpose built 'whare noke' or worm farms. Left to right: Alan Leckie, Lisa Langer, James Ataria. Photo credit Virginia Baker.

Potted fruit trees and wooden seats created by pononga (students) from recycled pallets sit in Te Pā's sustainability centre. Photo credit James Ataria.

[1] *A whakatau-ā-kī or proverb that has adapted by Te Pā o Rākaihautū that describes its holistic philosophy.*

AMANDA INGLIS – PhD STUDENT WORKING WITH LOUISE WEAVER WITHIN ESR AND CIBR

Investigating waste stabilisation ponds and the potential of enzymes present to inactivate human enteric viruses.

This project started as a Summer Scholarship through the University of Canterbury and ESR to identify if enzymes in wastewater possess the ability to inactivate viruses that are harmful to public health. I quickly became interested in the idea that such a simple wastewater treatment system (Waste Stabilisation Ponds) could outperform more "high tech" systems around the world with lower costs and energy requirements. The more I learn about Waste Stabilisation Ponds, the more I am convinced these "low tech" systems will play a vital role in wastewater treatment and reuse in the coming years as we see an increase of irrigation with wastewater globally. The development of this core-funded project into a PhD project, allowed me to learn a wide range of skills required to investigate not only wastewater, but enzyme mechanisms and viral surface properties, including microbiology, molecular biology, biochemistry and mass spectrometry, all of which can be applied to most of ESR's core science interests in other areas. As I come to the end of my project, and the end of core-funding, we see an ever-more increasing need for research in the environmental sector. It is really important to understand the processes occurring with an aim to improve wastewater treatment and gain knowledge to prevent further public health outbreaks in New Zealand and around the globe.

Thesis in Three: Canterbury University

Represented the UC Chemistry Department (Departmental Final) at College of Science Thesis in Three Finals (College Final)

Conference Presentations:

- 11th IWA Specialist Group Conference on Wastewater Pond Technologies, University of Leeds, United Kingdom, 2016
- New Zealand Microbiological Society Conference, 2015 and 2016
- Canterbury 'Omics Symposium V, 2016

Scholarships/Awards:

- ESR Vision PhD Scholarship
- University of Canterbury Chemistry Department Fee's Scholarship
- Canterbury Graduate Women's Federation Travel Grant (Leeds, UK 2016)

VERMICOMPOSTING BIOSOLIDS WITH PLASTERBOARD IN KĀPITI COAST

Jacqui Horswell, Jen Prosser and Sarah Quaife.

Each year, 1500 tonnes of thermal dried biosolids from the Kapiti Coast are disposed of at the Otaihanga landfill. The current resource consent allows this disposal until 2020, when alternative options will be required. Funded by a Waste minimisation grant, we investigated the potential for vermicomposting these biosolids, using plasterboard from the building industry as a bulking agent.

Construction and demolition waste (including plasterboard) currently accounts for 20% of waste going to landfill. Plasterboard is theoretically suitable for vermicomposting as it is composed of gypsum with a paper lining and has the potential to absorb excess water, aerate the compost, reduce the ammonia smell from biosolids and balance the C:N ratio required for vermicomposting success. In addition, as a final product, gypsum can be used as a soil amendment in agriculture to improve permeability in clay soils (the ability to allow water and air to pass through soil particles), and provide calcium and sulphur for plant growth.

Vermicomposting with biosolids and plasterboard has not previously been trialled in New Zealand. The trial has been described in detail in previous newsletters, but briefly: duplicate custom vermicomposting units were set up with a mixture of biosolids, green waste and plasterboard. These were compared with control units, which were a mixture of just biosolids and green waste. Monthly samples were taken for the following analyses: dehydrogenase (enzyme activity), phosphate, nitrate, ammonia and *E. coli* for the purpose of monitoring the vermicomposting process and determining its completion.

There were some significant initial teething problems as we quickly discovered that the vermicomposting worms did not like the biosolids/GIB mixtures. To find a solution we carried out small scale lab tests to determine optimum composting conditions and a mixture that the worms liked. These are outlined in the table below (Table 1.) along with the solution.

Table 1. Issues with the vermicomposting trial.

Problem	Consequence	Solution
High ammonia	Higher worm mortality	Pre-composting period
Biosolids pellets difficult to re-hydrate	Worms leave	Add more water, soak, mix well
C:N ratio	Worms leave	Add cardboard

We then went back to the field trial and mimicked the optimum conditions determined from the laboratory trial. As a result the worms survived and multiplied, and after 12 weeks they started to leave – job done?

To answer that question we undertook a range of analysis to look at compost maturity.

In a nut shell the results show us the following:

- There is plenty of soluble N in the final product to satisfy plant needs – earthworms stimulate nitrification.
- Ammonium levels are still high due to high N in starting material (biosolids)
- BUT greater than 50% soluble nitrogen is in the form of nitrate, good sign material has matured well
- The P content is similar to animal manure composts
- Metals and dehydrogenase results are still to come!

In summary, the addition of plasterboard to the mix appeared to positively impact the vermicomposting process when the C:N ratio was balanced for worm survival. This is good news as vermicomposting biosolids with a plasterboard bulking agent has the potential create a viable product and allow diversion of biosolids and some plasterboard waste from landfill.

Below: Control vermicompost unit in the first week following setup.

UP-DATE FROM THE ECOTOX TEAM

Louis Tremblay

There has been on-going work towards the risk assessment of emerging contaminants. We are using a range of toxicity bioassays to test some of the key micro-contaminants commonly found in sewage effluents and biosolids. Those bioassays include algal and crustacean tests that will help us assess the risk of individual contaminants but also of mixtures as found in the receiving environment. Olivier Champeau (Cawthron) provided an overview of the new exciting algal assay in Figure 1.

Graham Sevicke-Jones (Director, Science & Information, and Environment Southland), Grant Northcott, Jamie Ataria and Louis Tremblay attended the SETAC World Congress in Orlando, 6-10 November 2016. Of particular interest, they attended the final Global Horizon Scanning Research Prioritisation Project workshop. The Australasia workshop was hosted by CIBR at the 2015 SETAC conference in Nelson where 20 questions were identified and ranked. This represented a unique opportunity to identify the key issues relevant to each region for dissemination to the policy, business and scientific communities. This was followed up with a Royal Society funded national workshop that was held on the 1st and 2nd of December to develop a national strategy document to manage emerging contaminants in New Zealand involving many CIBR colleagues. More details from this exciting initiative to come in the next Newsletter.

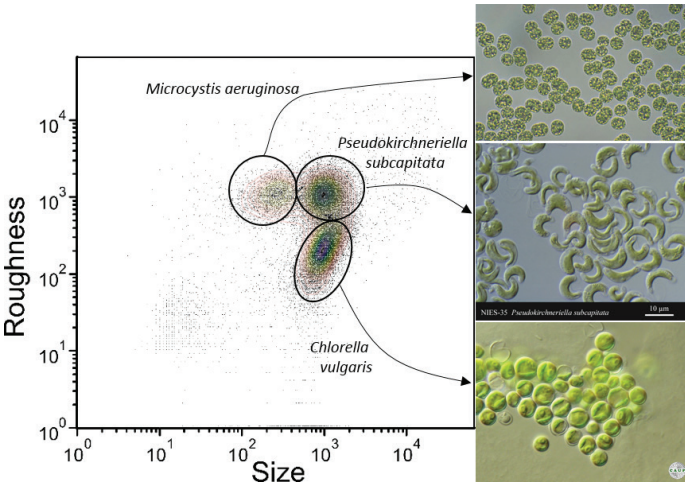


Figure 1. Simultaneous quantification of two freshwater green micro-algae (Pseudokirchneriella subcapitata and Chlorella vulgaris) and a freshwater cyanobacteria (Microcystis aeruginosa) using flow cytometry. It will be possible to assess the impacts of chemicals on two species at a time.

UPDATE FROM THE SOIL SCIENCE TEAM – LONG-TERM EFFECT OF BIOSOLIDS LAND APPLICATION ON THE GROUNDWATER QUALITY AT RABBIT ISLAND

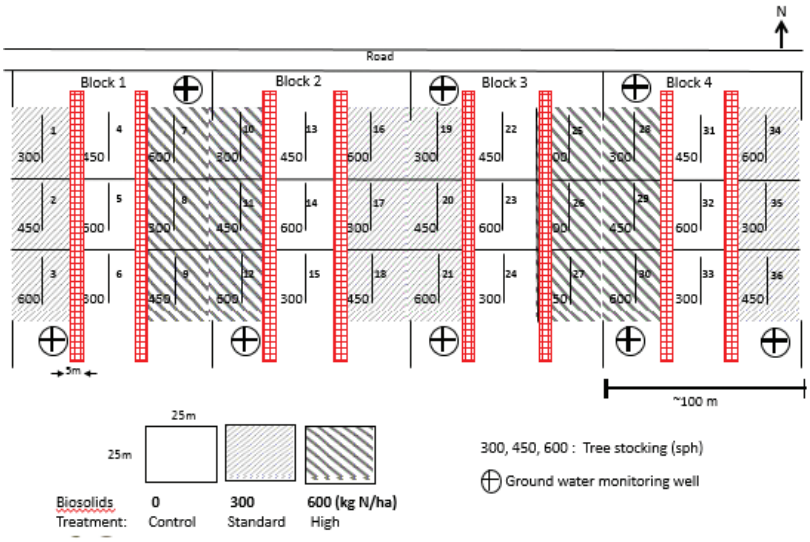
By Jianming Xue

Land application of biosolids as a supplemental fertiliser and soil amendment is one of the most common options for biosolids management. In New Zealand, application of biosoilds on forest land is preferred than on agricultural land because it can reduce the risk of contaminants entering the human food chain and can also increase tree growth and subsequent economic returns. Treated biosolids from the Nelson Regional Sewage Treatment Plant has been applied to a 1000-ha radiata pine forest plantation at Rabbit Island near Nelson City since 1996 (Fig 1). For a requirement of the resource compliance, intensive monitoring of soil and groundwater as well as tree growth and health has been carried out since biosolids spraying. An ecological assessment of the Waimea estuary is also carried out every five years. In addition, a long-term research trial was established on the site in 1997 to monitor the environmental effects of the repeated application of biosolids on the plantation, and to determine sustainable application rates. Since then tree nutrition, growth and wood properties have been assessed along with a number of environmental variables, such as soil quality. This newsletter provides updated information about the long-term effects of repeated applications of biosolids on the groundwater quality at Rabbit Island over a period of 17 years.

Fig.1 Land application of biosolids in a pine forest at Rabbit Island in Nelson.

To assess the change in groundwater levels and quality due to biosolids application, eight monitoring wells were installed around the research trial (Fig. 2). The wells were positioned along the expected southwestern groundwater flow direction towards the estuary. Three upgradient wells were installed to provide control data, five wells were installed downgradient of the trial site. Groundwater levels were measured quarterly (February, May, August and November). Groundwater samples were collected quarterly too for analysis of pH, electrical conductivity (EC), NO3-N, NH4-N, Cl, Ca, Mg, K and Na, and collected annually for analysis of heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni and Zn).

Fig.2 Rabbit Island biosolids trial design and layout in Nelson



Groundwater levels at Rabbit Island showed annual, seasonal and location differences. There was no biosolids application effects on groundwater levels likely due to the low frequency and hydraulic loading rates of biosolids application. However, the EC values and concentrations of Cl, Ca, Mg and Na increased over the years, and were greater in the downgradient wells than in the upgradient wells. This indicates some effect of biosolids application on groundwater quality. Although the mean NO3-N concentrations in groundwater were overall below the drinking water maximum acceptable value (MAV) of 11.3 g NO3-N m-3 over the years, some peak concentrations of NO3-N were much greater than the MAV in certain years and wells (in the compliance monitoring). This indicates that some biosolids-derived N was leached into groundwater when not taken up by the trees.

The concentrations of As, Cd, Pb and Ni were occasionally greater than the drinking water MAVs at certain years and wells. However, concentrations of all other heavy metals were below the drinking water MAVs during the whole monitoring period and at different locations. It appears that the occasional peak levels of these heavy metals were likely linked to the saltwater intrusion (into the shallow unconfined groundwater) in conjunction with periods of leaching of biosolids-derived heavy metals.

Increases in groundwater heavy metal concentrations possibly due to biosolids application were not significantly detrimental at this stage. However, further monitoring is warranted to assess the long-term fate of biosolids-derived heavy metals in the receiving environment.

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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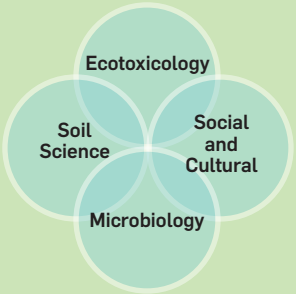

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