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Putting waste to work

A CENTRE FOR INTEGRATED BIOWASTE RESEARCH PUBLICATION

Centre for Integrated Biowaste Research

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Update from the Programme Manager

Welcome to the Autumn 2015 CIBR newsletter.

It has been a very busy start to the year for CIBR. The first of three big conferences this year, the annual New Zealand Land Treatment Collective conference (NZLTC), was held in Wanaka from 24 – 27 March.

This conference represents an important conduit for the programme to transfer research results and engage with end-users. As usual, a number of us attended the NZLTC conference and the programme presented a total of 5 oral presentations and one poster, providing a very high profile– well done everybody. Special mention to Gerty Gielen and Rebecca Stott who conjointly received 'Best Technical Paper' for their presentations – huge congratulations.

Each year CIBR holds an end-user workshop to review the latest research policy and guidelines, and offer the opportunity for knowledge sharing and fostering closer linkages within the biowastes industry. After three successful workshops associated with the NZLTC, this year we will be teaming up with the Society for Environmental Toxicology and Chemistry (SETAC) Australasia Conference which will be held 25 – 28 August, 2015 at the Rutherford Hotel, Nelson (http://www.setac2015.org.nz/). CIBR will be hosting a session at the conference focused on biowaste research which will provide a forum to discuss sustainable biowaste management in the Asia-Pacific region. We hope to see many of you at the SETAC conference and CIBR session!

The third conference is the IWA EcoBioRefinery Conference which has been coordinated with SETAC and will be held in Rotorua from 30 August – 4th September. This is the first IWA Conference on Lignocellulosic-based Biorefineries and the environment, and the first in a new series of conferences formally combining the IWA Symposium on Forest Industry Wastewaters and the International Conference on the Fate and Effects of Pulp and Paper Mill Effluents. Registrations are now open with a special offer available to those who register to attend both conferences.

CIBR and NIWA have begun an exciting collaboration with the community and Council in Gisborne. The Gisborne District Council (GDC) commissioned its new Biological Trickling Filter (BTF) in 2011. As part of the consent process a Wastewater Technical Advisory Group (WTAG) was established to assess BTF performance and investigate potential for alternative use and disposal of the treated effluent and biosolids, with the eventual aim of eliminating discharge to sea. WTAG and GDC, in partnership with CIBR and NIWA, are exploring the feasibility of a wetlands treatment system. Sludge treatment wetlands have not previously been applied in New Zealand and their efficiency in treating BTF sludge needs to be assessed under local conditions using native plant species, rather than the invasive common reed employed elsewhere in the world. Additionally, the removal efficiency and, the fate and effects of a range of key contaminants of concern in New Zealand (including emerging organic contaminants, pathogens and heavy metals) need to be assessed.

We will be working collectively to explore the establishment of a wetlands system and planted drying beds to treat and beneficially re-use wastewater and biosolids from the Gisborne BTF. The initial phases of the work have involved all parties turning out to build some pilot scale plant growth chambers to evaluate which plant species grow best in Gisborne BTF. CIBR are really enjoying this truly collaborative project.

I hope that you enjoy this quarter's newsletter and please let us know if you would like to publish an article – we'd love to hear from you.

Jacqui Horswell

Cashing in on biowastes for environmental benefits

Juergen Esperschuetz & Brett Robinson

Applying biowastes to land can improve soil fertility and reduce the requirement for mineral fertilizers, especially in degraded environments. While the organic matter contained in some biowastes promotes topsoil development, high rates of biowaste addition to soil can result in nitrate leaching that can contaminate drinking water and cause excessive growth of weeds and algae in lakes. Biowastes can contain contaminants and pathogens that pose risks to humans and ecosystems. High concentrations of heavy metals such as cadmium, copper, lead and zinc can result in reduced plant growth and endanger human health or animal productivity, either directly or via crop uptake.

Juergen Esperschuetz is researching how these risks can become benefits. One example is the copper and zinc contained in biosolids. While high concentrations of these elements can cause soils to become infertile, many soils are deficient in these elements, and some 25% of humans are deficient in zinc. Juergen and others have demonstrated that biosolids can fortify food and fodder plants with zinc, while ensuring uptake of contaminants remain well within safe levels. Such benefits can be realised by blending biowastes together and through judicious crop selection.

Figure 1. Researchers from Lincoln University involved in the lysimeter experiment (from left to right): Tao Zhong, Obed Lense, Dharini Paramashivam, Juergen Esperschuetz, Brett Robinson, Hannah Franklin, Nicholas Dickinson, Youngnam Kim, Shamim Mamun.

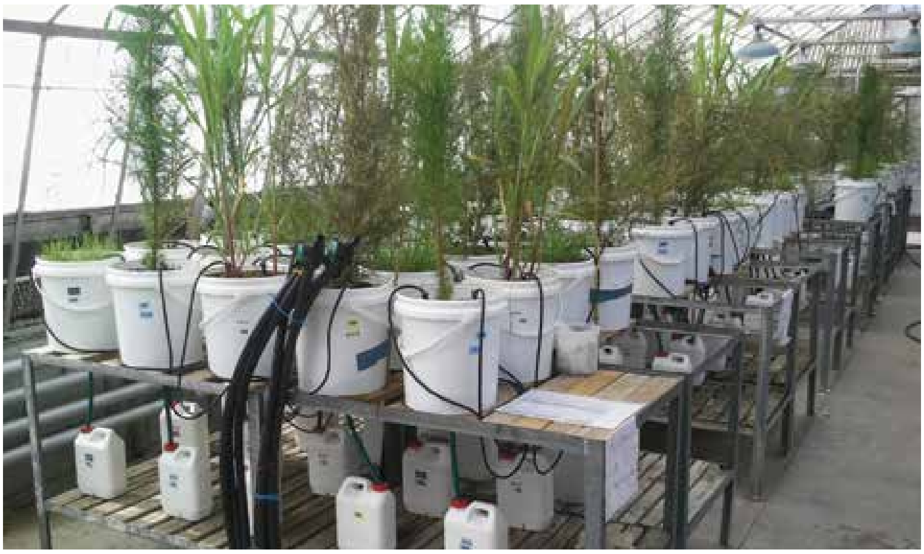

Figure 2. Lysimeter experiment including four different treatments (control, urea, biosolids, biosolids and sawdust) and six plant species (pine, ryegrass, mānuka, kānuka, sorghum and oilseed rape).

Juergen has overseen a large experiment, involving twelve researchers and students (some of which are pictured in Fig. 1) using devices called lysimeters that measure the mobility of nutrients and contaminants in the soil – plant system (Fig. 2). Native and exotic plants in New Zealand landscapes have been selected with a view of using these plants for environmental protection in agricultural systems. Plant species were chosen on the basis that they could add value to the land through timber, fibre or fodder production (pine and ryegrass), provide materials for cosmetics and medicine (kānuka, mānuka) or the production of bioenergy through bioethanol and biogas production (sorghum and oilseed rape).

All plants grew significantly larger when biowastes were added to soil. Biowastes also increased the concentrations of essential nutrients in the plants: the biowastes were effective in restoring a low-fertility soil. Interestingly, some of our native plants, kānuka and mānuka caused a large reduction in nitrate leaching: these plants could be used to protect drinking water and lakes from contamination following the application of biowastes to land. Hannah Franklin, who has recently completed her PhD at Lincoln University, reported that these plants could be incorporated into farming systems to directly intercept animal biowastes (urine, faeces) if they were used as sheltering trees or effluent disposal blocks. Mixing the biosolids with sawdust significantly reduced the uptake of cadmium, a toxic heavy metal, while still allowing the plant access to essential nutrients including zinc and copper. Hence, mixing sawdust with biosolids provides a suitable method for producing healthy plant product and prevents toxic contaminants from entering the food chain.

From a below ground perspective, the application of biowastes did not significantly perturb soil microbial activity, which is an indicator of soil health. This was in stark contrast to a mineral fertiliser (urea) that significantly decreased the total microbial biomass and microbial activity.

In a separate experiment, a urea application similar to an animal's urine patch was used to determine how plants affect the emission of nitrous oxide, which is a potent greenhouse gas that exacerbates global climate change. The results indicated that mānuka and kānuka suppressed the emission of nitrous oxide from soil. This could have significant financial benefits to New Zealand, which is signatory to international climate change agreements requiring us to limit our greenhouse gas emissions or incur financial penalties.

The outcomes of this study will be published in international journals and contribute to more sustainable and environmentally benign biowaste management practices in New Zealand and elsewhere. In particular, we seek technologies that are profitable and not prohibitively expensive. We would like to thank Lincoln University, Environmental Science and Research, Plant and Food Research and the German National Science Foundation DFG for funding. Furthermore we acknowledge all colleagues, analytical technicians and students for their excellent work and input enabling the realisation of the experiment.

Gisborne District Council's waste water treatment

Staci Boyte

The CIBR group at ESR have been working alongside the Gisborne District Council and NIWA as they prepare to upgrade their Biological Trickling Filter (BTF) wastewater plant, with the eventual aim of eliminating discharge of treated human effluent to the sea. The current system for the Gisborne District is a BTF, an aerobic system that relies on micro-organisms to remove organic matter from the wastewater which is then disposed of at sea. An alternative option of a wetland treatment system and sludge drying beds has been proposed which will treat and re-use the waste, eliminating the discharge of waste to the sea and potentially provide a useful soil conditioner. A project to assess the potential performance of this system will be conducted by ESR and NIWA, with the Biowaste group at ESR assessing the sludge drying wetland technology.

Sludge drying beds consist of wetland plant species planted into a fine medium (such as sand) overlying layers of fine and coarse gravel. Sludge or wastewater is applied regularly to the surface. The plants absorb water and nutrients for growth while the gravel and sand layers dewater and aerate the applied wastewater, increasing the solids content of the final sludge product (Nielsen, 2003, Stefanakis & Tsihrintzis, 2011). After several years, the sludge may be usable in land application as this technology has been shown to reduce heavy metal concentrations in sludge and has potential for organic contaminant removal, both key limitations to the use of wastewater sludge as a soil conditioner (Stefanakis & Tsihrintzis, 2012; Chen et al., 2009). Sludge drying beds have been successfully used in other countries such as Denmark, France, Belgium, the UK, Spain, Greece, Italy and the USA (Nielsen, 2003; Stefanakis & Tsihrintzis, 2012). However, New Zealand's climate and the desired use of native wetland plant species may cause results to vary from international studies and the effectiveness of the sludge drying beds needs to be proven.

The project with Gisborne District Council and the Tūranganui-a-Kiwa Wastewater Technical Advisory Group (WTAG) will involve a trial established at ESR that aims to determine whether the sludge-drying wetland technology will be as successful in effectively dewatering and treating solids from the Gisborne BTF wastewater as it has been overseas. The first phase of this trial was established in December 2014 on site at the Gisborne wastewater treatment plant and aimed to assess plant tolerance to the Gisborne BTF. This involved planting five native wetland plant species into either sand and bark (Figure 1). These plants have now become established and are currently receiving BTF applications. Later this year they will be transported down to ESR in Porirua where pilot scale sludge drying beds will be constructed using fine and coarse gravel and these plants, well established in the sand and bark, will be transferred onto the top of the gravel to complete the pilot scale sludge drying beds (Figure 2). The beds will then receive regular sludge applications and their performance will be determined over time by analysis of both the sludge and the leachate in order to determine the end quality of the sludge and potential for the beds to retain contaminants.

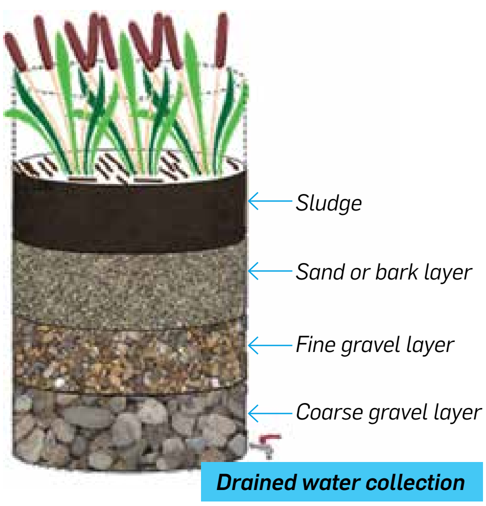

Figure 2. Schematic of the pilot scale sludge drying beds adapted from Stefanakis and Tsihrintzis, 2012.

Figure 1. Establishment of the plant tolerance phase of the sludge drying bed project on site at the wastewater treatment plant in Gisborne. Wetland species have been planted into both sand and bark.

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Progress towards new guidelines for the beneficial use of biowastes in New Zealand

Nick Walmsley, Technical Manager, Water New Zealand

This project aims to provide national guidance on the beneficial use of biowastes and biowaste derived products on land in New Zealand. It recognises that we are slow to divert these potentially useful materials away from landfill and on to land to boost productivity. The new guidelines are based on updating the 2003 Biosolids Guidelines and include other biowaste material and combinations that exist in the market place. Some of these products have science based regulations, some do not and some of the guidelines are outdated. This new guideline will supercede, update or cross-reference to existing guidelines and standards and provide a nationwide approach to enable the beneficial use of all types and combinations of biowaste products.

Water New Zealand, CIBR, WasteMINZ and the New Zealand Land Treatment Collective (NZLTC) are leading the project to develop a framework that recognises commonalities of different organic waste materials and describes quality criteria for beneficial reuse that will increase knowledge and streamline regulatory processes.

A Steering Group has been formed comprising members of the four key partners noted above together with MfE, MPI, MoH, Watercare and an environmentalist. Water New Zealand is programme manager.

The initial phases of this innovative approach have included national surveys of stakeholder viewpoints, consents issued and summary reports of scientific knowledge on pathogens, chemical contaminants and nitrogen effects. A summary of the review findings and current views of the Steering Group are listed below. This information is supporting the drafting of new biowaste guidelines for industry review and then finalisation as nationally agreed guidelines later this year.

Stakeholder Views

This survey documented views from stakeholder interviews selected to cover major interests across the biowaste industry. The survey suggested a need for approaches that are protective and restrictive, as well as flexible and enabling of innovation and good practice. Several important safeguards were preferred:

- The ability to discriminate between different streams of organic waste in the guidelines and to certify against these;
- The protection of New Zealand's entry into international export markets, avoiding food chain implications and ensuring good traceability;
- The implementation and auditing of a Qualmark certification framework for quality control and monitoring.

Existing Resource Consent Conditions

Every regional council was contacted and asked to provide conditions for consents granted for the land application of sludges, biosolids and composts or any other organic wastes in the last 10 years. Each council was asked to provide 4 – 6 resource consent conditions for a range of consents. Each set of conditions was then systematically analysed to answer six key questions:

1. What were the conditions with respect to nitrogen and contaminant limits?
2. Was there any monitoring? If so, what?
3. How do the consent conditions conflict with the biosolids guidelines? Is there any justification?
4. Are there any site management conditions?
5. What information do the councils use to make decisions about other wastes?
6. Apart from biosolids, what other organic wastes are commonly applied to land?

A total of 45 consents were reported on and the following was concluded.

- 31 consents included human wastes, of which 19 also included wastes for product manufacture (processing);
- The NZ Biosolids Guidelines 2003 were sometimes being used inappropriately;
- Wastes included could be categorised into 13 groups; and
- Documents referenced varied across 10 different national and international guidelines (excluding Regional Plans).

Wastes included were:

– Biosolids	– Horticulture wastes
– Boiler ash	– Meat works solids
– Cow manure	– Mushroom compost
– Dairy wastes	– Pulp and paper wastes
– Fish and animal waste	– Septage
– Fruit and vegetable wastes	– Winery wastes
– Grease trap solids	

Reference Documents (excluding Regional Plans) were:

– ANZECC Guidelines 2000	– NZS4454:2005
– Canadian Environmental Quality Guide	– Petroleum Hydrocarbon Guidelines 1999
– DoH Guidelines 1992	– Standard Methods
– NES Soil Contaminants 2011	– USEPA Part 503
– NZ Biosolids Guidelines 2003	– USEPA Region 9 Guide 1999

Pathogen Science and Effects

This report summarises existing knowledge on potential pathogenic organisms in organic wastes, relative to the NZ Biosolids Guidelines, 2003 and recommended which pathogens should/should not be monitored. Following review, the Steering Group concluded:

- Both process and product testing should be maintained;
- Testing for *Campylobacter* should remain;
- A table matrix of industry waste referenced to what should be tested, for Grades A and B should be produced;
- Regrowth testing should occur, ideally at the distribution point;
- There was no justification for increasing product monitoring requirements for organic wastes that are not directly sold and/or handled by the public, e.g. Grade B products.
- For sites where Grade B products are spread, soil testing for *E. coli* should be considered before lifting site restrictions to ensure there is no cumulative increase. This is in-line with the piggery guidelines but not universally accepted;
- Agricultural wastes such as animal manures should be at least isolated for six months before the land is released to the public and soil testing occur to check that background levels were achieved; and
- Monitoring of *Cryptosporidium* in Grade A biosolids is not required due to continued difficulties with measurements for viability/infectivity. There is justification for the continued inclusion of viral indicators in New Zealand guidelines.

Trace Element Contaminants

This report summarises existing knowledge on trace element contaminants in organic wastes, relative to the NZ Biosolids Guidelines, 2003 and review justification for nitrogen loading rates. Following reviews, the Steering Group concluded:

- Currently, biowaste application to land is mainly limited by its N content. However, while N is regulated on the basis of total N, only mineralised N can be taken up by plants. Therefore, the N application via biosolids is often insufficient for adequate plant growth; hence current guidelines are too restrictive for certain application scenarios;
- For the continual application of biosolids, nitrogen concentrations should not exceed current regulatory guidelines of 200 kg N / ha / year, whereas biosolids application to rebuild degraded soils should be limited based on a concentration of 150 kg / ha of mineral N;
- In most situations, using biosolids that do not meet Grade “a” trace element concentrations would not cause soil trace element concentrations to exceed internationally-recognised guideline values. Moreover, the threshold concentrations for trace elements in New Zealand’s Grade “a” biosolids are significantly lower than international values;
- In many cases, the addition of Zn and Cu to soil via biosolids could provide agronomic benefits to many New Zealand soils that are deficient in these essential micronutrients;
- The current trace element concentration thresholds for biosolids to be categorised as Grade “a” could be abandoned, while leaving in place current Grade “b” thresholds to prevent dumping of overly-toxic materials. This approach for the beneficial reuse of biowastes is consistent with the approaches used by fertiliser companies, e.g. the Tiered Fertiliser Management Strategy for cadmium, used by the New Zealand fertiliser industry;
- Home gardens are under different regulations so there is no need to soil test; and
- There is a need to engage with industry including regulators about the form of nitrogen to use in the guidelines.

Organic Contaminants

This report summarises existing knowledge on organic contaminants in organic wastes, relative to the NZ Biosolids Guidelines, 2003 and reviews which should be monitored. Following review, the Steering Group concluded:

- The organic contaminants listed in Table 4.2 of the NZ Biosolids Guidelines can be considered as obsolete;
- New contaminants should be considered; emerging organic contaminant (EOC) classes should include endocrine disruptors (e.g. steroids, nonylphenols), flame retardants (e.g. HBCD and selected PDBEs), antimicrobial agents (e.g. triclosan and ciprofloxacin) and pharmaceuticals (e.g. carbamazepine, diclofenac), persistent herbicide (clopyralid), and cleaning agent (LAS); and
- At this stage, there is not enough information to derive New Zealand specific limits but interim values could be used as suggested in the report. However, this is not definitive enough and further guidance is required cf the EU directive.

The reports are available for free download from the Water New Zealand website: www.waternz.org.nz

This work is being used to support proposed changes to allowable product contaminant concentrations, management protocols and their relationships with the raw material source used to manufacture the product, i.e. industrial or municipal sources. It also shows the importance of source control, not only for trade and commercial discharge limits, but also to educate the community on what is safe to reuse.

The Steering Group welcome your feedback – please contact:
Nick Walmsley, Technical Manager, Water New Zealand,
Tel: +64 4 472 8925, Email: technical@waternz.org.nz

CIBR Ecotoxicology update

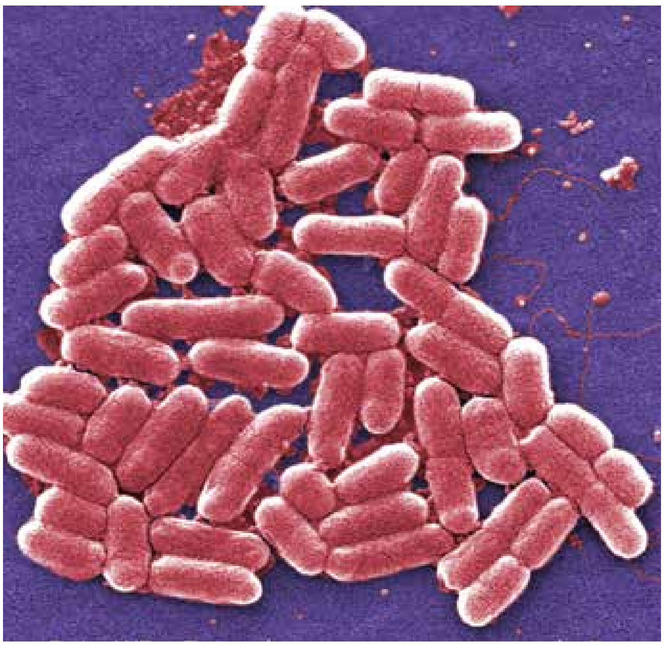
Jo Cavanagh

Well, it’s all been go with getting our process for fractionating extracts of biosolids to aid in identifying key contaminants of concern. As a first step we needed to determine whether the clean-up process influenced the observed toxicity. To do this, Grant Northcott (Northcott Consultants) extracted multiple samples of a biosolid to run through different clean-up processes. These samples were then run through a series of *in vitro* assays by the Landcare Research team (Kat Trought, Caroline Mitchell, Jo Cavanagh) with the results indicating that different clean-up processes did influence the observed toxicity. This enabled the selection of a clean-up method to best match maximal toxicity with analytical chemistry requirements. Grant is currently developing the fractionation process using high-volume HPLC and a series of standards to determine elution times, and thus collection times, of key contaminant groups.

The Landcare Research team are looking forward to participating in an international interlab comparison on thyroid dysfunction assays, with samples due to arrive in March. We are also commencing some molecular work with earthworms with collaborators from Massey University and China, initially to provide a baseline sequence for adults and juveniles of our common test species *Eisenia andrei*. We are currently seeking additional funding to enable this work to further progress and assess the genetic response of worms to exposure to different contaminants to provide a rapid means of assessing the full range of responses.

At Scion the focus has been method development for the extraction of acidic pharmaceuticals from biosolids, including, the commissioning of a new solid phase extraction (SPE) unit. B.Sc. student Letitia Hansen is leading the charge, ably supervised by Gerty Geilen and Grant Northcott. Gerty also presented at the recent Land Treatment Collective workshop on the seasonality of nutrient leaching of effluent application for which she won best technical paper jointly with Rebecca Stott. As usual, Marie Dennis was the force behind ensuring the LTC conference went smoothly.

At Cawthron the focus has been getting the zebrafish fetal embryo test up and running. Louis Tremblay has also been leading the organisation of 2015 SETAC Australasia conference supported by a conference organising committee including Marie Dennis and Jo Cavanagh. The conference is being held in Nelson 25 – 28 August and we look forward to seeing you there!



Escherichia coli – the indicator bacteria used to detect and estimate the presence of pathogenic microorganisms. *Photo: CDC*

UPDATE FROM THE SOIL SCIENCE TEAM

Repeated biosolids application continued improved tree growth of radiata pine plantation at Rabbit Island

By Jianming Xue

The CIBR soil science team has been conducting research on the environmental and ecological impacts of long-term application of biosolids to a radiata pine plantation at Rabbit Island. The research aims to develop sustainable land application of biosolids for the Nelson and Tasman communities, and provides indicative research findings for land application of biosolids throughout New Zealand.

Beneficial use 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 to agricultural land because it can reduce the risk of contaminants entering the human food chain and it can also increase tree growth and subsequent economic returns. Treated biosolids from the Nelson Regional Sewage Treatment Plant have been applied to a 1000-ha radiata pine forest plantation at Rabbit Island near Nelson City since 1996. A research trial was established on the site in 1997 to investigate the long-term effects of biosolids application on soil and groundwater quality, tree nutrition and growth. Biosolids have been applied to the trial site 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, groundwater quality quarterly and soil properties every three years to determine both the risks and benefits and sustainable application rates as well. The latest foliage sampling and growth measurement of radiata pine at the Rabbit Island biosolids research trial were completed in Feb 2013 and July 2014, respectively (Fig. 1). Here we update our recent findings on the impact of repeated biosolids application on tree nutrition and stem volume growth.

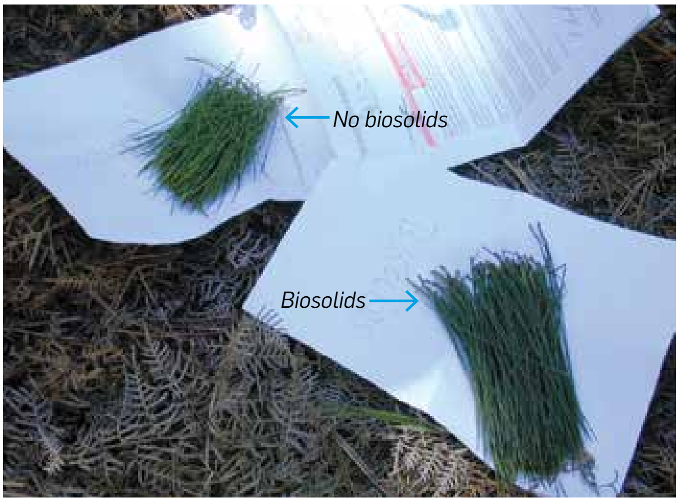


Figure 1. Effect of long-term biosolids application on needle (left) and tree (right) growth of radiata pine at Rabbit Island in Nelson

Foliar nutrient concentration means of treatment in 2013 are shown in Table 1. Biosolids application significantly increased foliar N and B concentrations, but the High treatment reduced foliar Ca concentration, which might be caused by growth dilution. In the Control treatment, foliar concentrations of all nutrients except N and Cu were in the "satisfactory" range of tree nutrition, indicating N was the main limiting nutrient for tree growth.

Table 1: Effect of biosolids application on foliar nutrient concentrations in March 2013.*

Treatment	N	P	K	Ca	Mg	Zn	Cu	B	Fe	Mn
	%					mg kg^{-1}				
Control	1.22 a	0.15 a	0.79 a	0.14 a	0.16 a	30 a	3.1 a	20 a	40 a	196 a
Standard	1.42 b	0.14 a	0.78 a	0.15 a	0.17 a	31 a	5.3 a	25 b	41 a	187 a
High	1.48 b	0.13 a	0.75 a	0.11 b	0.16 a	29 a	2.8 a	26 b	41 a	175 a

**Values within a column followed by the same letter do not differ significantly (P = 0.05).*

Foliar analysis has consistently shown that natural soil N supply in the Rabbit Island radiata pine was low, with foliar N concentration of the Control treatment (averaging 1.2% N) remaining consistently well below the satisfactory level of 1.5% N since monitoring began in March 1998 (Fig. 2, left). This indicates that without biosolids application, the radiata pine stand suffered from N deficiency and should benefit from N fertilisation. Overall, biosolids application significantly ($P < 0.05$) increased foliar N concentration of the Standard treatment to a marginal level (averaging 1.4% N) and the High treatment to a sufficiency level (averaging 1.5% N) (Fig. 2, left).

Successive applications of biosolids have produced a consistently positive response in foliar N concentration in the subsequent assessment when compared with Control trees (Fig. 2, left). The boost in foliar N generally declined over a period of several years following an application. However, this pattern was not so obvious during the period of last two applications. This could imply that the biosolids-derived residual N in the soil might become more influential than the freshly applied biosolids N on foliar N concentration. Following the 2012 application, foliar N concentrations in the Standard and High treatments were 0.21 and 0.26 percentage points respectively greater than the Control (Fig. 2, left).

As a result of improved N nutrition, application of biosolids significantly increased tree diameters (not shown) and consequently tree stem volume since the first biosolids application in 1997 (Fig. 2, right) of radiata pine. Stem volume remained significantly greater in plots with biosolids applied than those with no biosolids application.

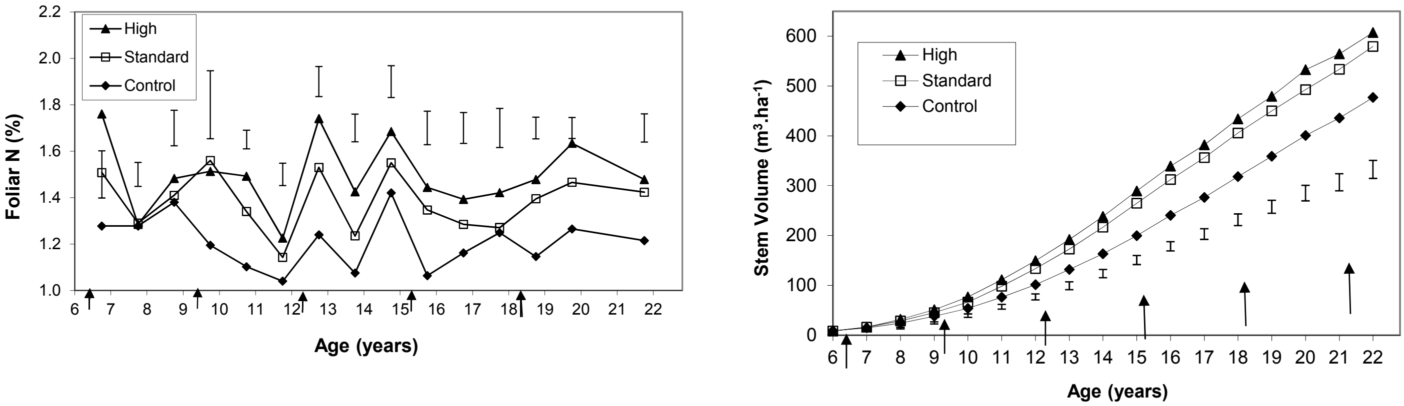


Figure 2. Cumulative effect of five biosolids applications on foliar N concentration (left) and tree stem volume (right). Arrows indicate time of biosolids application. Error bars show least significant differences ($P < 0.05$) for comparisons among the treatments.

In 2014, at tree age 23 years, stem volume of the High treatment (658 m^3 ha^{-1}) was 26% greater than the Control (523 m^3 ha^{-1}), and stem volume of the Standard treatment (632 m^3 ha^{-1}) was 21% greater than the Control, indicating a substantial gain in productivity.

We concluded that repeated application of biosolids to a plantation forest on a poor site could significantly improve soil fertility, tree nutrition and site productivity without causing significant adverse impact on the environment. Further monitoring is warranted to assess the long-term fate of biosolids-derived heavy metals in the receiving environment.

Extracting pharmaceuticals from environmental waste

In November 2014, University of Waikato student Letitia Hansen began a six month placement with Scion (in Rotorua) and Northcott Research Consultants (NRC Ltd) at Plant and Food Research in Ruakura, as part of her Bachelor of Science (Technology) degree. This project was made possible by funding from CIBR's Incubator Fund and is supervised by Gerty Gielen (Scion) and Grant Northcott (NRC Ltd). Letitia's project involves optimising the extraction of selected pharmaceuticals from biosolids.

Pharmaceuticals are an emerging class of organic contaminants, along with flame retardants, personal care chemicals, medications and agri-chemicals. Many of these are not completely removed during the sewage treatment process and as a result, found in sewage sludge and biosolids.

The complex matrix comprising sewage sludge and biosolids present a significant challenge to scientists attempting to determine the exact quantity of pharmaceuticals present and therefore what effects they may be having on the environment. Scion's newly acquired solid phase extraction (SPE) technology is capable of extracting trace concentrations of organic contaminants from very complex environmental samples such as grey water, sewage effluent, river water, solids and recycled materials. Extracted compounds can then be further analysed using gas or liquid mass spectrometry.

Letitia will be comparing various techniques for the extraction of pharmaceuticals from biosolids at both Scion and Plant and Food Research. These techniques include Soxhlet extraction, solvent ultra-sonication and accelerated solvent extraction. The pharmaceuticals of interest are mainly acidic and range from painkillers to hormones, plasticisers to anti-depressants.

Scion's SPE system will then be used to recover the target pharmaceuticals from raw solvent extracts for subsequent purification and analysis by gas chromatography mass-spectrometry. The successful conclusion of this project will provide an expanded analytical capability within CIBR to support on-going research on the fate and effects of emerging organic contaminants in biosolids and biowastes.

Ecotoxicology and chemistry conference

Many members of CIBR are coordinating a Society for Environmental Toxicology and Chemistry (SETAC) Australasian chapter conference in Nelson this year. The conference is likely to attract 200 delegates from New Zealand, Australia and around the world to Nelson for the week. The ambitious theme is 'System Approach to Environmental Management' and recognises the continuity of environmental processes in space and time, a concept that can enable us to better manage the environment and develop more sustainable solutions. It is well aligned with CIBR's research role in the sustainable management of biowastes. CIBR will coordinate a session at the conference entitled "System approaches to sustainable biowastes management" co-chaired by Jacqui Horswell and Lisa Langer. For more information visit: http://www.setac2015.org.nz/.

Louis Tremblay, *Conference chair*

SETAC
Australasia
Nelson 2015
25 to 28 August

Conference 25–28 August, 2015. Rutherford Hotel, Nelson

NEW ZEALAND LAND TREATMENT COLLECTIVE ANNUAL CONFERENCE 2015 "BEST TECHNICAL PAPER"

Effect of rainfall and temperature on catchment scale nutrient removal in the Rotorua land application system

Gerty Gielen

Treated sewage effluent from the Rotorua Sewage Treatment Plant has been irrigated onto Whakarewarewa Forest since October 1991. Every day, an average of 19,000 m³ of sewage from Rotorua undergoes activated sludge treatment. The final treated effluent is pumped to holding ponds in the forest and from there is irrigated nominally onto 193 ha of forested land within the Waipa stream catchment. Scattered throughout the catchment are 47 ha of wetland that filter water draining the catchment before it enters the Waipa stream.

The performance of this effluent irrigation scheme is monitored frequently for resource consenting purposes and because any nutrients leached into the Waipa Stream will then likely be transported into Lake Rotorua. Historically, Lake Rotorua has been prone to periods of poor water quality resulting in eutrophication and algal blooms although in recent years, algal blooms have been less frequent in Lake Rotorua.

Initially, nutrient removal in the system was high. After the first four to five years, soil storage of nitrogen was declining, as was evident from the increase in nitrogen leached from the catchment (Figure 1). Phosphorus was predominantly retained in the top 20 cm of the allophanic soil (Figure 2). After these initial years, the nitrogen stream export reached some form of equilibrium although seasonal and annual variability occurred. The nutrient stream export and removal efficiencies were correlated to rainfall and daily temperatures. This indicated that the site water flux is an important determinant of the overall nutrient removal efficiency of a land treatment scheme.

Nitrogen was predominantly exported as nitrate and some organic N, but almost no ammonium. Nitrate export is related to rainfall and in dry years the land application system appears to be performing better than in wetter years. This would be useful to keep in mind when assessing treatment performance and setting resource consent conditions.

The majority of total oxidised-nitrogen (Total Ox N, ie nitrite + nitrate) (TOxN) was exported to the stream between June and November. Therefore, by decreasing irrigation during this period, the mass of TOxN export via the stream would decrease in favour of temporary soil storage during drier periods.

In terms of improving effluent irrigation management, there are advantages to irrigating small volumes more frequently and decreasing irrigation volumes during wet/cold periods of the year. This will also decrease the period of time that soils will be saturated and thus will improve aeration of these soils.

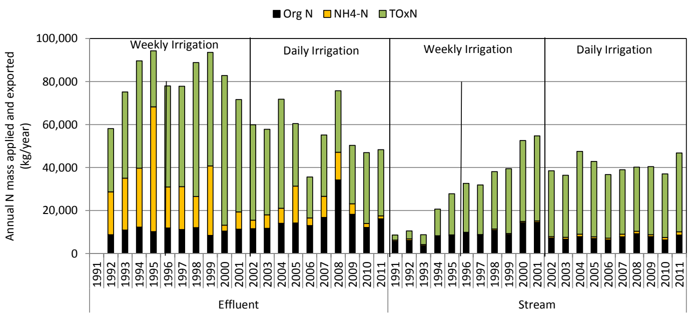


Figure 1

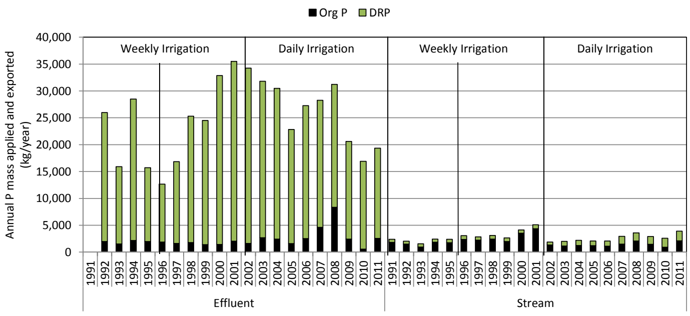


Figure 2

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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