Issue No. 20 June 2019

Putting waste to work

A CENTRE FOR INTEGRATED BIOWASTE RESEARCH PUBLICATION

Centre for Integrated Biowaste Research

www.cibr.org.nz

INSIDE THIS ISSUE

UPDATE FROM THE PROGRAMME MANAGER

Tēnā koutou,

The recent events that tried to break our peaceful community in Ōtautahi (Christchurch) have darkened our last weeks. Fifty people lost their lives, victims of extremism, hate, and intolerance. As Environmental Scientists, and according to nature's teachings, the CIBR team embraces diversity and complexity in order to build strong and resilient environmental systems in the future. The rise of the Ōtautahi community to defend diversity, tolerance and understanding is a powerful demonstration of hope.

Prior to these events and during, the CIBR team has been working hard to pursue our goal of a NZ without biowaste. Eighteen CIBR members participated in the Annual Planning Workshop on 18 February, discussing research that we consider necessary for a future NZ where all biowaste is beneficially reused with optimal ecological, social, and cultural outcomes. The continuous production of new chemicals, and subsequent release into the environment is one of the main concerns for the reuse of biowaste, and for environmental management in general. Our Ecotoxicology team is now working with overseas partners to develop a framework for managing these contaminants in Australasia (page 8).

Wastewater will become an important resource in the future. In climate change scenarios, where there is less continuous or predictable water availability, wastewater will rise as an alternative water resource, as it is a current reality in many countries exposed to droughts. Finding the best ways for treating and reusing the wastewater to minimise potential risks for people and the environment will be one of the priorities for CIBR. The reuse of wastewater, into native vegetation has been a strong research line of CIBR's, which has been very well received by NZ society, in the light of the multiple projects that are supported by communities, councils and companies (see pages 2 and 6).

Special attention will be paid to other types of biowaste, which are produced in high quantities in NZ, and whose potential benefits and risks are similar to those identified for human waste. The data regarding organic waste produced in industry is not readily accessible. However, given the size of the livestock and forestry industries in NZ, it is likely the production of biowaste from those industries will be much higher than human waste production. The population of livestock in 2017 was almost 40 million, including sheep, cattle and deer, in contrast with the almost 5 million people censused in 2018. Forestry is 3% of New Zealand's GDP, covering an area 1.751 million hectares – about 7% – of New Zealand's land area. Although a high producer of biowaste, forestry has also been the main industry benefiting from biowaste land application, as CIBR has been demonstrating in the last 20 years (see page 3).

All these research lines are underpinned by a strong Social and Cultural team, who ensure that the research recognises and responds to the needs, expectations, and values of New Zealand's multi-cultural society. The team has been working on an educational model that better represents the Māori worldviews and values for interpersonal relationships and with the environment. Go to page 4 for updates.

Ngā mihi nui,
Maria

THE POT AT LEVIN PART OF A NATIONWIDE STUDY *Jacqui Horswell, Maria Gutierrez Gines and Brett Robinson*

Two native NZ plants, mānuka and kānuka could soon join the battle to improve New Zealand's freshwater quality.

Scientists from the Centre for Integrated Biowaste Research (CIBR) are two years into a nationwide study to investigate the native trees ability to filter out freshwater harming nutrients and pathogens.

'The Pot' at Levin is the latest field site to be planted with an mānuka, kānuka dominated ecosystem. Other field sites include a plots of land on the shores of Lake Waikare, Lake Wairarapa, and Duvauchelle.

Lake Waikere: 4 ha of mānuka dominated ecosystems planted at Lake Waikare, in the Waikato in collaboration with Waikato River Authority, Waikato Regional Council, Ngā Muka, and Nikau Trust Farm.

Lake Wairarapa: Planting in the Wairarapa Moana in collaboration with farm owners, Greater Wellington Regional Council, and Ngāsti Kahungunu ki Wairarapa.

Duvauchelle: the trial at Duvauchelle in year 1 (left) and year 3 (right), in collaboration with Christchurch City Council.

Funded by the Freshwater Improvement Fund from the Ministry for the Environment, and Horowhenua District Council, a 10 hectare trial at The Pot is underway. Mānuka, kānuka and 12 other NZ-native species have replaced radiata pine at the Pot and over the next five years the team will investigate if this special plant can enhance the land treatment of wastewater.

Over the last six months, >70,000 native trees have been planted at the site and over 350 soil samples have been taken. The soil sampling at this early stage will give the scientists a baseline to compare against once the trial is finished. The natives largely consist of mānuka and kānuka, but also include more than 20 other native species. The planting has been undertaken in a specially designed way to allow the scientists to compare the different species, with measurements of growth and drainage water.

Base-line sampling before the pine trees were harvested
Planting of the native trees by local iwi, council members and the CIBR team

Next was the installation of specialised scientific equipment, water flux meters, that will measure the drainage water flow around the roots of the mānuka, kānuka and other plants. This will ultimately tell us what happens to different contaminants in the wastewater as they interact with the root systems of the plants.

Picture of the soil flux meters that will be installed at The Pot trial site.

Alexandra Meister and Brett Robinson installing a Water Flux Meter in the Pot experimental site

The hope for this site is that the native ecosystem approach will significantly reduce contaminant leaching and will enhance biodiversity, protect vulnerable soils and improve water quality in the Waiwiri catchment.

APPLICATION OF BIOSOLIDS ON PLANTATION FOREST – A GROWING OPTION FOR NEW ZEALAND'S TREE FARMERS

Jianming Xue (Soil Science Group Leader)

BACKGROUND

New Zealand forests are a resource that really enhance the quality of life of her citizens. Our forests are a source of income – from timber harvesting to a variety of forest-related products. This Government has a bold and ambitious vision for our forestry sector to create sustainable jobs, diversify our economy and catalyse new opportunities in regional New Zealand. Forestry is a major employer in regional New Zealand and contributes around $6.4 billion a year to our economy in export earnings (June 2018). Maybe more importantly, forests protect our streams and soils from runoff and help clean the air we breathe and the water we drink.

Forests are also at the centre of New Zealand's climate change response efforts, and forestry is New Zealand's largest potential carbon sink. The Government has set a goal to plant one billion trees by 2028. The One Billion Trees Programme will deliver improved social, environmental, and economic outcomes for New Zealand.

In order for New Zealand to realise the considerable opportunities offered by planting forests on marginal land, improved technologies and integrated management practices are needed to enable forest growers to earn money from environmental services, such as carbon sequestration. The marginal land has several biophysical constraints with poor soil as one of main constraints. There is an opportunity to improve forest growth through the application of organic waste high in nutrients such as biosolids and enhance soil organic matter content along the way.

Application of biosolids to forests is recognized as an effective method of fertilisation and soil conditioning. Biosolids can improve soil fertility, enhance tree health and growth, and improve wildlife habitat. When best management practices (BMP) are used, research shows that biosolids can help protect water quality. Based on research from CIBR/Scion, the plantation of pine forests is particularly well suited to land application of biosolids.

WHAT ARE BIOSOLIDS AND WHERE DO THEY COME FROM?

The Resource Management Act 1991 requires communities to treat their wastewater and return this resource safely to the environment.

Biosolids are the nutrient-rich organic materials resulting from the treatment of municipal wastewater. At municipal water reclamation facilities throughout the country, incoming streams are monitored and regulated to ensure that wastewater generated by businesses is compatible with the municipal treatment process. Today, municipalities provide additional safeguards through small business and household education programs, treatment plant controls and source control regulations.

Once the wastewater reaches the plant, the sewage goes through physical, chemical and biological processes that clean the wastewater and remove solids. Water is then removed. The solids collected must undergo additional treatment to meet regulatory requirements that protect public health and the environment. The result is an organic material that can be used on farms and forests.

Approximately 320 000 wet tonnes of biosolids are currently produced by municipal wastewater treatment plants across New Zealand.

WHAT DO WE DO WITH BIOSOLIDS IN NEW ZEALAND?

Currently, most local authorities put biosolids in landfills, largely because of the perceived and real uncertainties about the risks of alternative disposal methods.

A national survey commissioned by the Australian and New Zealand Biosolids Partnership in 2015 showed that 61% of biosolids produced in major wastewater treatment plants in New Zealand end up in landfill or monofill (a type of landfill where only one product is disposed of) – only around 17 % is re-applied to land. In contrast, only four percent of biosolids from major Australian wastewater treatment plants end up in landfill. Over half of Australian biosolids are used in agriculture, with a further 10 percent composted, and one percent applied in forestry.

WHAT ARE THE CHALLENGES OF RE-USING BIOSOLIDS?

Biosolids are carbon-rich and generally contains high concentrations of valuable nutrients that, if properly treated and/or processed, can become a sustainable soil conditioner with the potential to provide valuable physical (e.g. increased water holding capacity), biological (e.g. beneficial organisms) and chemical (e.g. essential elements and plant nutrients) attributes. However, the beneficial reuse of biosolids on land in New Zealand is low when compared to the other parts of the world.

Concern about the potential negative effect of biosolid application arising from the presence of pharmaceuticals and other organic contaminants in the biosolids is a barrier to facilitating further beneficial reuse.

The level and nature of contamination in biosolids varies, and our knowledge of contaminant bioavailability and contamination potential is still evolving. Biosolids may contain potentially toxic or eco-toxic substances, which require careful management.

CIBR can help local government agencies and their communities to consider the options, enabling them to decide on the best solution for their situation.

BIOSOLIDS AND FORESTRY – A BENEFICIAL CONNECTION

Biosolids are a good source of nutrients since they act as a slow release fertilizer that supplies most of the essential elements needed to increase tree growth, including nitrogen and phosphorus. In New Zealand, application of biosolids onto forest land is often preferred to on agricultural land because the biosolids can increase tree growth and subsequent economic returns without the risk of contaminants entering the human food chain. The benefits of biosolids application on forest land include:

- Improved tree nutrition
- Increased tree size
- Increased economic return
- Maintained soil and ground water quality

Additionally, the cost of commercial fertiliser has increased dramatically, making the cost savings of biosolids significant to private tree farmers. According to Dr Jianming Xue of CIBR/Scion, the application of biosolids to plantation pine forest has been gradually increasing mainly because of considerable economic return.

"The growth of most pine stands in New Zealand is limited to some extent by the availability of nitrogen and phosphorous," said Dr Xue. "Large radiata pine forests at Rabbit Island and Woodhill are well suited to the land application of biosolids since most of these forests grow on nutrient deficient soils and will grow better if fertilised. Nutrient uptake by tree roots in the soil is rapid which decreases the potential for runoff." He said that research shows that exotic tree species grow faster when applied with biosolids. While some respond dramatically, others (e.g. native species) may show only a slight response.

Much like best management practices are used in silviculture to provide environmental benefits, BMPs are also used with a forestry biosolids application. Some of these include carefully selecting and designing application sites, maintaining buffers from waterways and developing and implementing a nutrient management plan.

FOR YOUR INFORMATION

Farmers and forestland owners who choose to use biosolids should be knowledgeable about the resource and should be prepared to talk with their neighbours. Because biosolids is a by-product of the wastewater treatment process, it has a certain "yuck" factor for some people. Additionally, the information contained on the Internet about biosolids can be scary, suspect and confusing. Because of this, and because of occasional temporary odours that occur during application, some people question the use of biosolids on farms and forests or in the production of soil amendments such as compost.

However, forest land owners at Rabbit Island in Nelson and Bottle Lake in Christchurch have been applying biosolids on their forests for decades. For them, the benefits are compelling – they have learned that biosolids are rich in nitrogen and other essential plant nutrients; they improve the quality of soils; and they are safe.

For more information on biosolids, interested foresters and forest land owners can visit the following websites.

http://cibr.org.nz/projects/rabbit-island/

http://www.nrsbu.govt.nz/services/bells-island-sewage-treatment-plant/rabbit-island-biosolids-programme/

https://www.waternz.org.nz/Folder?Action=View%20File&Folder_id=101&File=biosolids_guidelines.pdf

http://envirolink.govt.nz/assets/Envirolink/742-TSDC53-Best-management-practices-for-applying-biosolids-to-forests.pdf

SOCIAL AND CULTURAL TEAM UPDATE

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

As-Salaam-Alaikum

He parekura – he atua nui – he whārona awatea! Aue taukiri e!

Kei te haere tonu o mātou whakaaro aroha ki te hunga e pehitia ana e tēnei taumahatanga nui. Ka tūtira mai ngā iwi katoa – tātou tatou e!

Our hearts are with all the families, communities and whānau affected by the tragedy visited upon our Muslim brothers and sisters and whānau in Ōtautahi, Christchurch.

In the face of this huge and intense loss it is heartening to see an outpouring and upwelling of community-led responses from so many in Aotearoa. In the face of this horrific act, we can take strength from the processes of our nation coming together collectively to grieve and support those impacted. We have seen how, striving to connect meaningfully and honestly with each other, we have drawn collectively and intuitively upon the models of social and cultural responsiveness guided by our Tiriti-partners and grounded in our indigenous culture. For example, manaakitanga is a practice of welcoming, hosting and holding our relationships and connections with each other as well as upholding values of integrity, trust, sincerity and equity. We see manaakitanga in the coming together of people and communities, as well as in the work between different agencies and organisations to respectfully shape and plan the moments of national remembrance and prayer together that connect us across our multiple belief systems and the international social landscape of the internet. Manaakitanga is also enacted more spontaneously, as we've seen with our creative communities (and our creative selves) helping through waiata – the healing work of song and music.

The strength radiating from the collective response from Ōtautahi reflects a growing and dynamic expression of the models we are gifted from Te Ao Māori. It is timely to reflect on these models and how they inform our practice as researchers. We can see the importance of these outward expressions of aroha - love, support and kindness - for each other in our interactions with our colleagues and those we don't know so well in our wider communities. Known in the educational sector as 'culturally responsive pedagogies', the following interdependent systems are beginning to be recognised in our Aotearoa research and policy communities as fundamental in helping guide and shape good practice. These principles are:

- Manaakitanga (as above—hospitality, respect, and care for others);
- Whānaungatanga (Relationship, kinship, or a sense of family connection – built through shared experiences and working together to provide a sense of belonging. It develops as a result of kinship rights and obligations, which also serve to strengthen each member of the kin group. It also extends to others with whom one develops a close familial, friendship or reciprocal relationship. Can be considered as actively engaging in respectful working relationships with Māori);
- Ako (Ako is grounded in the principle of reciprocity and also recognises the cultural origins of people and that people should not be separated from their culture);
- Tino Rangatiratanga (Absolute sovereignty, the ability of self-determination, sovereignty, autonomy, self-government);
- Tangata Whenuatanga (Providing contexts for learning where the language, identity and culture of Māori are affirmed).

The responses of our nation and whānau to the recent tragic event in Ōtautahi show living examples of these principles emerging in many different ways within our communities. Our cultural frameworks guide our leadership and our abilities to respond collectively to crises; these frameworks and the knowledge gained from practices of Te Tiriti Partnership equip us as a nation to honour those who have been affected and address the current situation we are confronted by. We come together as a community united by our grief attempting to better understand and learn, in this case from a shocking act of violence, and to build better ways to ensure that we completely reject behaviours, attitudes and philosophies that feed and underpin a culture of inequality and hate.

Our people in Ōtautahi and from across our nation respond from a place of horrific and sudden loss; our hearts and thoughts are with all families who have lost their treasured loved ones. We are with you.

Rātou te hunga mate ki a rātou

Tātou te hunga ora ki a tātou

Tēnā koutou, tēnā koutou, tēnā tātou katoa.

Against this background of recent and extreme loss, our CIBR team, many of whom are Christchurch-based, are continuing their work to support the building of shared understandings around a 'knew' (innovative model based on traditional thinking) and evolving Pā Wānanga model of education. Te Pā o Rākaihautū is a special character school based in Ōtautahi, Christchurch. This Pā Wānanga (site of educational and community activities) is an intentional response to historical and contemporary injustices within our Treaty partnership, particularly in education. Facing the challenge of building new pathways of leadership, culturally responsive learning and education, Te Pā o Rākaihautū is also designing collective responses to a slower and less visible crisis of loss of life and diversity in our natural environments. Reclaiming and celebrating ancestral knowledge passed down, human connections with each other and the natural environment, mātauranga Māori in this instance is directed to supporting different ways of working toward an equitable and sustainable future, including youth leadership and innovation in science, industry and policy.

Understanding and supporting a kaitiakitanga-centred learning village: Our CIBR Social and Cultural research team has completed in-depth interviews and is now analysing the data and preparing for a feedback workshop with Te Pā. In this work we explore the Pā Wānanga model as an intentional design of culturally grounded educational models, fostering connection and whakapapa with whānau and whenua. The work with Te Pā will extend shared learnings of how this model works and will contribute to their designing an evaluation system to best support the aspirations and culturally responsive teaching and learning practices within the school.

Microplastics and culturally grounded innovation (AIM2): With Te Pā's guidance, the learnings from their Pā Wānanga educational model will be shared and extended in the new Microplastics (MP) project, a 5-year research programme funded by the MBIE Endeavour Research fund. This newly funded project is called AIM2: Assessing the Impacts of Microplastics on New Zealand's bioheritage systems, environments and ecoservices. The new microplastics/AIM2 project grows from the Cawthron-led Emerging Contaminants project, and is supported by many of our CIBR relationships and work over the years. This project aims to build new science knowledge within a dedicated kaupapa Māori aligned research stream. We focus on the interface of mātauranga Māori and western science models to support culturally grounded innovation and sustainable change, and explore ways to collectively practice kaitiakitanga, protection and stewardship of our environment.

Alan Leckie at Te Pā

Supporting kaitiakitanga-centred cleaning: Alan Leckie has led a study of the use of chemical cleaners and other chemical usage data with changes over time at Te Pā. The Pā Wānanga aims to maintain kaitiakitanga practices by using alternative eco-friendly cleaning products to reduce the use of harmful chemicals.

The primary focus of this study is to determine how efficacious alternative commercially produced and "home-made" eco-friendly cleaners are. Te Pā recently changed their cleaning service provider to one which only uses cleaners that have passed the Environmental Choice New Zealand certification. This is an eco-labelling scheme, which is a "voluntary method of environmental performance certification and labelling". (https:// environmentalchoice.org.nz/get-licensed/faqs/). A table of all cleaners used, past and present, was prepared for comparison. This showed differences between chemicals; how different their hazard ratings and disposal methods are; and demands and practices around storage and use of personal protective equipment when used by cleaning staff. Te Pā kitchen staff have produced and are using alternative cleaners in their kitchen, and at least one of these will be included in the tests against known pathogens.

Five cleaning products have been selected to enable ESR to consider testing standards that can be applied to determine whether they kill the pathogens being tested and hence, whether there is any pathogen risk from their use. From this research, new standards can be set for eco-friendly cleaning products.

We draw heavily on our indigenous knowledge, our leaders and systems to guide us through difficult times, to help us through our immediate and historic social hurts, and to better understand and prepare for the anticipated crises we face in our relationships with our natural environment.

Collaboration/Marsden EOI: Members of the CIBR Social and Cultural research team have also been collaborating with colleagues from Te Rū Rangahau: The Māori Research Laboratory, University of Canterbury (Professor Angus Macfarlane, Dr Richard Manning); Te Pā o Rākaihautū (Rangimarie Parata-Takurua) and SCION (Marie McCarthy) and have submitted an EOI to the Marsden Fund. This collaborative research proposes to investigate kaitiakitanga (environmental stewardship) within a Pā Wānanga context as a critical driver that underpins the advancement of its community, economic, social and educational aspirations. This Marsden Fund EOI builds off Ngā Pae o Te Māramatanga Kia Ārohi Kia Mārama; Scoping Excellence funding secured in 2017 as a collaboration between CIBR and Te Rū Rangahau.

Publications: James Ataria, in collaboration with Prof. Angus Macfarlane, Dr Richard Manning and other University of Canterbury Te Rū Rangahau: The Māori Research Laboratory academics, has contributed a chapter to an international peer reviewed book in the Cultural Studies of Science Education series. The book chapter, entitled Wetekia kia rere: The potential for place-conscious education approaches to reassure the Indigenization of science education in New Zealand settings, has been accepted and publication is imminent.

Persistence has been rewarded with a paper on a choice experiment application of household preferences when purchasing handwashing liquid soap conducted in 2016-2017 by Richard Yao, Lisa Langer, Alan Leckie and Louis Tremblay. The paper has been reviewed, revised and returned to the Journal of Cleaner Production. Fingers crossed for an acceptance for publication in the near future.

Alan Leckie at Te Pā

USING BIOSOLIDS TO ESTABLISH NATIVE ECOSYSTEMS ON DEGRADED LAND AND A NEW MULTI-SPECIES TRIAL

Robyn Simcock, Maria Gutierrez-Gines, Brett Robinson and Jo Cavanagh

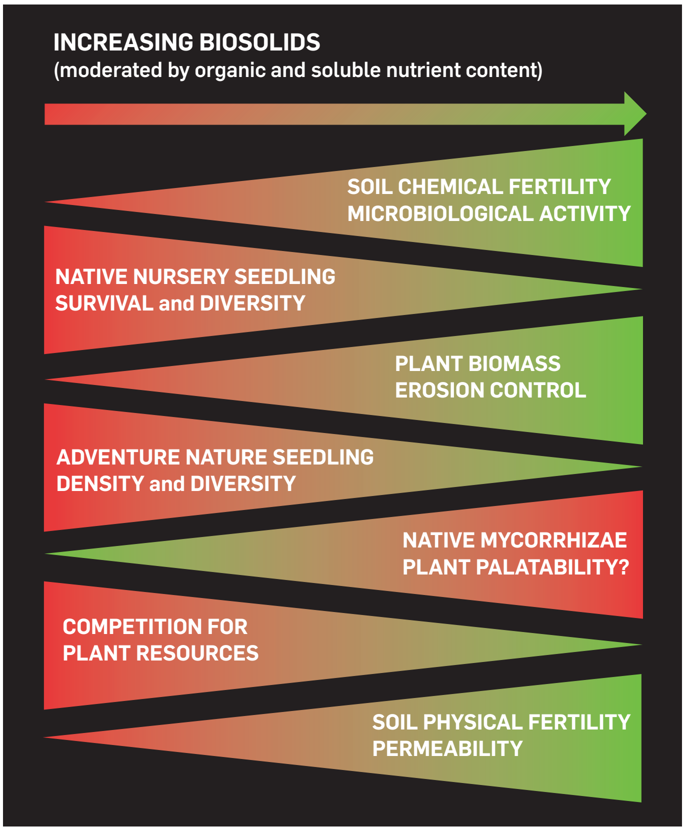
INTRODUCTION

Biosolids have been used to revegetate degraded lands for decades. Such land typically has biological, nutritional and/or physical limitations to plant growth due to erosion, contamination, topsoil removal, earthworks killing macro-soil fauna, dilution with subsoils and/or compaction. Organic-rich biowastes have multiple values for revegetation and ecosystem restoration in these degraded sites.

BIOSOLIDS FOR REHABILITATION OF MINED LAND TO PASTURE

In New Zealand, organic-rich municipal biowastes from Auckland and Hamilton have been used to revegetate degraded, mined land in Waikato with marked success. Rehabilitation of mined areas is limited by low organic matter, Nitrogen (N) and Phosphorus (P) levels because the root zone is mainly weathered ash subsoil that immobilises P. In the May 2016 CIBR newsletter, we reported one-off basal applications of 100 to 400 dry t/ha (at average 3% N) boosted pasture production at Rotowaro coal mine compared to conventional applications of mineral fertilisers. Benefits from these one-off, relatively high applications lasted at least 7 years, and reduced maintenance costs because the resulting pasture was dense enough to exclude weeds, and maintenance superphosphate fertilisers were not needed.

The trial showed this soil needed at least 100 dry t/ha of the tested biosolids to overcome all limitations for pasture growth and very high rates to significantly improve the soil's plant-available moisture storage. Incorporating 100 or 200 dry t biosolids/ha delivered soil copper (Cu) and zinc (Zn) concentrations at less than half of 'threshold' values specified by national guidelines. Earlier research at the same site showed a pulse of leached N followed biosolids application, but this was short-lived even in treatments with high total N applied. This result is typical of biosolids containing N mostly in organic form. The trial also showed resource consent processes need to take into account individual biowaste sources, as aged biosolids had much lower leachable N than 'fresh' biosolids, and application limits for N should therefore be based on leachable N, not total N, which is often regulated at 200 kg/ha/annum.



Summary of effects of increasing biosolids on native vegetation and ecosystems. Effects are unlikely to be linear, and will differ with biowaste and baseline soil characteristics.

Figure 1. Planting a biosolids trial plot, April 2019 – at least the drought had broken!

BIOSOLIDS FOR REHABILITATION OF DEGRADED LAND TO PLANTATION FORESTRY

Biosolids have also been used to rehabilitate mined land to plantation forestry in New Zealand. Here, growth limitations of mined lands are generally comparable to coastal plantations receiving municipal effluent. These coastal plantations are Raw Sands prone to wind erosion with low organic matter level, for example The Pot (Levin, 30 years of municipal effluent application with 10 ha of the pines planted in native species in 2018), Rabbit Island, (Nelson/Tasman) and Bottle Lake (Christchurch). On both raw dunes and mine sites, biosolids applications provide two primary benefits. First, biowastes help rapidly establish groundcover, usually pasture or cereals. Dense groundcover protects soils from erosion. Secondly, repeated applications of biowastes can supply the high nutrient demands of fast-growing plantation species, and in some cases may improve soil water storage (increasing drought resilience) and permeability (reducing runoff).

A case study in Waikato coalfields was reported in the March 2017 CIBR newsletter. Biosolids was spread at rates up to 600 kg/ha of total N in two years over 1 to 4-yr old pine seedlings but was not enough to overcome N limitation as identified by foliar analyses measured at canopy closure. Only one of the six replicate plots exceeded 1.5% foliar N, the threshold value below which radiata pine may benefit from fertilisation; Mean foliar %N was 1.40 ± 0.08 and total soil N 0.17 ± 0.02. The biowaste applications did overcome P limitation boosting Olsen P from 3 ± 1 mg/L to 19 ± 12 mg/L. This short term trial complements the long term, internationally important Rabbit Island study reported in CIBR newsletters (e.g. Issues 18 and 19, 2018). Here three rates of biowastes spread three-yearly from 1997 to 2012 has shown biosolids application increases tree productivity with minimum or negligible impact on timber quality, soil health or groundwater (Xue et al 2015). At Rabbit island and Rotowaro, competition between groundcover and trees has been controlled by herbicide or shading.

BIOSOLIDS AND NATIVE PLANTS

Biosolids are only starting to be used to support growth of native plants and native ecosystem rehabilitation in New Zealand. However, until about 2010 there have been few trials investigating NZ native plant and soil microbiome responses to biowastes. Applying biosolids should help protect, stabilize and rebuild degraded soils, as seen in pasture and plantation forestry sites. Using native plants generally avoids the risk contaminants associated with biowastes entering the human food chain, as few native plants are harvested for foods. Native woody plants also appear effective at limiting transfer of contaminants through an ecosystem – for example, when used to revegetate metalliferous mine tailings.

New Zealand's eighty million years of isolation has resulted in ancient and unique plants, animals, fungi and ecosystems with complex interrelationships adapted to soils that are generally acidic, chemically infertile and stable. All native tree and shrub species have symbiotic mycorrhizal associations, and these can enhance water and nutrient uptake (Davis et al 2013). Ectomycorrhizal associations allow mānuka, kānuka and beech to access N and P directly from organic sources (Williams et al 2011). They may also protect plants from fungal diseases. In most cases native plants are established by planting nursery-raised seedlings as native woody species are typically poorly represented in seed banks, viable native seed is not readily available in large quantities, and field germination is unreliable.

POT TRIALS

Pot trials have shown how common native plant species used in revegetation respond to different rates and types of biosolids in a variety of soils and mine wastes (Waterhouse et al 2014, Xue et al 2016, Reis et al 2017, Seyedalikhani et al 2019). These trials show native plants can grow adequately in soil considered infertile by agricultural measures of fertility. Slower growth rates than common 'control' species (ryegrass, oats or radiata pine) indicate native plants are typically less responsive to pulse of available nutrients supplied by biosolids. Further, a height and/or biomass growth response is usually linked to a decreased shoot: root ratio (Waterhouse et al 2014). A pot trial using urea showed eight common native revegetation species tolerated highly elevated N, from 200 to 1600 kg/ha, by assimilating N into foliage through 'luxury uptake' (Franklin 2014). Studies consistently show the native plant response depends on the severity of nutrient deficiency in the 'control' and availability of soluble N and P in biosolids. Hence anaerobically-digested biosolids with high NH4+ and low NO3- produces a greater growth response than a mature, stockpiled biosolids (Seyedalikhani et al 2019). Native plants generally show positive responses to biowaste additions when the control is impoverished to the extent that N or P supply is the primary factor constraining plant growth. For example, Reis et al (2017) reported a 40-fold increase in mānuka biomass grown in low-fertility sand amended with 90 t/ha fresh biosolids. Red tussock (*Chionochloa rubra*) growth doubled and mānuka growth significantly increased relative to control when grown in biosolids-amended, low-fertility mine soils (Waterhouse et al 2014). But kānuka (*Kunzea serotina*) grown in a 'low fertility soil' showed growth responses to additional N but not P (Dollery 2017). Further, a high rate (20% v/v) of nutrient-rich biosolids disrupted colonization of mānuka roots by arbuscular mycorrhizal fungi. However, pot trials with totara and mānuka using lower-strength, vermi-composted biowastes report no significant effect on Ecto- or Arbuscular- mycorrhizae (Jianming Xue, pers. comm.).

Some pot trials have also investigated the response of soil organisms to biowastes. Degraded soils typically have depleted soil invertebrates, due to less food (depleted organic carbon and reduced inputs from stressed plants), absence of leaf litter layers, poorer soil physical conditions and extremes of temperature and moisture. Effects are magnified by earthworks and soil stockpiling; large-bodied fauna such as earthworms, and fauna of leaf-litter are especially vulnerable. For example, earthworm numbers in rehabilitated Southland lignite pastures were less than 10% of the undisturbed soil in the first year, and exceptionally low where the topsoil and subsoil were mixed (Widdowson and McQueen, 1990). New Zealand has a highly diverse group over of 179 species of endemic earthworms. Waterhouse et al (2014) reported 100% mortality of native earthworms incubated in 20% v/v municipal biosolids; 42% in stockpiled soils and 25% in source topsoils. In contrast, Kim et al (2018) found survival of two native *Maoridrilus* species was not significantly different between treatments

Figure 2. Measuring a revegetated area at Stockton mine where nursery-raised native seedlings were planted in 1999 into stripped soils in the absence of biosolids. Growth rates are a relatively slow 5 to 7 cm p.a. Beech, flax (and toetoe) are in the foreground, rata and mānuka in the background (photo March 2019).

with 0, 6.25, 12.5, 25 and 50 % v/v biosolids, but worms lost weight with greatest weight losses in control, 25% and 50% v/v treatments. The next issue of CIBR newsletter will report trials where adding biosolids to toxic mine wastes allowed germination and growth of mānuka, and survival of earthworms and springtails.

FIELD TRIALS

Most degraded areas have non-native herbaceous and woody plants that compete with native species. Ineffective control of competing vegetation is a common reason for poor revegetation outcomes in New Zealand. Weeds smother above ground growth and compete below ground with native plants for nutrients and moisture. Most field trials establish native seedlings using forestry techniques; spot-sprays limit competition between slower-growing natives and faster-growing adventive species, for example, Duvauchelle (Robinson 2017) and 'The Pot' (Gutierrez-Gines 2018). This, and alternative methods are being tested at a new trial at Stockton mine where biosolids are mixed with overburden and soils at between 1:8 to 1:4 v/v before seeding non-native grasses to rapidly stabilise the soil against 4 to 5 m p.a. rainfalls, then planting native seedlings. Growth of native seedlings in soils without biosolids is slow (Figure 1).

The trial compares three methods of establishing nursery seedlings at four replicate sites from about 700 to 1000 m ASL. All have established grass and a few scattered native seedlings from original plantings (most seedlings were smothered). Tauhinu (*Ozothamnus leptophyllus*) and mānuka were planted at all sites. At the two higher altitude sites, rātā and mountain flax (Phormium cookianum) were planted (Figure 2). At lower-altitude sites these were replaced with silver beech (*Lophozonia menziesi*) and broadleaf (*Griselinia littoralis*). All plants were grown from propagules above 600 m ASL in the Ngakawau Ecological District. The establishment treatments are either pre-plant herbicide spot spray or no pre-plant spray, using either tall seedlings (300 to 500 mm, i.e. above grass height) or standard short seedlings.

A 'control' treatment is planting standard seedlings into areas with no pre-planting spot pray – this is the 'traditional' method that has had generally poor, inconsistent native plant survival. A second control is repeating the establishment treatments in adjacent areas where biosolids have not been applied. The trial will allow us to compare and contrast results of CIBR native revegetation trials in Levin's 'The Pot' and at Duvauchelle, as some treatments and native species are common to all sites. Stockton has the added advantage of having a range of temporal and spatial applications of biowastes, a high leaching regime that quickly 'ages' soils, and a native ecosystem 'baseline' that includes native earthworms.

REFERENCES

1. Davis M, Dickie IA, Paul T, Carswell F. 2013. Is kanuka and manuka establishment in grassland constrained by mycorrhizal abundance? *New Zealand Journal of Ecology 37*(2):172-177
2. Dollery R. 2017. Ecological Restoration of Dryland Kānuka Communities in an Irrigated Agricultural Landscape. PhD Thesis, Lincoln University
3. Franklin HM. 2014. The Interaction of New Zealand Native Plants with Nitrogen in Canterbury's Agricultural Landscapes. PhD Thesis, Lincoln University
4. Guierrez-Gines M. 2018. Manuka and kanuka for the land treatment of municipal wastewater – an update. *Putting Waste to Work* 17: 3
5. Kim Y-N, Robinson B, Horswell J, Boyer S, Dickinson N. 2017 Impacts of endemic Maoridrilus earthworms (Megascolecidae) in biosolids amended soil. *Journal of Environmental Quality* 46:177-184
6. Reis FVP. 2015. The response of manuka (*leptospermum scoparium*) to homogenous and heterogeneous distribution of biosolids in soil. B Sc (hons). Lincoln University
7. Robinson B. 2017. Final report (June 2017): a lysimeter experiment and field trial to determine options for the beneficial reuse of wastewater from Duvauchelle and Akaroa, Banks Peninsula.
8. Seyedalikhani S, Esperschetz J, Dickinson NM, Hofmann R, Breitmeyer J, Horswell J, Robinson BH. 2019. Biowastes to augment the essential oil production of *Leptospermum scoparium* and *Kunzea robusta* in a low-fertilty soil. *Plant Physiology and Biochemistry* 137:213-221
9. Simcock R, Cavanagh J. 2016. Underpinning a holistic biosolids business case for coal-mined pasture. *Putting Waste to Work* 15: 2
10. Simcock R, Xue J. 2017. Biosolids assist mine rehabilitation to plantation forestry. Putting Waste to Work 15:4-5.
11. Waterhouse BR, Boyer S, Adair KL, Wratten SD. 2014. Using municipal biosolids in ecological restoration: What is good for plants and soil may not be good for endemic earthworms. *Ecological Engineering* 70:414–421
12. Williams A, Ridgway HJ, Norton DA. 2011. Growth and competitiveness of the New Zealand tree species Podocarpus cunninghamii is reduced by ex-agricultural AMF but enhanced by forest AMF. *Soil Biology and Biochemistry* 43: 339–345.
13. Xue JM, Kimberley MO, Ross C, Gielen GJH, Tremblay L, Horswell J, Wang H. 2015. Ecological impacts of long-term application of biosolids to a radiata pine plantation. *Science of the Total Environment* 530-531: 233–240.

ECOTOX NEWS

DEVELOPING A JOINT AUSTRALIA- AOTEAROA (NEW ZEALAND) FRAMEWORK TO MANAGE POLLUTANTS IN AUSTRALASIA

Louis Tremblay[1, 2], Grant Northcott[3], Anu Kumar[4], Graham Sevicke-Jones[5], Virginia Baker[6], and James Ataria[1]

[1]Cawthron Institute, Nelson, [2]University of Auckland, [3]Northcott Research Consultants Limited, [4]Environmental Contaminant Mitigation and Biotechnology, CSIRO Land and Water, Australia, [5]Landcare Research, Wellington, [6]ESR, Wellington

The assessment and management of the risks associated with the presence of chemical contamination in our environment is challenging. CIBR scientists are involved in a range of research initiatives to investigate the fate, impacts, and risks of chemicals in receiving environments. The assessment processes to characterise the risk of the increasing number of chemicals produced each year requires substantial resources and capability with over 300 new chemicals registered globally every hour. This scientific assessment work accompanies the design of supporting tools and systems that can inform and support workable policy interventions across various jurisdictions and settings. These include environmental monitoring, retail, importing, industry compliance systems, and consumer behaviour change. As such, it is recognised that we need to work closely with international colleagues and experts, particularly those in Australia who are working closely on this issue.

There have been several previous initiatives to bring scientists and regulators together to address specific issues related to chemical contaminants. In the early 2000's, members of the Australasian Society for Ecotoxicology (now part of the Society of Environmental Toxicology and Chemistry (SETAC)) formed a special interest group to investigate endocrine disruption. This was followed up at a meeting at CSIRO's Black Mountain site in Canberra in 2007 to further formalise the need to better protect Australian aquatic ecosystems from the impacts of endocrine disrupting chemicals (EDCs). Many Australian and international researchers (including New Zealanders), policy makers, regulators, water suppliers and research scientists drafted "The Black Mountain Declaration on Endocrine Disrupting Chemicals in Australian Waters" (Land and Water Australia, 2007). The aim of this document was to recognise the need for on-going research and to raise policy attention and public awareness of the environmental impacts of endocrine disruption. This 2007 declaration was recently revisited at a workshop following the 'What's in Our Water' 2018 Symposium in Canberra. Hosted by Anu Kumar, members of CIBR were actively involved in the planning and running of the workshop, and contributions were provided by Grant Northcott, Jinny Baker, Graham Sevicke-Jones, Olga Pantos, Sally Gaw and other researchers and policy makers from New Zealand.

The workshop was entitled: "Safeguarding the health of Australasia's environments and people from the impacts of Micropollutants and Emerging Contaminants." We wanted to widen the scope from focussing solely on EDCs to address a broader range of environmental micropollutants and to acknowledge the social and cultural complexities that exist in addressing any issue. The objective of this initiative is to build an enduring partnership of Australasian environmental and policy experts to develop a framework, aligning with European Directives, and complementary resources to support ongoing work to assess and manage the risk micropollutants pose to our unique ecosystems and people. Recognising the complexity of this challenging issue, the approach that has been adopted draws on social sciences and inter/trans-disciplinary science approaches to guide the design of policy tools that are scientifically and socially robust.

We recognise that neither behaviour change, nor regulatory approaches are sufficient in themselves. 'Joined up' policy, industry and community partnership approaches are required to better manage the issue, in addition to the ongoing scientific research to better understand the chemicals and environmental interactions. As a result those participating in developing this initiative include chemists, toxicologists, social and Māori scientists, and environmental managers and policy makers from different levels of government that are experienced in developing guidelines and policies to sustainably manage environmental contaminants. The partnership with our Australian colleagues brings greater breadth and depth of experience to draw upon from both the science and policy sectors. These relationships lend support to the continued partnerships with key international groups and experts, and underpin the development of complimentary frameworks and tools. Concurrently this work seeks ways to involve local resources and indigenous knowledge and experiences towards robust assessment frameworks and the design of viable interventions and enduring outcomes. Building shared learning of the risks that micropollutants pose to our unique ecosystems and indigenous species is paramount to protecting our land and freshwater resources and realising a healthy environment, a healthy community and strong economy.

A follow up workshop is planned for the July 2019 SETAC Australasia conference in Darwin, Australia. We will continue to discuss options to develop a Trans-Tasman Framework to manage environmental contaminants predominating in Australasia with an emphasis on sharing processes, tools and approaches to facilitate robust policy design and the meaningful inclusion of local indigenous and community values specific to our regions.

Land and Water Australia. 2007. The Black Mountain Declaration on Endocrine Disrupting Chemicals in Australian Waters 2007, https://static1.squarespace.com/static/598a4b42ff7c50af8e873573/t/599a2a573e00be6b0e397606/1503275608356/Black+Mountain+declaration+with+style+final_July08.pdf

Figure 1. Participants at the What's in Our Water 2018 workshop in Canberra, Australia.

If you would like to subscribe to this newsletter please email izzie.alderton@esr.cri.nz with your contact details.

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

PROGRAMME MANAGER

Dr Maria Gutierrez Gines
ESR, Christchurch
27 Creyke Road, Ilam
Maria.Gutierrez-Gines@esr.cri.nz
Phone: (03) 351 6019

SOCIAL AND CULTURAL RESEARCH

Lisa Langer
Scion, Christchurch,
PO Box 29-237, Christchurch
Lisa.Langer@scionresearch.com
Phone (03) 364 2987 ext. 7204

SOIL SCIENCE

Dr Jianming Xue
Scion, Christchurch,
PO Box 29-237, Christchurch
Jianming.Xue@scionresearch.com
Phone (03) 364 2987 ext. 7826

ECOTOXICOLOGY

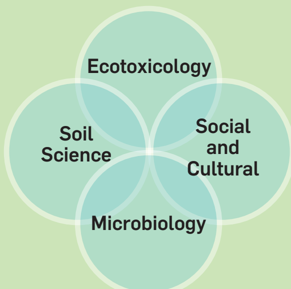
Dr Louis Tremblay
Cawthron Institute, Nelson,
98 Halifax Street, Nelson
Louis.Tremblay@cawthron.org.nz
Phone (03) 539 3290

MICROBIOLOGY

Dr Louise Weaver
ESR, Christchurch
27 Creyke Road, Ilam
Louise.Weaver@esr.cri.nz
Phone: (03) 351 6019

NEWSLETTER EDITOR

Izzie Alderton
ESR, Wellington
izzie.alderton@esr.cri.nz
Phone: (04) 914 0689



www.cibr.org.nz