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Putting waste to work

A CENTRE FOR INTEGRATED BIOWASTE RESEARCH PUBLICATION

Centre for Integrated Biowaste Research www.cibr.org.nz

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UPDATE FROM THE ACTING PROGRAMME MANAGER

10 ha of pine harvesting in 'The Pot' Levin. Photo: Hamish Lowe.

Tena koutou and welcome to our Winter newsletter. We are almost half way through 2018 and CIBR researchers are continuing to grow our knowledge for the beneficial and sustainable reuse and management of our biowaste. The CIBR team is very aware of the difficulties of these objectives, and has always advocated for long term research and solutions. In this newsletter, we present an update on three important long term programmes of biowaste research.

One of the best examples of the work that CIBR is undertaking to demonstrate how biosolids can be beneficially and sustainably reused is the amazing long-term experiment that the Soil Science group has been carrying out in Rabbit Island, Nelson. This 20-year full scale experiment for the use of biosolids in forestry will be a great legacy for CIBR in both national and international research about biowaste. This experiment is in its last stages, and the Soil Science team are collating and analysing the large amount of data created during the last two decades. Something as easy as collecting leaves can be very complicated when trees are 30 m high. Check how the scientists manage those tasks in page 4.

Although the Rabbit Island experiment is nearing completion, the experiment in The Pot (Levin) is just starting. The 10 ha of pine plantation has been harvested (pictured above), and this Winter the area will be replanted with 100,000 kānuka and 20 other NZ native trees. This native ecosystem will receive treated effluent from the Levin Wastewater Treatment Plant in a full scale experiment led by LEI, and is funded by Horowhenua District Council and the Freshwater Improvement Fund (MfE) (page 3).

Reduction in biowaste production and opportunities for their reuse involves a change in people's behaviours. These changes do not happen straightaway, and the Social Science team has demonstrated that long term programmes for exploring new ways of learning and behaving are possible. The team has been successful in obtaining research funds from Ngā Pae o Te Māramatanga to further explore the long term research that the team has carried out at Te Pā. A brief summary of the work done is presented in page 7.

The CIBR team is very pleased to have successful students. Congratulations to our future Dr. Olivier Laroche, who submitted his thesis *Investigating innovative technologies for assessing the ecotoxicity of emerging contaminants*. Oliver completed his PhD with the Ecotoxicology Team at Cawthron, to learn more turn to page 5.

Another student at ESR, Seinalyn Villanueva, presents "an educational outreach day" when a group of 25 students from Whanganui visited ESR to participate in hands on laboratory activities designed around greywater and microbial quality of greywater see more on page 2.

Finally, part of CIBR's commitments are to share our knowledge with the wider community and industry members working in the field of biowaste reuse. This year a number of CIBR members attended the Land Treatment Collective Annual Conference in Rotorua. An overview about the work presented is in page 6.

Ngā mihi nui
Maria Gutierrez Gines

EDUCATIONAL OUTREACH *Seinalyn Villanueva*

The CIBR Biowaste team engages in a number of educational outreach opportunities, partnering with schools to educate students on current environmental issues, such as greywater and reducing contaminants in biowaste. In May the ESR team (Vikki Ambrose, Izzy Alderton and Seinalyn Villanueva) hosted a school visit at the Kenepuru site from Whanganui City College. This trip was organised by The Partnership Through Collaboration Trust. The Trust is a not-for profit organisation set up to provide opportunities for practical hands-on training and development in science for youth who are traditionally underrepresented in the sciences. The students (from year 10 and year 12) participated in a number of activities designed to help them learn about greywater reuse and microbial analysis of greywater, which they could then use to help them with their own school project of building a functioning greywater system on the school grounds, using native plants for water filtration. The school are going to look at the effects of greywater on plant growth and health, using four varieties of native plant species – *Melicope ternata, Pseudopanax arboreus, Hebe elliptica var crassifolia and Kohekohe* (see photo below).

The day was split into three parts: an educational session and experimental design brainstorming for the student's project on plant health and greywater, followed by three practical laboratory activities, finishing with a site visit to a local property with a working greywater system. The hands-on laboratory activities were held in the microbiology laboratory, with the laboratory split into three separate activities.

School project native plant species.

Bay 2 small lysimeters and cow manure slurries! Photo Ramesh Ganesan.

Microbial analysis practical exercise for visiting students.

The activities were set up and organised so that each one followed on from the previous one. In Bay 1, led by Seinalyn Villanueva, students made up 'good' greywater using eco-friendly household products and 'bad' greywater using regular household products. The greywater recipes used were given to the students, for use in their greywater projects back at school. The greywater made in Bay 1 was then used in Bay 2's activity of planting small lysimeters with native plants, applying a cow manure slurry and then performing a rainfall event using the pre-made greywater followed by collection of the leachate, this was led by Vikki Ambrose (see photo below). The use of plants for filtration of water was discussed and how this could be implemented within the greywater system that the class were to build. This bay proved to be the messiest of the day! The leachate was to be taken to the activity in Bay 3, learning about the different types of microbial testing that can be done on leachate, soil and greywater. This bay was led by Izzy Alderton (see photo 3). The students learned about microbial tests that can be done out in the field and in the laboratory. One of which was the Colilert test which measures the levels of total coliforms and *Escherichia coli* present within a sample. Students each made up their own Colilert tests with the leachate from Bay 2 and were then shown what the results would be expected to look like using a pre-made sample. However as always things did not go to plan with the students and some improvisation was required between bays!

The last part of the school visit was a trip to a local residential property that had installed their own greywater system. The students learned about the different components of a greywater system, to give them ideas for their own system. The day was very busy but successful, and much was learned by the team for use in future hosting activities!

Bay 3 Microbial analysis. Photo Ramesh Ganesan.

MĀNUKA AND KĀNUKA FOR THE LAND-TREATMENT OF MUNICIPAL WASTEWATER – AN UPDATE *Maria J Gutierrez-Gines*

Baseline sampling at The Pot. From left: Charlotte Sitz, Izzy Alderton, Sky Halford and Vikki Ambrose (photo – Maria Gutierrez Gines).

The CIBR team at Lowe Environmental Impact (LEI), ESR, University of Canterbury and Northcott Research Consultants are running an exciting project studying the potential of mānuka and kānuka to reduce the impacts of land-application of treated effluent. For the last 30 years, treated municipal wastewater from the Levin wastewater treatment plant has been stored in a 7 ha effluent pond, and then irrigated over 40 ha of pine plantation. This land treatment system is locally referred to as "The Pot". This project funded by the Freshwater Improvement Fund and the Horowhenua District Council, seeks to convert 10 ha of pine plantation at The Pot, into the first full scale trial for treated effluent land-application on to NZ native vegetation (more details about the background of this project were explained in the Issue no. 16 October 2017).

In the six months since this project started, a vast amount of work has been completed. The 10 ha native vegetation ecosystem will be comprised of 60% mānuka and kānuka, with the remaining 40% a mixture of 17 other native species that naturally thrive in the region. The location of each of the species will respond to their natural habitat and the conditions of the plot (wet or dry areas, slope, neighbouring species, etc). The native ecosystem plot will be divided in areas which will receive non-effluent (control areas) and increasing rates of effluent irrigation (1000 mm/year, 2000 mm/year, 4000 mm/year).

The setting at The Pot, with areas of pine that have been irrigated with treated effluent over the last 30 years and areas that have received no irrigation, created an exceptional "natural experiment" to investigate the effects of long-term land application schemes. For this reason, in December 2017, the team conducted a large sampling campaign of the area. About 400 samples of soil were collected to cover the areas of pine plantation irrigated for 30 years, pine plantation non-irrigated, pasture irrigated, pasture non-irrigated, and an old kānuka stand as a control of native vegetation. Soil samples were collected at increasing depths down to 2 m, and are currently being analysed. The importance of this data is demonstrated by the co-funding received by ESR-Pioneer Fund to contribute to the chemical analysis.

At the moment, the pine plantation is being harvested, and the experimental plot will be ready for planting this winter.

The first meeting with the projects Governance group took place in early May. The projects Technical Group, with representatives from District and Regional Councils, Department of Conservation and local iwi will take place at the end of May.

Sarah Lowry (MfE), and two Mauopoku members (George and Dean) planted the first tree, a 'ceremonial' Totara, on the 6th of June 2018.

The Pot research team members include: ESR: Jacqui Horswell, Maria J Gutierrez-Gines, Vikki Ambrose, Sky Halford, Izzie Alderton, Charlotte Sitz. Northcott Research Associates: Grant Northcott, LEI: Sian Cass, Hamish Lowe, University of Canterbury: Brett Robinson.

UPDATE FROM THE SOIL SCIENCE TEAM

RABBIT ISLAND FOLIAGE SAMPLING AND UPDATE: WHY SAMPLE FOLIAGE? MONITORING THE RESIDUAL EFFECT OF APPLIED BIOSOLIDS ON TREE NUTRITION

Alan Leckie and Jianming Xue (Soil Science Group Leader)

BACKGROUND

Biosolids application to forestland enables the beneficial reuse of biosolids-derived nutrients and organic carbon (C) for improving soil fertility and forest productivity without the risk of contaminants entering the human food chain.

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 tree nutrition and growth, and soil and groundwater quality. 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 loading rate) and 600 (High loading rate) kg N per hectare.

WHY DO WE COLLECT FOLIAGE SAMPLES?

Tree nutritional status and growth were monitored for radiata pine in the Rabbit Island research trial annually from 1997-2012 and every 2 years afterwards. The latest foliage sampling at the research trial site was completed in April 2018, to further investigate the residual effect of applied biosolids on tree nutrition – i.e. the lasting effect of previously applied biosolids on the improvement of current tree nutritional status.

HOW DO WE COLLECT AND PREPARE FOLIAGE SAMPLES?

We have to sample the pine needles following Scion's protocol of foliage sampling.

- Correct time – Needle samples must be collected during the period of mid February to early April.
- Correct age class - current-year fully grown needles on the most recent second order branches in the top third of the crown (Fig. 1).
- Foliage samples should be collected from dominant or co-dominant trees.
- A minimum of 10 different trees per plot must be sampled.
- 150 fascicles (or 450 individual needles) that have not been subject to insect attack or obvious nutritional deficiencies are collected.
- Keep foliage samples in cool chilly bin and bring back to Scion's Veritec Lab.
- Dry samples in a forced-air oven at 70 °C for 72 hours, then ground to a fine powder using a laboratory mill.
- Samples are digested in a mixture of nitric acid and hydrogen peroxide and analysed by inductively coupled plasma optical emission spectroscopy (ICP-OES).

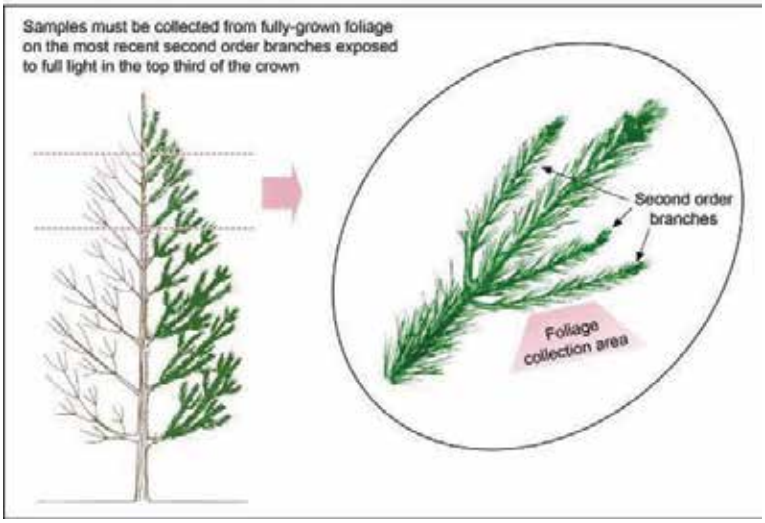

Fig. 1. For radiata pine and other needle-leaved conifers, collect mature length needles on the youngest second-order branches.

WHO DID FOLIAGE SAMPLING?

Scion's field crews for foliage sampling are David Henley and Alan Leckie. Sampling foliage is easy if the tree is up to 10 metres in height – use either secateurs or a pole pruner. But for trees between 11 and 30 metres, the best method is using a shotgun to collect samples. Over 30 metres in height samples can be collected by climbing.

David Henley at Scion has been using a shotgun for foliar sampling for 25 years and has fired more than 25,000 rounds during that time (Fig. 2).

Fig. 2. David Henley collecting foliage samples using a shotgun

For anyone interested in foliar and soil sampling of forests have a look at this website: https://gcff.nz/publications/videos/.

INTERPRETATION OF FOLIAGE ANALYSIS DATA

For nutritional management purposes, the method of interpretation based on known deficient and adequate nutrient concentrations is the most widely used. However, such standards for interpreting analytical data must be used cautiously. The current growth performance of the stand, preceding climatic conditions such as drought or unusually moist conditions, and factors such as insect or disease attack, should be considered when interpreting foliar nutrient data.

For the ranges given by Will (1985) for radiata pine, for most nutrients (calcium, zinc and manganese are exceptions) a fertiliser response would be expected from trees where nutrient concentrations are in the deficient zone. Responses are less likely where concentrations lie in the marginal (between deficient and adequate) zone for nitrogen, potassium, magnesium, boron and copper. For phosphorus, response is likely where concentrations are in the marginal zone (Table 1).

	Radiata pine [a] Deficient <	Adequate >	Radiata pine [b] Deficient	Adequate
		%		
N	1.20	1.45	<1.0	1.2
P	0.10	0.13	<0.10	0.14
K	0.30	0.50	<0.35	>0.50
Ca	0.10	0.10	<0.06	0.08
Mg	0.06	0.10	<0.05	0.10
S	-	-	-	>0.13
$^{f}SO_4$-	-	-	<0.008	0.02
		mg/kg		
B	8	12	5-12	16
Cu	2	4	<2	2.4
Zn	10	20	<11	14
Mn	10	20	<10	25
Fe	-	-	<35	70

[a]New Zealand data (updated from Will, 1985).
[b]Australian data (Boardman *et al.*, 1997).

Table 1. Deficient and adequate foliar nutrient concentrations for radiata pine

Historical foliar analyses (data not shown) have consistently shown that natural soil N supply in the Rabbit Island radiata pine forest is not satisfactory, with foliar N concentration of the Control treatment remaining consistently well below 1.5% N (c.a. 1.1-1.3%), a threshold value below which radiata pine may benefit from N fertiliser (Will 1985).

The needle samples collected in April 2018 were sent to Scion's Veritec Lab for analyses of nutrients and heavy metals. In the next issue of newsletter, we will update the results about the residual effect of applied biososlids on tree nutritional status.

ECOTOXICOLOGY NEWS *Louis Tremblay*

Cawthron-based PhD candidate Olivier Laroche submitted his theses "Investigating eDNA/eRNA metabarcoding methods for assessing impacts of offshore oil and gas activities on benthic ecosystems." He has received the reports from the external examiners and both were very positive and Olivier will have his oral exam at the end of May. Following that Olivier is making the move to Hawaii where he has accepted a 1-year postdoc fellowship at the Department of Oceanography, University of Hawaii at Manoa. His research has provided some valuable insight to establishing methodologies that will be used as part of the new emerging organic contaminants project (more information on this project can be found in Issue 17 – February 2018).

Flame retardants are a series of contaminants of concern that are being currently investigated by the CIBR team as they are regularly found in the environment. The effects of some of the main chemicals found in flame retardants are being assessed using soil invertebrate assays using springtails; using the standard springtail test provides information on the potential impacts contaminants can have on the reproduction of the parthenogenetic collembola *Folsomia candida* (see figure).

Collembolans are hexapods with a thin exoskeleton that is highly permeable to air and water, and represents an arthropod species with a different route and a different rate of exposure compared to other soil invertebrate test species, such as earthworms. *F. candida* is distributed worldwide and is found in very high numbers at humus rich sites. It is an eyeless, unpigmented collembolan with a well-developed furca (jumping organ) and an active running movement. It can jump readily if disturbed. *F. candida* has an omnivorous feeding habit, including fungal hyphae, bacteria, protozoa and detritus in its food. It reproduces parthenogenetically but males may occur at less than 1 per thousand. That makes it a suitable model to assess the impacts of soil contaminants and the tests are performed according to a guideline (OECD 232; 2009). We continue to test the most persistent flame retardants in the soil both individually and in mixtures, as they are likely to be found in complex mixtures within the receiving environment. Opportunities are being explored to develop molecular approaches to better define the mechanisms of toxicity of these chemicals. So this small soil invertebrate is a very important tool in our objectives to assess the impacts of micro-pollutants on soil health.

Figure: The OECD standard species Folsomia candida and a few of its New Zealand native springtail cousins. Photo credit for the pictures of the native springtails - Massey University.

NZ LAND TREATMENT COLLECTIVE CONFERENCE (ROTORUA, 7 – 9 MARCH 2018)

Bronwyn Humphries

Panel discussion during the 2018 NZLTC conference

Keynote speaker Rob Bell (NIWA) presenting on climate change

Site visit to a Lake Tarawera property, attendees talked about the process to petition the Rotorua Lakes District Council to have their community provided with a community wastewater system/connection (photo credit: Brent Fletcher of the Waikato Regional Council).

2018 NZLTC conference dinner

The 2018 NZLTC conference was held in Rotorua with speakers providing a breadth of interesting and relevant talks. The conference theme was 'benefits and risks' of land treatment with one of the keynote speakers, Professor Sally Brown (University of Washington), presenting on the beneficial use of biosolids and the journey that the US has taken since the early 1990's which has involved utilising their waste to create a product which is a market success in the gardening industry (https://nzltc.files.wordpress.com/2018/05/ltc-newsletter-no-57-may-2018.pdf).

The conference also included a special session on the impact of climate change on land treatment. Keynote speakers, Dr Rob Bell (NIWA) and Professor Iain White (University of Waikato), gave the delegates an overall summary of climate change and its impact on land treatment. These presentations have formed the basis of the NZLTC 35th Technical Review entitled 'Daily impact of climate change on land application of waste' which will be available in June. The aim of the review is to provide NZLTC members a reference when considering how to future proof land application solutions for resilience from the impact of climate change. Please contact the NZLTC Technical Manager for how you can access the publication: bronwyn.humphries@esr.cri.nz

The conference concluded with a fieldtrip to land treatment sites within the Rotorua lakes area. The fieldtrip gave delegates an insight into the On-site effluent testing (OSET) facility, onsite land treatment and its impact on waterways.

The conference highlights were our keynote speakers, time available during breaks to network with other delegates, the strength of our student presenters and of course the social events. We are already in the planning stages for 2019 with Invercargill confirmed (3 – 5th April) and a theme of primary production and land treatment touching on the issue of limit setting.

For further information please contact:
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SOCIAL AND CULTURAL UPDATE

Alan Leckie, Lisa Langer, Jamie Ataria, Joanna Goven, Jinny Baker, & Marie McCarthy

A view of Rāpaki in Whakaraupō (Lyttelton Harbour)

FUNDING AND FUTURE COLLABORATIVE RESEARCH

In December 2017, CIBR's Social and Cultural team, the University of Canterbury Māori Research team and Te Pā o Rākaihautū (a new designated special character school) received Kia Ārohi Kia Mārama scoping research funding from Ngā Pae o Te Māramatanga (Centre of Research Excellence). This funding will be used primarily to develop a Marsden Fund application and secondarily, explore research opportunities within the National Science Challenges that align with the core strengths of this collective and relevant research educational, environmental and kaupapa Māori based issues.

A hui was held at Rāpaki Marae in Whakaraupō (Lyttelton) in Āperira (April) bringing together all of the researchers and members of Te Tautarinui (Board of Trustees of Te Pā o Rākaihautū) to discuss the topic of kaitiakitanga (sustainability or guardianship) and decolonizing methodologies for Māori succeeding as Māori in education. Te Pā is a pā wānanga, a Māori learning village, which has kaitiakitanga and oranga/hauora (health and wellbeing) of the environment and people as an enabler of positive educational outcomes for the future.

The hui set out to be aspirational; to solve issues with better engagement to create better outcomes. Why is there cultural disengagement and loss of identity; how can we improve student-teacher relationships; is the current curriculum relevant?

This scoping study is a rare opportunity to find research questions that fit the expertise of both the Social and Cultural team in the field of sustainability around chemical use, biowaste reuse and waste, and the UC Māori Research team with expertise in education.

SOCIAL & CULTURAL RESEARCH AT TE PĀ O RĀKAIHAUTŪ – A PĀ WĀNANGA

The social and cultural team is exploring Māori worldviews of sustainability that can be applied to the management of biowastes and to the adoption of alternative cleaners.

BIOWASTE MANAGEMENT

The Māori worldviews at Te Pā can be described by their ideas and beliefs. A framework of kaitiakitanga/sustainability being taught at Te Pā will be applied to organic waste management. The social and cultural team have documented the origin, production, usage and reuse/recycling/disposal of organic wastes on site.

As part of the social and cultural group's study of the reuse and recycling of organic waste, non-teaching staff at Te Pā (including the groundsman, chef, and cleaner) were interviewed and asked a set of questions on the types and volumes of wastes produced, how wastes are generated, and also where wastes could be reduced or prevented within their areas of work. They were also asked if they were willing to look at new approaches to reduce wastes in both their areas and in other areas of Te Pā.

An example of where wastes are generated at the pā wānanga is in the kitchen. Every day, up to 250 children are fed both breakfast and lunch producing wastes daily. An early estimate of weekly organic waste produced is between 50 and 70 kg. Other organic wastes, such as paper napkins, can be composted, but kitchen wastes such as food-contaminated paper, cardboard, and plastics have to be recycled or removed as non-recyclable. Putrescible wastes that create odours that can attract flies or rodents need to be separated and dealt with away from other wastes. These wastes are disposed of in the municipal waste collections.

To return organic wastes to the site, an open-air composting system operates. A small vermicomposting unit has been built at the early childhood centre to show the tamariki (young children) how worms decompose organic wastes. The vermicomposting unit also is part of learning in the early childhood curriculum.

This research enables Te Pā to look at how to reduce waste by making changes to practices. The waste data recorded can be used to modify

Alan Leckie at the entrance to Wheki, the site of the CIBR, UC and Te Pā Hui

purchasing practices such as making bulk purchases of non-perishable food items (rice, pasta, herbs) or hiring vegetation chippers to create mulches or wood chips for the garden. These mulches are from the annual prunings of Te Pā's trees. The grounds staff have also asked if a heavy-duty wood chipper can be purchased to reduce hire or removal charges associated with prunings.

Composted organic wastes have been applied to the vegetable garden and used in the seedling mix that produces plants for the garden. A novel idea to decompose organic wastes using worms has been discussed and a prototype has been built. Funding to build a working example is being sought.

CHEMICAL CLEANERS: HOW SAFE ARE THEY AND DO ALTERNATIVE CLEANERS CLEAN WELL ENOUGH?

Kaitiakitanga practices are being applied to the current usage of chemical cleaners at Te Pā. Alternative eco-friendly cleaning products can add to the efforts within Te Pā to reduce chemical use. How efficacious are alternative commercially produced eco-friendly "home-made" cleaners? Testing standards will be applied to these 'new' cleaners to determine whether there is any pathogen risk from their use: do they kill the pathogens being tested?

From this research, new standards can be set for eco-friendly cleaning products. Three eco-friendly products will be tested against bacteria causing outbreaks in New Zealand (e.g. *E. coli*). Kitchen staff at Te Pā are interested in producing and using alternative cleaners in their kitchen, and these will be included in the tests against known pathogens.

Te Pā has recently had a change in the cleaning contract and the new company brings a new set of chemicals used to clean the school. The new cleaning company only uses cleaners that have passed the Environmental Choice New Zealand certification. The certification gives an Eco-label which is a "voluntary method of environmental certification and identifies overall preference of a product within a specific product based on life cycle considerations" (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. The new cleaning company states that all staff must be trained to NZQA level and that chemicals are monitored for effective cleaning.

QUALITATIVE AND QUANTITATIVE RESEARCH

Social scientists will be asking Te Tautarinui (BOT), kaiārahi (teachers) and kaimahi (staff) a number of questions that focus on school culture and activities to explore Māori worldviews of sustainability and the cultural customs that can be built to develop practices that can be applied to the management of biowastes and also can lead to the adoption of alternative cleaners. The questions fall into four categories:

1. The culture of the school and how it relates to education.
2. Place-based education that immerses the students in the narratives of their cultural landscape and its history. These stories can be the basis in their studies of mathematics, science and all lessons within the curriculum.
3. Kaitiakitanga which means guardianship and sustainability. It serves as a means of protecting the environment based on Māori world views of connectivity to the land and to nature.
4. Well-being or oranga/hauora. Being healthy is an important feature of life. Māori tikanga believes that the healthy physical body, a clear thinking emotional mind, social and family relationships, and spiritual well-being are pillars to a good life as these provide for a positive personal identity.

These questions will provide the researchers with clear views of the culture of the pā wānanga at its current temporary site.

CIBR's social and cultural research will explore Māori worldviews of sustainability/kaitiakitanga and the cultural customs that can be, or are being, built upon to develop sustainability practices. How these can be applied to the management of biowastes and to the adoption of alternative cleaning products as expressed by Te Pā 'village' is being tested.

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:

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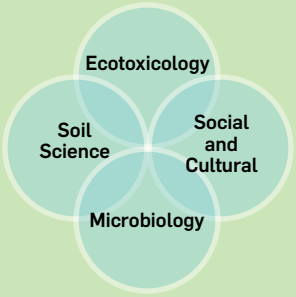

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