CORE FUND PROJECT - FINAL REPORT FOR 2013/14

Project title:

Centre for Integrated Biowaste Research (CIBR)

Project leader(s):

Dr Jacqui Horswell

Duration:

Ex-FRSt funding, continues until 2017

List the capabilities developed and by whom (include students)

CIBR core capabilities

- Microbiology
  - Public and environmental health risk assessments.
  - Assessments of waste processing technologies for microbial reduction.
  - Generating environmental fate, transport and effects data for microbes.
- Ecotoxicology Team - Building an ecotoxicological platform that provides the science to underpin risk assessments for contaminants found in biowastes:
  - develop chemical and biological assays to characterise the effects of micro-pollutants;
  - provide data to inform the risk assessment and management of emerging organic contaminants in biowastes that are being land applied including the impacts of mixtures of contaminants;
  - generate environmental fate, transport and toxicity data to assist the risk assessment and management of high priority chemicals.
- Environmental life cycle assessment (LCA)
  - A framework that can help establish the environmental impacts associated with a product or service, for example, using it to assess options for biosolids reuse.
- Cost benefit analysis (CBA)
  - Systematic process for calculating and comparing benefits and costs of a project, for example, using it to assess the economics of biosolids reuse options.
- Soil science
  - Assessing fit for purpose re-cycling/re-use of biowastes.
  - How different waste treatment processes affect soil fertility and productivity.
  - Long-term field trials in a forest, glass house pot trials with native plants, and laboratory studies.
  - Use of biowastes in rehabilitating and restoring degraded soils.
- Forest ecology

- Impact of biowaste land application on forest biodiversity and functions.
- Identifying and manipulating ecological processes for improving forest use of biowastes and minimising the environmental risks.
- Enhancing carbon sequestration in forests and soils through beneficial use of biosolids.
- Best management practices for applying biosolids to forest plantations.

- Social science and cultural knowledge and approaches
  - Community engagement methods including stakeholder analysis, relationship building, in-depth interview and survey design, collaborative planning hui, community dialogue workshop design and facilitation, collaborative hui informed by Tikanga.
  - 'Fit for purpose' community-engagement framework to support local council decision-making.
  - Sustainable behaviour change, new curriculum science education for engaging teachers, students, whānau and households in addressing wicked problems.
  - Supporting iwi development, enterprise and waste management.

Capability development - students

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Completed students

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List the external research or grant proposals submitted (include $ value) and any research funding obtained that have been made possible as a result of CF investment in the project, include proposals awaiting funding decisions:

Grant proposals submitted

Funding body	Project title	Funding requested	Successful/declined/pending
[Withheld under section 9(2)(b)(ii) of the OIA]	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*	Declined
[Withheld under section 9(2)(b)(ii) of the OIA]	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*	Declined
[Withheld under section 9(2)(b)(ii) of the OIA]	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*	Declined

List all external research revenue obtained seeded by this CF project:

Co-funding and subcontracting

Funding type	Organisation name	Amount
Co-funding	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*
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Co-funding	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*
Sub-contract	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*
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Co-funding	*[Withheld under section 9(2)(b)(ii) of the OIA]*	*[Withheld under section 9(2)(b)(ii) of the OIA]*

Show commercial benefits from the investment, list any new products or services made possible by CF, both actual and potential (*be realistic, not far fetched*) and estimate revenue, clients and timeframe for achieving this:

[Withheld under section 9(2)(b)(ii) of the OIA]

How does your research contribute to ESR's IMPACT/s?

The CIBR programme contributes specifically to **Outcome 4** by improving the safer use of biowastes.

The key impact area for outcome 4 is **Reducing morbidity and mortality rates from contaminated water by:**
Decreasing exposure to hazardous substances and water-borne pathogens, and Decreasing environmental contamination from grey water and biowaste: CIBR has assessed waste processing technologies, such as vermicomposting to improve biowastes quality, reduce risks and enhance their reuse as soil fertiliser or amendment. We have characterised chemical and microbial levels in biowaste and found that levels of key contaminants of concern are similar to those found overseas. Environmental fate, transport and effects data for priority chemicals and mixtures of these chemicals has found that compounds such as triclosan (an antimicrobial used in hand soaps and toothpastes) can cause ecotoxicological impacts in the environment. Microbiological contaminants in biowastes can be managed by process controls such as anaerobic digestion, followed by land treatment site management (e.g. withholding periods).

Information for national and regional water policy: CIBR provides the science that underpins the development of national guidelines for sustainable waste re-use (e.g. the Organic Waste Guidelines currently under development); provides advice and peer review of human health impacts for resource consent applications and district planning, with respect to land application of wastes; CIBR team members sit on national and international advisory groups, boards and Steering Committees (e.g. Australia/New Zealand Biosolids Partnership; NZ Land Treatment Collective; BRANZ).

List anything else that can demonstrate value from this CF investment:

Science Quality:

Indicator	**Number**
Peer-reviewed journal articles accepted for science publication	15
Masters or doctorate theses	6
Published conference proceedings	55
Keynote presentations	2
Commissioned Reports:	22
Workshop/hui	14
Number of non peer reviewed published articles	18

Executive summary – *Three to four sentences giving an overview of your project and the results obtained. This will be used for the board report so keep in mind that not everyone is an expert in your field.*

Three key achievements:

1. **Manuka**: ESR has been working with Lincoln University on a joint project to explore the benefits of applying biosolids to manuka plantations. Biosolids are carbon-rich and contain high concentrations of valuable nutrients that are effective for the rebuilding of soil that has become degraded from pine forestry. NZ native *Leptospermum scoparium* (manuka) is widely used in land restoration projects in New Zealand due to its hardy, tolerant nature. It addition, manuka components have economic value through commercial production of honey and essential oil-related products. This makes establishment of manuka plantations a viable option, particularly if this can be achieved on low quality or degraded land. We have shown that some of the negative effects of biosolids and dairy waste addition to soil can be mitigated by planting of manuka. In the ESR led part of the project we demonstrated that manuka can increase the die-off of waste-borne pathogens in soil, this work also led to a successful Pioneer fund project. Lincoln University work showed that manuka can interfere with the nitrogen cycle in soil, significantly reducing the evolution of nitrous oxide a potent greenhouse gas, and reduce nitrate leaching that poses a threat to groundwater. Results indicate that the most effective use of a waste such as biosolids would be during establishment of manuka seedlings in degraded soil, rather than being continually added as a fertiliser during manuka production. This new knowledge could provide additional economic benefits through commercial production of manuka honey and provide a more cost-effective beneficial re-use of biosolids, and mitigate some of the environmental impacts of waste application to land.
2. **CIBR workshop** – ESR organised the second CIBR end-user workshop "Advancing resource recovery/reuse from biowastes" in April. Over 60 representatives from District and Regional Councils, Biosolids industry and other end-users attended. Presentations were made by all parties, including an international speaker Mr Tung Nygen from Sydney Water who gave the keynote address. The workshop also included presentations of the latest research from the CIBR team and facilitated discussions on the new "Organic materials" guidelines, an initiative involving Jacqui Horswell from ESR and in partnership with WaterNZ and WasteMINZ.
3. **Up the Pipe solutions** – In this Ministry for the Environment co-funded project we went back 'up the pipe' to involve school children in research projects to better understand and reduce the waste that goes down our drains. ESR led the social/cultural component that developed a 'vehicle' to engage students in science and expand young minds, and generated resources, activities and

approaches. The resources support behaviour change initiatives by encouraging students to be 'change instigators' within their whānau. Minimising contaminants in biowastes will ultimately support higher rates of waste recovery and re-use. This project has seeded two research proposals (outlined above), resulted in a number of popular media articles (e.g. Consumer magazine and North and South) and radio interviews (e.g. RNZ Morning report)); provided track record for ESR in the area of "Science citizenship" and positions us for participation in the "Science in Society strategic plan" recently launched by MBIE. We have developed a network of key stakeholder relationships in this area including New Zealand Centre for Educational Research (NZCER), Enviroschools, EcoStore, and a number of schools.

4. **Australia and New Zealand Biosolids partnership** – Jacqui Horswell continues to contribute to the governance of this partnership as a board member by directing initiatives within Australasia. This has resulted in commercial benefits and raising the profile of the New Zealand collaborators including CIBR. Jacqui and Lisa Langer presented papers on community engagement for biosolids decision-making and up the pipe solutions to the AWA Biosolids and Source Management National Conference in Melbourne. The research was well received and it highlighted that the social and cultural research performed by CIBR is well ahead of research within the Australian biosolids and source management industries. The Australians are keen to receive community 'buy-in' and think of communities as requiring education rather than seeking sustainable solutions with communities. The conference presentations provided an opportunity to signal CIBR expertise in this area and hopefully it will mean the Australians will seek more input if community discontent arises in the future.

Project report – *Make this a stand-alone final report suitable to include in a consolidated report to the ESR Board. Include brief background, what you did, what you found, conclusions (**2-3 pages**). This is the opportunity to tell a success story that ESR can use in Briefing and other communications.*

The CIBR is a virtual centre, combining the expertise of 8 New Zealand research institutes, universities and research partners dedicated to developing both the biophysical and social science behind appropriate and sustainable beneficial reuse of organic, biodegradable waste such as sewage sludge, industrial and agricultural waste; kitchen/food waste; and green waste. Led by ESR, CIBR brings together a multi-disciplinary team of scientists and researchers from ESR, Scion, Cawthron Institute, Landcare Research, Lincoln University, Lowe Environmental Impact, Northcott Research Consultants Ltd. and Kukupa Research.

CIBR science

The 'reduce, reuse, recycle' message from government is a compelling reason for communities to look at sustainable options for waste management. Each year, New

Zealanders send around 3.2 million tonnes of waste to landfill, over a tonne of rubbish per household. The organic waste stream comprises more than 62% of the total waste stream going to landfill in New Zealand, and at around 700,000 tonnes per year, it is growing (Ministry for the Environment, Indicator update, October 2012; INFO 654). The burden on the environment and the dollar cost to councils is increasing with resource consent applications and the physical act of burying the material. These wastes are carbon-rich and generally contain high concentrations of valuable nutrients which, if properly treated and/or processed, can have added value through resource recovery. An example is the re-use of organic wastes as a sustainable soil conditioner that has the potential to provide valuable physical (e.g. increased water holding capacity, infiltration and aeration), biological (e.g. beneficial organisms) and chemical (e.g. essential plant nutrients and ability to mitigate chemical contaminants) attributes.

However, some organic wastes can also contain a range of micro-contaminants such as heavy metals, agrichemicals, pathogens, pharmaceuticals and personal care products, thus management requires technical guidance and regulation to ensure minimal environmental/public health risk and maximum value recovery.

Despite having science-based regulations or guidelines to facilitate beneficial reuse of many organic wastes (e.g. Guidelines for the Safe Application of Biosolids to Land in New Zealand, New Zealand Standard for Composts, Soil Conditioners and Mulches (NZS 4454:2005)), progress has been slow towards achieving the NZ Waste Strategy target of improving the efficiency of resource use and diversion of organic wastes from landfill. In part this is because land application of biowastes, especially the more contentious wastes such as sewage sludge, hinges on the outcomes of integrating both biophysical and social science; there is also insufficient understanding of the risks (perceived and otherwise) with some wastes and no nationwide consistency of approach. Some guidelines are outdated and in need of review as new science is now available on quality criteria such as contaminant limits. CIBR provides the science that underpins the development of national guidelines such as the new Organic Wastes Guideline currently being developed in collaboration with WaterNZ, WasteMINZ, CIBR and the Land Treatment Collective. These new guidelines will increase reuse of waste by clarifying and streamlining regulatory processes to facilitate greater beneficial re-use of organic wastes.

Working with our two case-study communities (Kaikōura and Mokai), we have development a blueprint for successful community engagement, which has guided the implementation of biosolids solutions in our case study regions, and provided a basis for regional planning, national guidelines and policy directions.

Four years of most successful community engagement hui and underlying biophysical research for the Kaikōura case study culminated in community recommendations for land applications of 1500 tonnes of stockpiled biosolids, Following an invitation by the Kaikōura District Council CEO, the CIBR social and cultural team presented the Kaikōura case study community engagement report to the Kaikōura District Councillors.

The councillors unanimously accepted the CIBR report paving the way for the Council to implement the research and the community recommended biosolids reuse options. The team continue to have dialogue with the Council and Te Rūnanga o Kaikōura to discuss plans to spread biosolids on land at the Wastewater Treatment Plant and plant it with native species. CIBR will present manuka research to a forth coming rūnanga meeting to present knowledge and research capability on the establishment of native species.

The Mokai case study was somewhat challenging. More complex cultural and local government arrangements meant that much of the social research was focused on more hypothetical scoping for iwi enterprise around beneficial reuse, rather than actual decision support. Highlights included deepening our understanding of' tapu to noa' cultural management frameworks, a waste survey with Mokai households, and a 'willingness to pay' exercise conducted by *[Withheld under section 9(2)(a) of the OIA]* in the final hui. *[Withheld under section 9(2)(a) of the OIA]* was involved in a very successful extension of the 'Up the Pipe' and greywater exercise with Tirohanga Primary School, and the Principal *[Withheld under section 9(2)(a) of the OIA]*, helped us develop 'Up the Pipe' resources for primary school level. Based on the survey results, the students also designed posters for the Mokai marae to highlight good practices for care of the Marae's newly upgraded septic tank systems. Research into vermicomposting and septic tank waste were several highlights of the biophysical science research, but overall there was not the same degree of integration between the social and biophysical sciences, and science, iwi, council and community partnerships that characterised the success of Kaikoura. We would also like to acknowledge the recent passing and enormous support of the late *[Withheld under section 9(2)(a) of the OIA]* who was a keen champion of the Mokai work.

Integration of biophysical, economic, social and cultural science including Life Cycle Assessment (LCA) and economic modelling were demonstrated within the two case studies. The lessons learned from community engagement in the two case studies and past research has led to the development of a community engagement framework for end-users.

Our long-term field trial has been investigating the sustainability of biosolids land application in plantation forests. Biosolids from Nelson have been applied to a radiata pine forest on Rabbit Island since 1996. Research has focussed on the effects on tree growth, nutrition, soil and the ecosystem environmental quality. This trial is providing important information on the sustainability of land treatment of biowastes and its economic outcomes, resulting in improved soil fertility and stand productivity (by 35%) and increased soil fertility. Long-term biosolids land application has transformed the forest site from relatively low to moderately high productivity without causing significant adverse effect on the environment.

Our extensive ecotoxicology platform allows us to characterise range of contaminants commonly detected in biowastes such as biosolids. This is underpinned by chemical analysis allowing us to provide biowaste producers and regulators with a comprehensive

risk assessment of the environmental and public health impacts of waste water and waste solids.

A key focus of our research is to understand the impacts of mixtures of contaminants in biowastes on the environment. We investigated how the mixtures of copper, zinc, and triclosan (antimicrobial used in bodycare products) effects soil microbes and key indicator species (e.g. earthworms). We found that the presence of co-contaminants in complex waste materials such as biosolids may combine to produce synergistic or additive ecotoxicological impacts upon soil function and health indicators. Further work into mixtures using 'in vitro' laboratory bioassays (such as zebra fish) has demonstrated that the chemicals tested showed toxicity and the potential to interact with other chemicals. The research identified high risk chemicals including the disinfectant chloroxylenol, the UV filter/sunscreen agent octyl-methoxycinnamate, and the antimicrobial chemical triclosan. A series of experiments were conducted using an earthworm standard toxicity test with mixtures of triclosan, bisphenol A (BPA, a plasticiser) and carbamazepine (a psychiatric drug). On-going research continues to assess the potential toxicity of a wider range chemicals commonly found in biosolids, particularly the long-term chronic impacts (e.g. effects on reproduction) of individual chemicals and mixtures. In the future guidelines should acknowledge and take into account the combination of chemicals present in organic wastes and develop new risk assessment procedures that incorporate thresholds for mixtures of chemical contaminants.

We have continued to extend our capability in 'ecotoxicology; and developed new assays to assess oxidative stress and influence on thyroid function that provide new information on the potential environmental effects of contaminants and contaminant mixtures associated with biowastes and that have led to new international collaboration.

The CIBR programme has been developing smarter ways of mitigating potential environmental impacts of contaminants present in biowastes. Biosolids can be combined with wood waste or pyrolysed wood-waste (biochar) to reduce leaching of nitrate. Research has shown that most nitrate leaching occurs as a single pulse immediately following biosolids addition. Mixing biosolids with sawdust or biochar can adsorb the free nitrate present in the biosolids thereby eliminating the pulse of nitrate though to groundwater. Using biochar results in the long-term increase of soil carbon, which has agronomic and environmental benefits. The nitrogen leaching from biosolids may also be reduced by some NZ native plants. Preliminary results indicate that manuka and kanuka can reduce both nitrification (which leads to nitrate leaching) and denitrification (which leads to nitrogen loss and nitrous oxide emissions).

The high cadmium (Cd) concentration in biosolids can result in unacceptable plant uptake of this toxic heavy metal. CIBR has found that mixing biosolids with other biowastes such as lignite can significantly reduce plant Cd-uptake. Biowastes such as compost can also reduce Cd-accumulation in plants grown in other Cd-contaminated soils. Most NZ soils contain elevated Cd concentrations through the repeated application of superphosphate fertiliser.

The CIBR has worked this year on development of a strategic plan and formed a Business Development Working Group to support revenue growth. A new Business Leader has been appointed (Rob Lei from Scion) with broader expertise and linkages to the 'whole' waste sector to reflect the CIBR's wider focus from biosolids to all biowastes.