Biowastes Project

Issue No.2

Autumn/Winter 2011

Inside this issue

Landcare Research Manaaki Whenua

SCION Next generation biomaterials

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News from the Programme Manager

– Jacqui Horswell

Takahanga Marae - venue for the Biowastes Programme Hui in February 2011

Welcome to the Autumn "Biowastes" newsletter. It has been a difficult quarter for many New Zealanders with the Christchurch earthquake. Many of our team members and their families have been badly affected; indeed the Scion offices were closed for several weeks. Our thoughts and best wishes go out to all who have friends and family in Christchurch. Like all New Zealanders, the Biowastes team are looking for ways to help out. It has been suggested by our Advisory Group that we could provide information on composting toilets or other 'waste' disposal systems so we will be looking at posting information on our websites that might be useful to those without sewerage systems long-term.

New Zealand and Australia continually work towards closer relations and, although we battle it out on the sports field, each country provides support to the other in times of need such as in recent disasters experienced by both countries. We can also help each other with advances in research and technology in the waste arena. The Biowastes programme has joined the "Australian and New Zealand Biosolids Partnership" whose objective is to support sustainable biosolids management. Further information can be found on their website: www.biosolids.com.au

In February, Biowastes programme collaborators from ESR, Scion, Landcare Research, Plant and Food and Cawthron participated in a hui at Kaikōura along with representatives from local government and the community. Presentations were made by all parties and a discussion facilitated to determine some re-use/disposal options for the Kaikōura biosolids. The hui was a huge success with positive feedback from the participants and a number of realistic biosolids re-use options focussed on land application. You can read more about the hui in the update from the Social and Cultural Team.

The New Zealand Land Treatment Collective (NZLTC) annual conference was held in Palmerston North in March. The LTC is an important conduit for the programme to transfer research results and engage with regional and district councils, Ministry for the Environment, Crown Research Institutes (CRIs), and universities. Grant Northcott (Plant and Food), Hailong Wang (Scion) and I presented papers. Grant's presentation has been summarised in the special interest article, Emerging Contaminants.

This quarter I met with the Wellington Advisory Group members: Jill McKenzie (Hutt Valley District Health Board), Nigel Clarke (Ministry for the Environment), Mike Enis (Friends of the Earth), Hamish Lowe (Lowe Environmental Impact and the NZLTC) and Paul Bruce (Wellington Regional Council and Appropriate Technology for Living Association (ATLA) to discuss our Biowastes Programme workplans. I'd like to take this opportunity to thank all members of the Advisory Group for providing guidance and direction on programme milestones and outputs.

Updates from the Social and Cultural Team – *Lisa Langer & Jacqui Horswell*

Kaikōura case-study update

Kaikōura is a Green Globe certified community with a strong commitment to protecting the environment and working towards sustainability for their community, visitors and future generations. Their wastewater treatment plant serves a permanent population of approximately 3500 and a tourist population of up to one million visitors per year. Sewage sludge was dredged from Kaikōura's oxidation ponds three years ago (they are generally dredged every 25 years) and about 1500 tonnes have been stockpiled on-site. The community and Council must decide the most appropriate way of reusing or managing these biosolids before the current stockpiling consent runs out in 2016.

In October 2009, the first hui was held in Kaikōura to introduce the Biowastes Programme and to begin engagement with key stakeholders who had direct interest in, or were likely to be affected by the management of Kaikōura biosolids. This included representatives of tangata whenua, Te Korowai o Marokura, business operators, local government, commercial and recreational fishing and environmental groups. During 2010, environmental and biophysical work was undertaken to characterise the biosolids to provide stakeholders with information for their decision-making.

Alongside the biophysical science, twenty key stakeholders were interviewed to explore what they value about their environment, what they thought should be done with existing biosolids, what concerns they had about the possible impact of biosolids disposal or reuse and what role the community should play in the decision-making process.

Few of the key stakeholders had extensive knowledge about biosolids and how it should be managed, and almost all felt that whatever happened to it would depend on what was in the biosolids. Land application was the popular choice for managing the current stock-piled biosolids, with varied views of what would be the most appropriate means of achieving this.

A number of concerns were raised including the cost of the solution, not wanting to transport the 'problem' elsewhere, and 'unknowns' around microbes, metals, chemicals, pharmaceutical and bodycare product issues.

In February 2011, the Biowastes team returned to Kaikōura for a second hui with key stakeholders to develop a number of options for reuse or management of the stock piled biosolids that could be developed further – within the capability of the current programme. The biophysical, social and cultural science undertaken to date was presented to inform stakeholders and aid decision-making.

Results from the characterisation of the Kaikōura biosolids show that the nutrients present are comparable to composts, thus the biosolids could be used as a soil amendment to improve the fertility of poor quality soils in local indigenous re-vegetation restoration projects. However, several of the heavy metals (cadmium, zinc, copper and mercury) were elevated and although these levels are not a concern to human health, any application to land needs to be managed to ensure there are no adverse environmental effects. Additional care should be taken when applying biosolids near rivers and waterways. Although microbial contaminants in the Kaikōura biosolids were low, the presence of *E. coli* suggests that the biosolids are not suitable for amending soils for food production.

After presentation of the biophysical, social and cultural science results to date, a facilitated workshop session was held to enable key stakeholders to discuss a number of feasible options for their biosolids. Participants were asked to discuss the environmental positives and negatives, social and cultural positives and negatives, economics and feasibility of each of the options. Favoured options were then ranked.

Of the potential biosolids reuse or management options the following were ranked highly:

- Further stabilisation – composting (including vermicomposting with worms)
- Farm application outside food chain
- Exotic forest application
- Rehabilitation of disturbed sites and native species.

The Biowastes team will now further investigate the potential options for the Kaikōura biosolids. The biophysical scientists will work towards filling in some of the knowledge gaps identified (e.g. impacts on native worms of biosolids applied to land). A third hui will be held in 2013 with the wider community to present options and formulate community recommendations to present to the Kaikōura District Council.

The Biowastes research team would like to thank all the key stakeholders who have taken part in our research programme. We would also like to thank our Māori research partner, Te Rūnanga o Kaikōura for their wonderful hosting of the hui and for their invaluable contribution to the research to date.

Updates from the Soil and Micro group

– Jacqui Horswell

A key focus of our research programme is to understand what happens to mixtures of micro-contaminants (metals, and new emerging contaminants, such as pharmaceuticals and personal care products) when they interact with each other and with the soil. It is now recognised that additive effects from multiple chemicals can result in a combined effect that is, sometimes, orders of magnitude greater than the sum of the individual effects. We have established small lysimeters (soil cores, pictured above) using field soils historically contaminated with copper and zinc, with the addition of the organic contaminant triclosan (a commonly used antimicrobial in bodycare products). The environmental safety of triclosan has been questioned and at the concentrations found in biosolids, it may also cause adverse effects in the soil environment. A range of biological indicators of soil health (e.g. soil enzymes, sensitive microbial biosensors, nitrogen fixing bacterium Rhizobium) will be measured to determine impacts of the metal plus organic mixtures. The first set of lysimeters using soils sourced from Hamilton have been harvested and analysis is underway. Some of the soil enzymes are certainly showing a metal and a metal plus triclosan effect so we will be very interested to see what the other soil health indicators show.

Updates from the Ecotox Team

– Louis Tremblay

The ecotoxicology research to assess the risk of micro-contaminants present in biowaste is continuing. The team has collated more information on levels of micro-contaminants present in New Zealand biosolids, including those from Taupō and Kaikōura.

Some emerging contaminants such as pharmaceuticals and personal care products (PPCPs) have been detected and are now being tested using standardised earthworm toxicity tests. Carbamazepine and fenofibrate are two commonly used pharmaceuticals that have been detected in biosolids. Carbamazepine is a psychiatric drug and fenofibrate a drug lipid regulator to reduce fatty substances in the blood. The two pharmaceuticals were selected for further testing both individually and in combination. Contaminants are often found in complex mixtures in the environment and it is important to assess the interactions between multiple stressors. A test using earthworms will be used to characterise the effects of those compounds on their reproduction fitness. Earthworms are an excellent indicator of toxicity as they live in close contact with the contaminants and the tests used are well established and recognised worldwide. Further work is being conducted to develop toxicity tests using New Zealand earthworm and snail species. This research will complement the information generated using internationally recognised standard tests by providing data relevant to our unique New Zealand soil fauna.

The presence of emerging contaminants in biowastes has been identified as a major barrier to the beneficial use of biowastes like biosolids. To raise the profile of this new research area and coordinate resources and capability across organisations and government departments, members of the team are working closely with colleagues from the Ministry of Science and Innovation to develop a FutureWatch trend paper that will summarise the information available in the international and national literature. Members of the team are also developing a document that will assist regional authorities to manage consent applications that have issues related to potential risk associated with emerging contaminants with the wider aim to develop a national strategy.

Advisory Group Feature

The role of the Biowastes Advisory Group is to provide guidance and direction into the long term direction of the programme. They are a panel of: industry, government and non-government representatives with a keen interest and/or expertise in the biowastes area. This quarter we feature Sandy Ormiston from Ormiston and Associates (www.ormiston.co.nz). Sandy is also the Chairperson of the New Zealand Land Treatment Collective (NZLTC), and represents the NZLTC's interests on the Advisory group.

The NZLTC was established to support research on treatment of waste products by land application, provide its members with the most recent information on land treatment technology, research and information, and to improve communication to all stakeholders in the industry. The NZLTC is a national organisation whose membership includes Regional and District Councils, Ministry for the Environment, CRIs, and Universities and it represents an important conduit for the Biowastes Programme to transfer research results and engage with stakeholders and end-users. More information on the NZLTC can be found at www.scionresearch.com/nzltc.

Q & A with Sandy Ormiston

What is your interest in the Biowaste Programme?

The NZLTC had its first conference in 1989 and has subsequently had a very strong interest in biosolids being under the umbrella of Scion (Formally NZFRI) based in Rotorua. Research results from ongoing and completed projects by CRIs are presented at the annual NZLTC conference providing a conduit for dissemination of the latest research results directly to the industry.

The NZLTC input into the biowaste industry has developed to include the inaugural and well attended Biosolids Workshop. This workshop was developed and presented by the NZLTC with the support of WaterCare Services and held at the Mangere Wastewater Treatment Plant in November 2010.

In my business I have a strong focus on on-site wastewater treatment and land application of treated effluent and have co-authored the Auckland Regional Council design guidelines (Technical Publication 58, 2004) and the Horizons Regional Council design guidelines (2007).

How do you see the information produced being useful to the NZLTC and to New Zealand?

The NZLTC has been a conduit for active biowaste research results over the past 22 years. Although there is a wide breadth of experience within the NZLTC the collective is wanting to increase the level of knowledge within local authorities and the community with the view to long term sustainable reuse of biowastes. The Biowastes Programme feeds more information into the arena but more importantly has connected directly with Iwi and interested groups rather than focusing purely on the scientific community. This can only benefit the community at large.

What else would you like to see in the programme?

I note from the Summer 2010 newsletter that hui around the country indicated the need for more research on how septic tank effluent might be managed on-site which is a subject dear to my heart!

Wastewater is viewed by the majority of unsewered property owners as something to get rid of whilst it is actually a valuable resource for irrigation of gardens, reducing reliance on potable water supplies. There are many challenges for the on-site and land treatment industries including emerging contaminants and public education. Many of the same issues face the dairy industry with land treatment of wastewater and other industries managing waste via land treatment.

If you had a million research dollars how would you spend them?

My main area of interest is the reuse and land treatment of wastewater such that the water becomes a resource for the benefit of the community. However there are many unknowns concerning actual impacts from land application irrigation systems on various soils, surface and ground water with a range of application rates and effluent qualities, vegetation cover, slope and climate. The results would provide increased certainty for councils setting guidelines, designers and processing officers.

Sandy Ormiston is Chair of NZLTC

Vermicomposting biosolids with waste biomass – *by Hailong Wang*

In collaboration with ESR, Landcare Reseach and Plant and Food Research, Lincoln University and Whenua Biz, scientists at Scion conducted a trial to evaluate whether vermicomposting is effective in reducing pathogens in biosolids, whilst retaining beneficial nutrients and organic carbon.

Two types of biosolids, including aged Kaikōura biosolids and fresh Taupō biosolids, were vermicomposted with locally available organic bulking materials, such as lake weeds, greenhouse tomato pruning, mulched broom plants and pulpmill wastewater solids, over a period of four and a half months. Preliminary results showed that types of biosolids and bulking material can influence composting worm breeding and development as well as the properties of the resulting vermicompost. Compared with aged biosolids, fresh biosolids contain higher concentrations of organic carbon and nitrogen, which can promote breeding and growth of composting worms. On the other hand, nutrient rich organic bulking materials may be used to improve the quality of aged biosolids as a soil amendment. Information on changes in persistent organic pollutants and pathogens during vermicomposting will be reported in the near future.

Joining the Biowastes Team are:

Dr Jo Cavanagh – Jo has been with Landcare Research since 2002 and has an extensive background in environmental chemistry and toxicology, particularly in the soil and air environments. A particular focus has been the development of soil guideline values for the protection of human health and ecological receptors – primarily for regional councils and the Ministry for the Environment. Jo undertook a toxicological review of selected priority contaminants that underpinned the development of soil guideline values used in the proposed National Environmental Standard for assessing and managing contaminant in soil. Her role in the Biowastes Programme will be to provide oversight for the soil ecotoxicology component, and linking with environmental contaminants research at Landcare Research.

Dr Jo Cavanagh

Dr Lynn Booth

Dr Lynn Booth – Lynn worked within the original 'Waste to Resources' programme working with the ecotoxociology group, principally with soil organisms, before moving into vertebrate pesticide research. Lynn has been with Landcare Research since 1994 in a variety of roles from technician in the toxicology laboratory to researcher in ecotoxicology and now manages the toxicology laboratory at Lincoln. While working in ecotoxicology, Lynn completed a PhD developing biomarkers in earthworms, followed by an 18 month stint in the USA as a Postdoctoral fellow at Oklahoma State University and then Ohio State University. Lynn was looking at the bioavailability of contaminants in soils to soil invertebrates and development of ecological soil screening levels. Lynn has recently rejoined the ecotoxicology group and will resume working on the soil bioassays in biowastes.

Dr Jianming Xue – Jianming joined Scion in 2004 and will lead the soil function tasks following the departure of Hailong Wang. The main focus of his research is to improve resource use efficiency through manipulating plants and soil, especially through enhancing plant-microbe synergies in the rhizosphere to improve soil nutrient bioavailability and productivity. His early work was on land treatment of meat-processing effluent and agricultural industry wastes. He feels excited about joining the Biowastes team and the opportunity to use his expertise. He is determined to make quality delivery of the milestones in soil functions during Hailong's leave of absence.

Marie Dennis – Marie will take on Sean's role within the Biowastes Programme. Marie will complete a Masters on viral/bacterial and algal interactions and the effect on nutrient and carbon cycling in freshwater systems at the University of Waikato in late August.

Jen Prosser is back from maternity leave and will be working three days per week at ESR, making sure she has a great life/work balance!

Up and coming events

- On the 13th of July the Biowastes team will hold a programme planning meeting in Christchurch to discuss progress and plan the next two years work.
- Progress is being made with the Tuaropaki trust and Mokai community around scoping the development of a vermicomposting trial to incorporate septic tank waste.

Leaving the Biowastes Team are:

Dr Tom Speir – After 40 years in Soil Science Dr Tom Speir is hanging up his soil corer and retiring. Tom has made a huge contribution to biosolids research and we are very sorry to see him go. Tom – may the sun always shine on the golf course!!!! All the best from your friends and colleagues in the Biowastes Programme.

Dr Hailong Wang – Hailong will commence one year's leave without pay to take an appointment at Zhejiang A & F University (Agricultural and Forestry) at Lin'an, Hangzhou, Zhejiang Province, China. Hailong will remain a collaborator on the programme and we wish him all the best for his new appointment.

Sean Taylor – Sean has accepted a new technical position within Scion's Wood and Biofibre Technologies team but will retain some oversight over the worm ecotoxicity studies.

ESR Biowastes team.
Back from left to right: Andrew Van Schaik, Tom Speir, Jacqui Horswell.
Front: Jen Prosser and Jinny Baker.

Emerging contaminants – what are they and why are they important? *by Grant Northcott*

In our day to day lives humans use multiple products and medications that contain numerous chemicals. Scientists and regulators have become increasingly aware of the burden these chemicals can have on the environment, and in recent years they have become the subject of intense research. Because of the recent interest in these chemicals they are conveniently described as emerging contaminants (ECs).

An emerging contaminant can be broadly defined as any synthetic or naturally occurring chemical or microorganism that is not commonly monitored in the environment but has the potential to enter the environment and cause known or suspected adverse ecological and/or human health effects.

ECs include chemicals, microorganisms such as pathogens, and nanomaterials which are structured chemical substances. By far the greater number of ECs are man-made chemicals. They include new classes of halogenated persistent organic pollutants (POPs), pharmaceuticals, chemicals in personal care products, steroid hormones, and endocrine disrupting chemicals (EDCs).

Emerging contaminants are differentiated from traditional POPs like polychlorinated biphenyls and organochlorine pesticides (DDT for example) by their bioactive properties. Many of the chemicals classified as ECs are manufactured to provide a specific biological mode of action, for example, pharmaceuticals which are designed to treat specific medical conditions.

Emerging contaminants are components in products that are commonly and frequently used by humans. In comparison to industrial chemicals they are sourced from products that are used in relatively small amounts. However, because they are used daily by multiple individuals the total amounts released to the environment can be significant.

Emerging contaminants include new generation organic compounds containing bromine and fluorine. Polybrominated diphenyl ethers are used as flame retardents in plastic, electrical goods and all manner of electronic circuit boards. Perfluoroctanoic acid is used to produce non-stick coatings on frying pans and other household items, and perfluorooctanesulfonic acid was the ingredient in 3Ms Scotch Guard fabric coating.

These new generation organic compounds have similar properties to other POPs and are highly bioaccumulative, persistent in the environment, and toxic. Some of these chemicals have already been identified as substances to control and are being considered for inclusion under the Stockholm Convention.

Pharmaceuticals and personal care products (PPCPs) include a wide variety of chemicals used as medicines, disinfectants, fragrances,

Emerging contaminants are widely released to the environment wherever humans live . . .

insect repellents, and surfactants and other chemical components in personal care products like shampoos, body washes, and cosmetics.

High volume prescription medicines (pharmaceuticals) include common pain killers such as paracetamol. Endocrine disrupting chemicals include natural hormones, synthetic hormones used in the contraceptive pill, plasticisers, surfactants, some pesticides, and some pharmaceuticals used to control hormonal conditions.

Emerging contaminants include a wide variety of chemicals in everyday use. The persistence and toxicity of some ECs is similar to harmful manmade chemicals that have been banned by numerous countries. The quantity of ECs produced each year is similar to some intensively used agricultural pesticides. But in comparison to agrichemicals and industrial chemicals, we have little idea of how ECs behave in the environment and what effects their long term impact may be.

The main sources of ECs to the environment include industrial discharges, effluents from waste water treatment plants, landfill leachates, land application of biosolids, septic treatment systems, animal manures and oxidation pond effluent, animal processing plants and aquaculture.

The main sources of ECs into the New Zealand environment are discharges of treated waste water effluent, septic tank seepage, animal wastes, and biosolids.

Scientists have enough information on ECs to know they are widely released to the environment wherever humans live. What they don't know is the risk ECs pose to environmental and human health. Unlike agricultural and industrial chemicals most ECs have not undergone screening to determine whether or not they will have an adverse environmental effect. The standardised test methods used to assess the impact of chemicals in the environment assess acute effects, or the amount of chemical resulting in the death of test organisms. The amount of an EC needed to cause the death of an organism is very high, and for this reason they have previously been considered safe.

Grant Northcott - busy in the field and lab!

But the effects of ECs are more subtle and they cause chronic or long term effects on organisms that are more difficult to assess, but are no less dangerous. New test methods are currently being developed to measure the long term effects of ECs on exposed organisms.

Many ECs degrade in the environment and this has previously lead to them being considered environmentally safe. But the real situation is more complicated than it first appears. While many ECs degrade in the environment within a matter of days they are constantly replenished by fresh sources, for example, from waste water treatment plant effluents which are continually released to the aquatic environment. This continuous replenishment means there is always a source of undegraded ECs being introduced into the environment.

Most ECs have been produced for human use and have been assessed for their potential effects on humans and other mammals. Pharmaceuticals provide a useful example- some common antibiotics used to treat humans are also used as veterinary medicines for the treatment of sick animals. But, scientists have little knowledge of the effect of these chemicals on non mammalian species such as insects, fish, and birds which may come into contact with them in the environment.

There is a lot that scientists do not know about ECs but they generally agree their combined long term effects could be dangerous.

These concerns have led to the funding of a number of international research programs investigating ECs in Europe and North America. These research programs are investigating the potential for ECs to contaminant groundwater and drinking water, their effects on aquatic and terrestrial organisms, whether residues of pharmaceuticals and other ECs can contribute to antibiotic resistance, and their potential long term impact on human health.

A question that is often asked is whether or not research on ECs is relevant in New Zealand. As scientists we believe it is. New Zealand has numerous streams and rivers that support our productive economy. Water is a valuable commodity for our economy, but we often don't consider it in this way. New Zealand has established land based industries that rely on having access to suitable sized water resources, and water that is not degraded, for example the dairy industry. New Zealand has a number of established urban centres that continue to expand to support growing populations. This expanding population is placing increasing pressure on waste water treatment facilities, many of which are aging. Currently about 1.5 billion litres of sewage is treated and released to the environment each day in New Zealand. The level of treatment commonly in place in New Zealand waste water treatment plants is not as advanced as that in Europe and North America. This means the quality of treated effluent being released to the New Zealand environment is not treated to the same level. As the New Zealand population continues to grow water resources come under increasing pressure, and this pressure will be compounded by future effects of climate change. As a consequence the New Zealand environment is not immune/protected to the effects of ECs in sewage effluents.

The limited research completed on ECs to date in New Zealand demonstrates our sewage effluents and biosolids contain similar concentrations of ECs to other western countries. At times some of these contaminants exceed international limits for application to land.

What we need to do now is obtain data on a wider range of ECs in treated effluents and biosolids in New Zealand. We expect the concentration of these ECs, pharmaceutical residues for example, to also be similar to concentrations reported overseas. Therefore we can expect these contaminants will display a similar range of effects to those observed in other countries.

We want to ensure the chemicals and products we use each day are not going to impact or degrade our environment. We need to ensure the risk they could pose to our environment is acceptable and not detrimental.

As we continue to grow our knowledge on ECs in New Zealand we'll provide updates within this newsletter.

If you would like further information on the programme or have any questions please contact a member of the Science Leadership Team:

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