2021 NZLTC Conference Proceedings

Technical Session 41

PART 3

New Zealand Land Treatment Collective

CONFERENCE

4 - 6 May 2021, Palmerston North

Coachman Hotel

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- Design of monitoring systems
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PDP specialise in land treatment of wastewater and biosolids management and have assisted clients in both the dairy and meat industry, as well as municipal clients, with consenting, design and implementation of land treatment systems. We are able to advise on appropriate solutions and negotiate resource consents with regional authorities. Our team of water infrastructure engineers have extensive experience in design of land treatment systems and biosolids management.

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Daryl Irvine
+64 9 523 6917
daryl.irvine@pdp.co.nz

Eoghan O'Neill
+64 3 422 1690
eoghan.oneill@pdp.co.nz

Jack Feltham
+64 9 523 6930
jack.feltham@pdp.co.nz

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+64 9 523 6906
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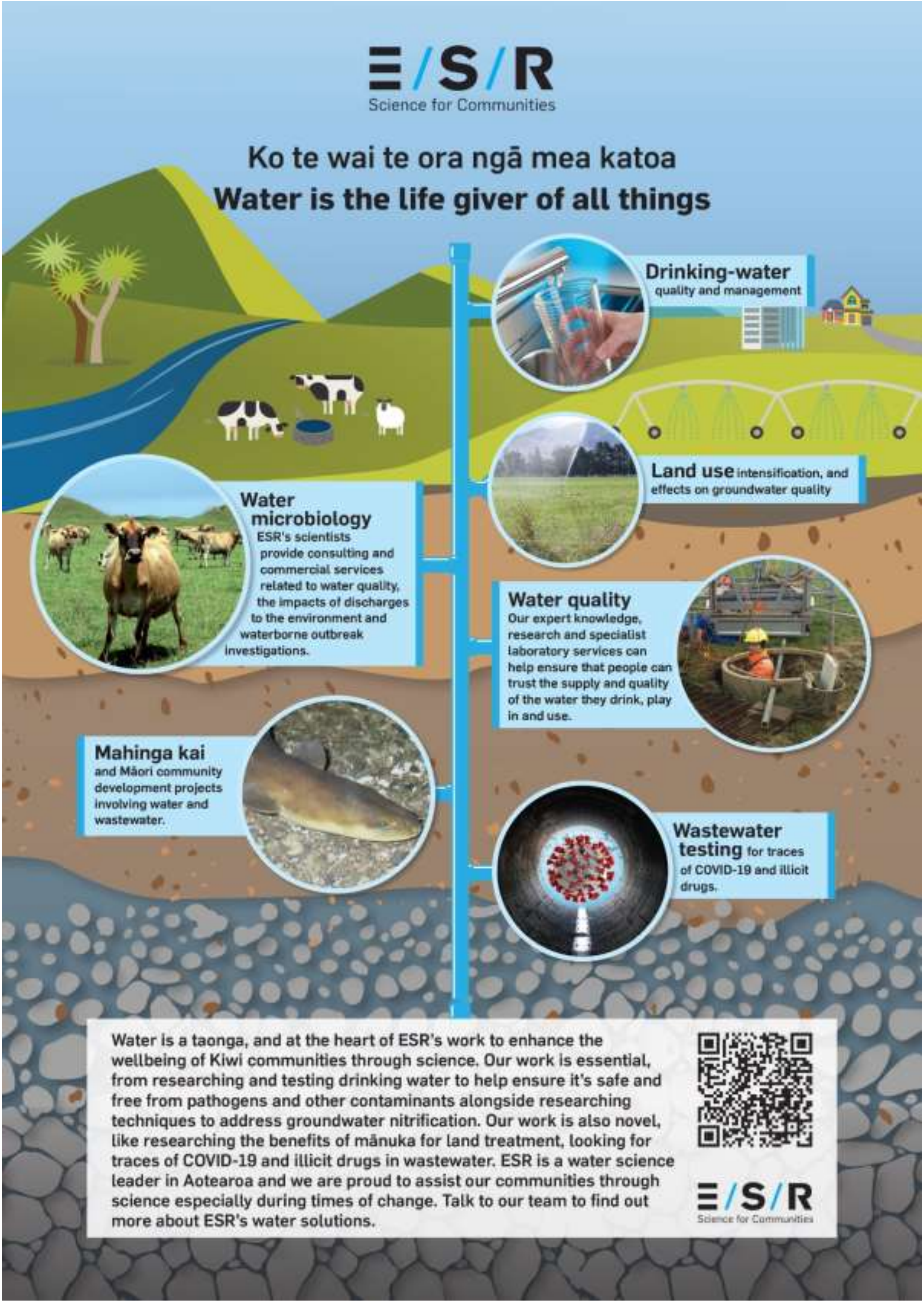
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CONTENTS

MICROPLASTICS IN SOIL-PLANT SYSTEM: SOURCE, FATE AND ECOLOGICAL IMPACT

Jianming Xue [AB]

[A] New Zealand Forest Research Institute (Scion), PO Box 29237, Riccarton, Christchurch 8440, New Zealand

[B] Corresponding author email: Jianming.xue@scionresearch.com

ABSTRACT

Antibiotic pollution has become a global environmental problem, threatening aquatic ecosystems and human health. Prior research has shown that land application of biosolids and animal manure can cause residual antibiotics and antibiotic resistance genes (ARGs) to enter the soil and food chain and increase environmental antibiotic resistance. In both China and New Zealand there is a pressing need to address this issue through developing sustainable approaches to minimise the risk of antibiotic resistance transmission from municipal and livestock wastes to humans or animals via the soil-water environments.

The dissemination of ARGs depends mainly on the growth of microbes. The ARG profile and bacterial community may co-evolve with a changing territorial environment. However, various bacterial phyla are found to be related to the evolution of ARGs. The horizontal gene transfer of plasmids may contribute to the dissemination of ARGs. This suggests that there will be higher risks of the prevalence of ARGs following application of biosolids. Previous studies have focused on the risks of biosolids application regarding changes in the abundance of ARGs, but have not addressed the evolution of ARGs, especially under the multiple stresses of other biosolids-derived contaminants (e.g. heavy metals, microplastics) in the soil environment. This presentation outlines available information about these aspects.

Putting waste to work

Microplastics in soil-plant system: source, fate and ecological impact

Jianming Xue

Centre for Integrated Biowaste Research

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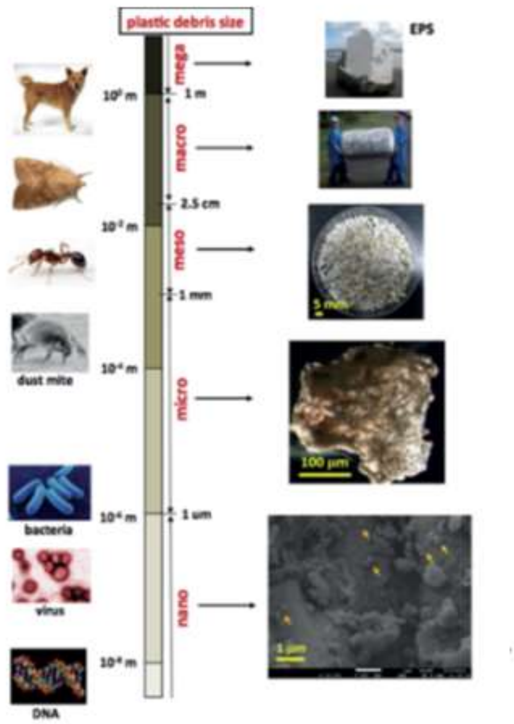
Background

Size range of plastic objects observed in the marine environment and some comparisons with living material.

These size distinctions could form the basis of a more rigorous description.



Background

- More than 80% of plastics found in marine environments has been produced, consumed and disposed of on land.
- Microplastic (MPs) contamination on land is estimated to be between 4 to 32 times higher than in the oceans.
- In addition to inadequate end-of-life treatment of plastic waste, plastics reaches our soils through increasing use for agricultural purposes.

(From Susanna Gionfra, MAY 2018)

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Background

- Yearly inputs of microplastics in European and North American farmlands are estimated to be 63,000-430,000 and 44,000-300,000 tonnes respectively.
- A greater consideration of the issue of plastic pollution in soil and its implications is needed in research, policies and legislation.

Sources of MPs in the soil

- **Plastic mulch films**
- **Biosolids, composts and treated wastewater**
- Soil conditioners (e.g. polyurethane foam and polystyrene flakes).
- Greenhouse materials
- General littering

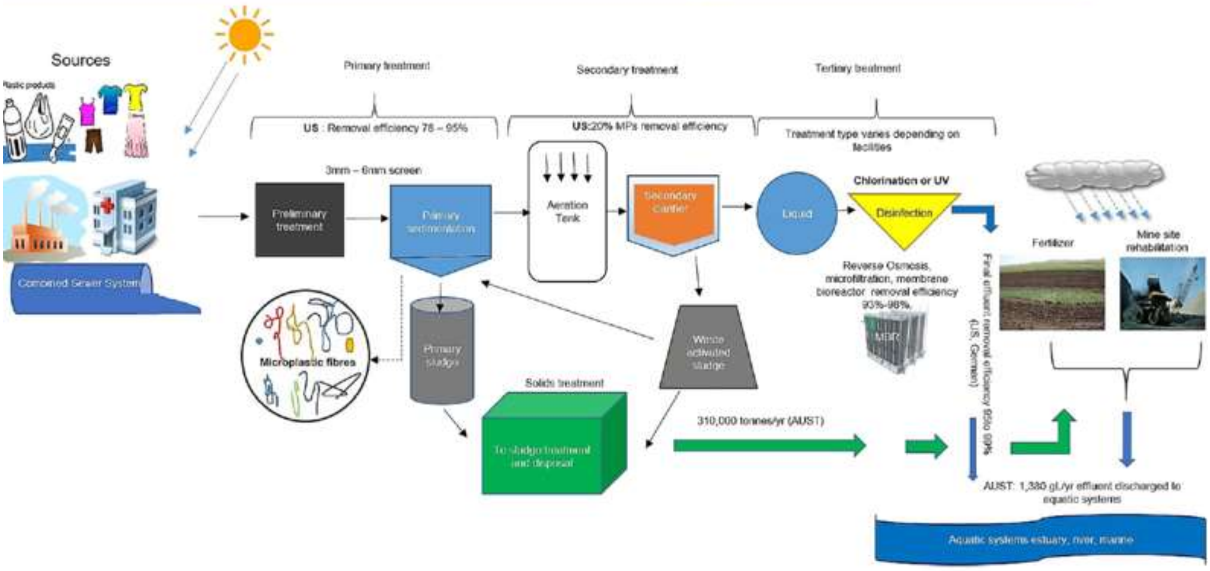
Sources of MPs in the soil

- **Use of plastic mulch -** to increase crop yield.

Figure 1. Plastic film mulching field in Tongchuang, Shaanxi and plastic mulch residue field in Shihezi, Xijiang, China.

Sources of MPs in the soil

Sources, transport and fate of MPs in wastewater treatment plants



Raju et al. "**Transport and fate of microplastics in wastewater treatment plants: implications to environmental health.**" *Reviews in Environmental Science and Bio/Technology* 17.4 (2018): 637-653.

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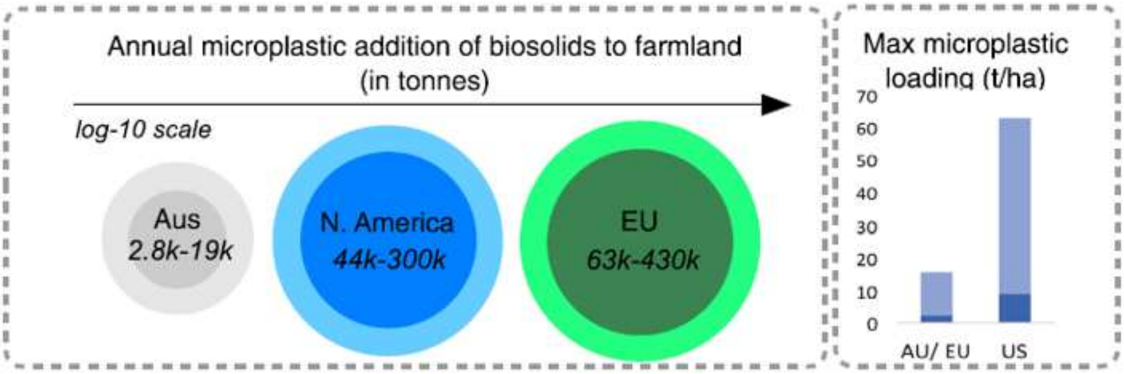
Estimated microplastic pollution loads released into the Soil via WWTPs

(Nizzetto et al., 2016; Ng et al. 2018).



- During the treatment process, around 95% of Microplastics is retained in biosolids (Ziajahromi et al. 2016).
- PE, PP, PVC, PA, co-polymers and zinc stearate-coated particles appeared in sludge applied to land in Denmark (Lassen et al. 2015).

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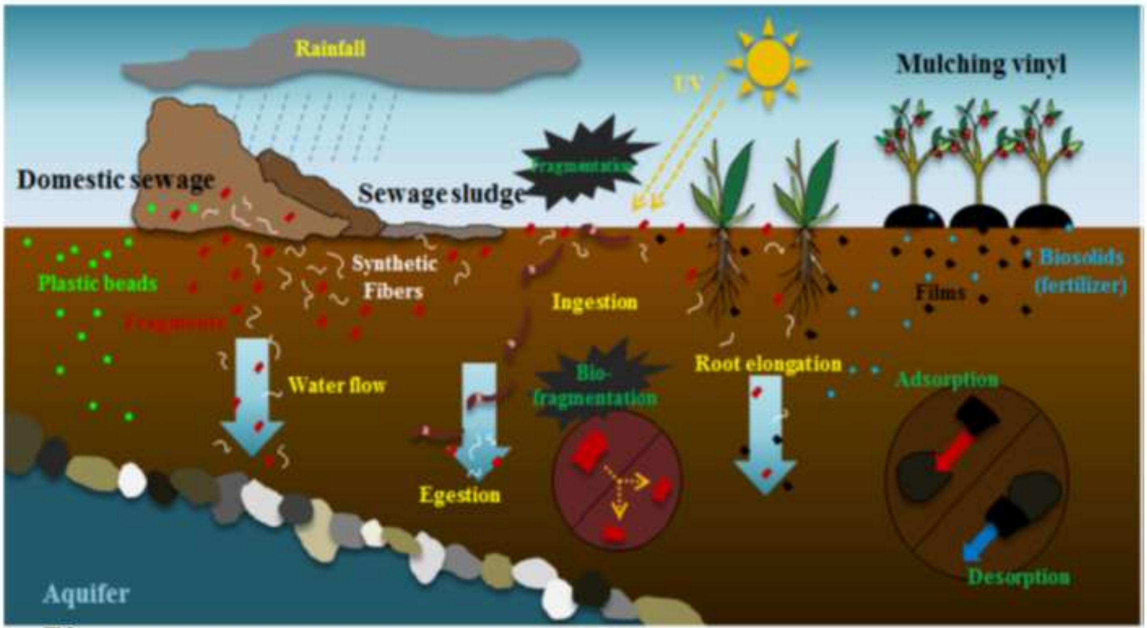
Compost – another sources of plastic pollution in agroecosystems

- Some compost collection programs accept plastic-coated paper products.
- When composted, these products produce plastic fragments that do not biodegrade.
- Plastic fragments can make their way from compost-treated soils into the larger environment, and may be ingested by living organisms.
- Plastics fragments accumulate persistent organic pollutants and can transfer these chemicals to living organisms.




Sources and pathways

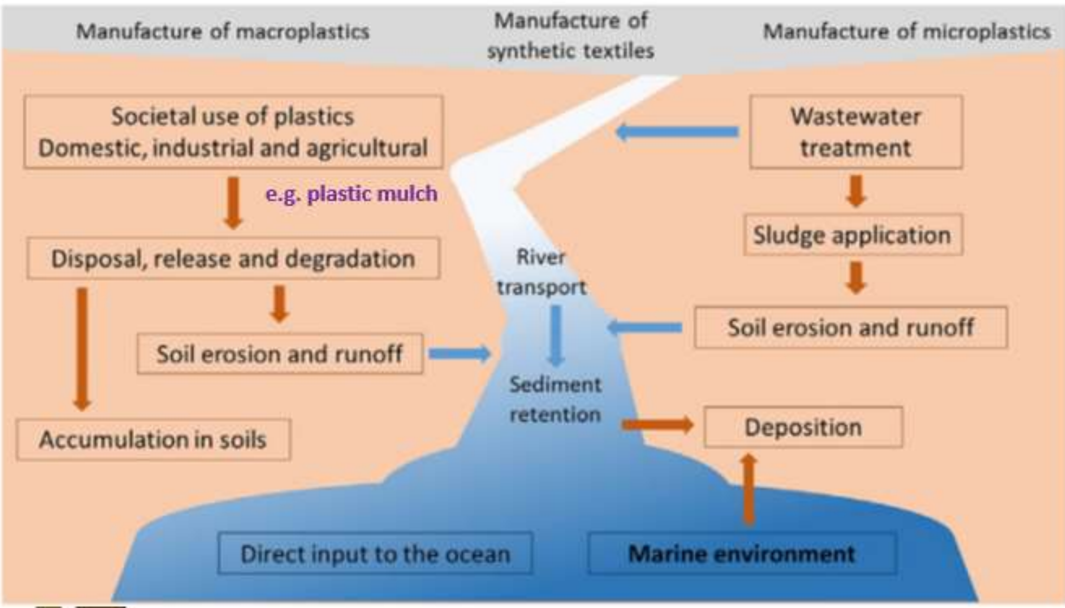
How microplastics are transported to the terrestrial ecosystems and the soil?



Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review (Chae & An 2018)

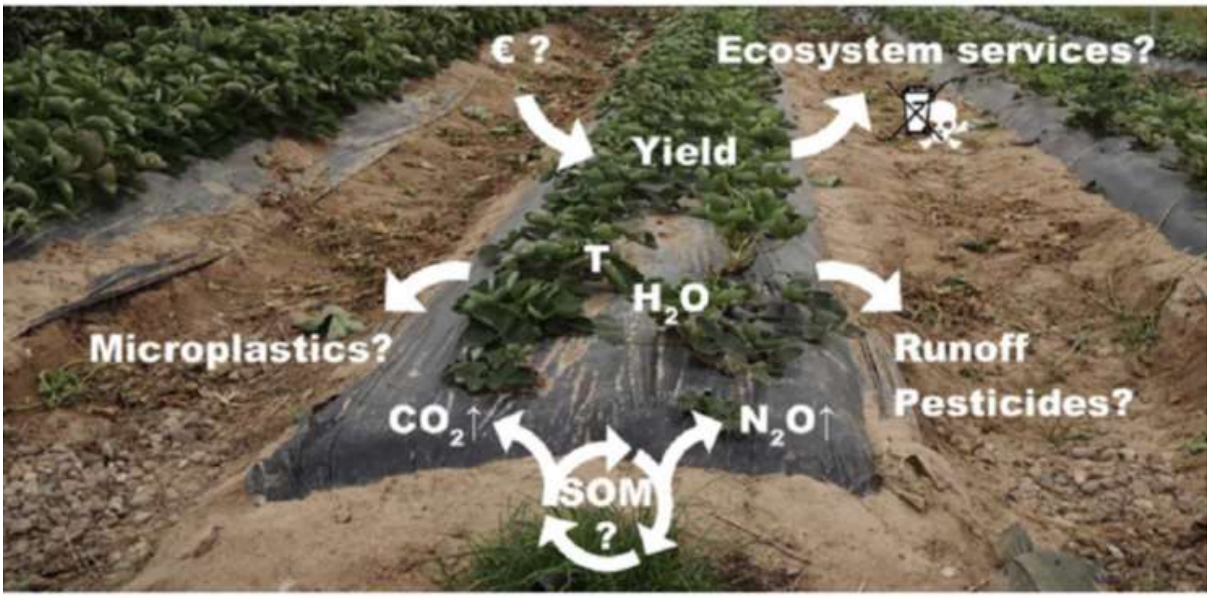
Pathways to Aquatic Environments

More than 80% of plastics found in marine environments has been produced, consumed and disposed of on land.



Plastics in the terrestrial and aquatic system (Hortson et al. 2017)

Ecological impacts of MPs in the soil



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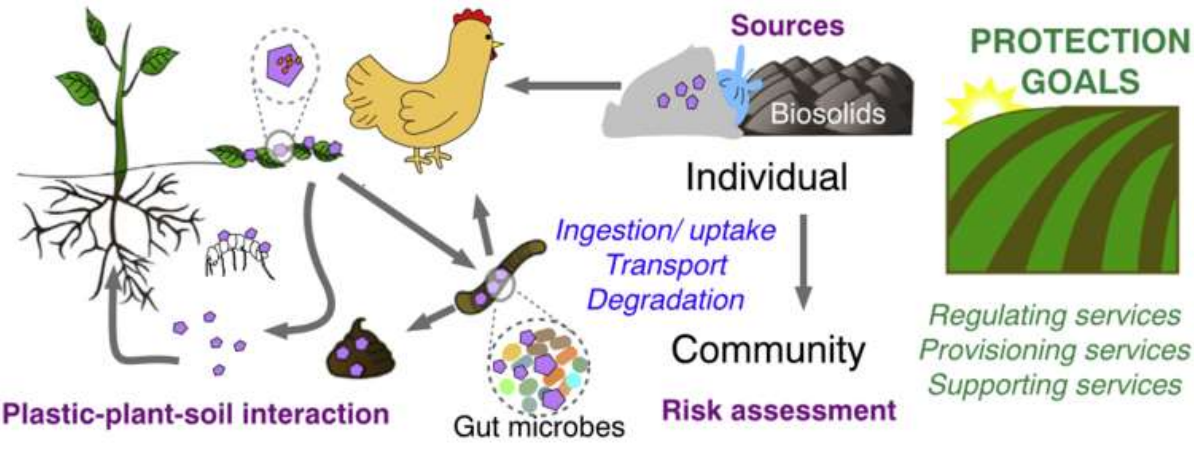
Steinmetz et al. 2016 Plastic mulching in agriculture. Trading short-term agronomic benefits for long-term soil degradation. *STE*

Ecological Impact of MPS on Terrestrial Ecosystems

Ng et al 2018. An overview of microplastic and nanoplastic pollution in agroecosystems. *Science of the Total Environment* 627, 1377–1388



Ecological impact of MPs in the soil

- Microplastics (MPs) potentially affected
  - ➢ bulk density
  - ➢ water holding capacity
  - ➢ Soil biota – e.g. microbial functions
- The gradual accumulation of **MPs in the soil** can lead to an **adverse impact on soil biota** such as earthworms, termites, collembola, nematodes and small rodents

(De Souza Machado et al. 2018)

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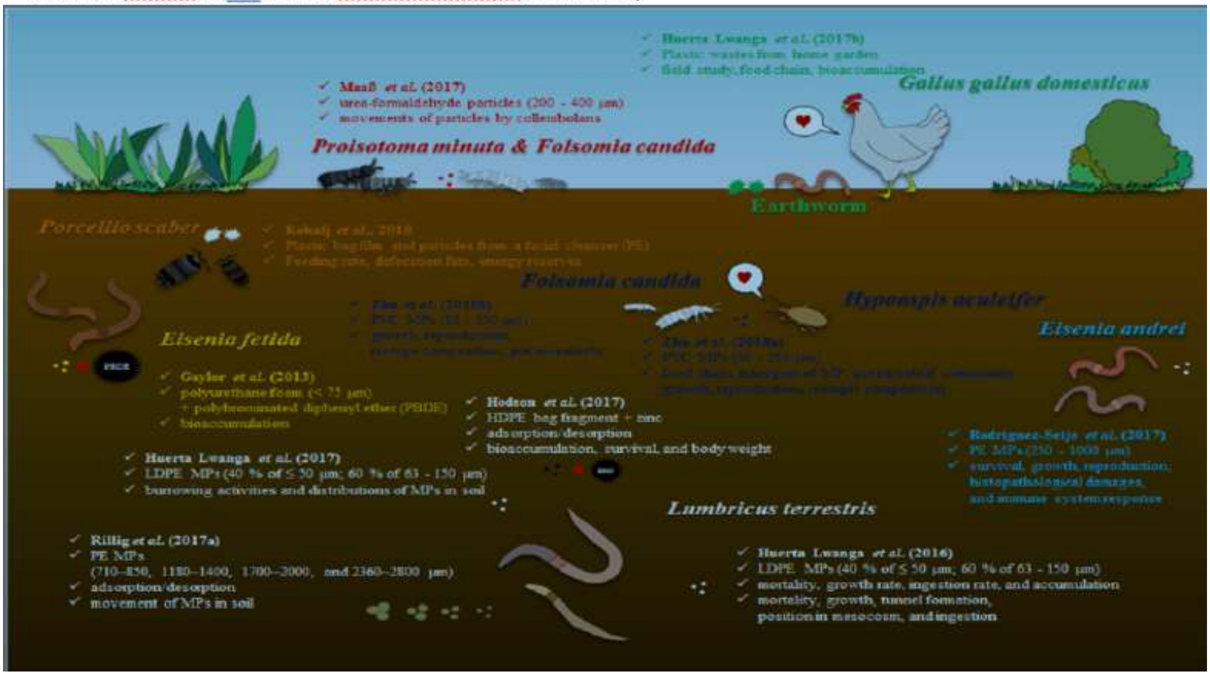
Impact of MPs on soil biota

Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review (Chae & An 2018 *Environmental Pollution*)



Effect of MPs on earthworm

What effect of MPs on soil invertebrates (soil ecosystem indicators) i.e. earthworms?

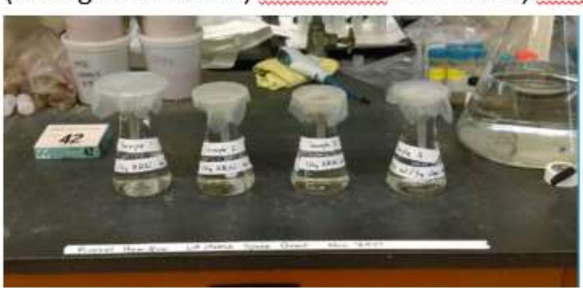
- **Mortality, growth, ingestion, reproduction rate**
- **Behaviour (avoiding behaviour?)**
- **Bio-acumulation of MPs in casts**)

Field evidence for transfer of plastic debris along a terrestrial food chain (Prof Geissen et al., Dr Lwanga et al., Netherland)

Effect on soil properties –Water holding capacity

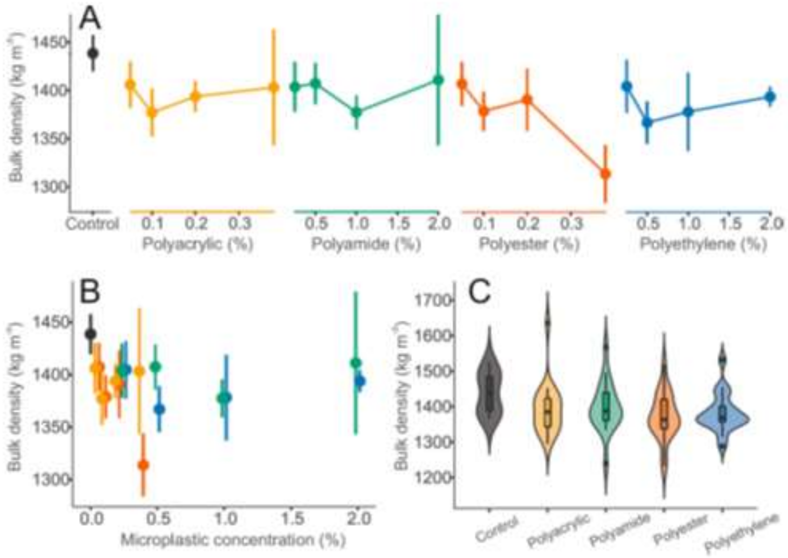
- Soil water holding capacity: how much water the soil can retain—important to agriculture
- Experimented on the presence of polyethylene (PE) powder and pellets on soil water holding capacity
- Found that soil and plastic mix had water holding capacity reduced by 15% (plastic pellets) and 85% (plastic powder)

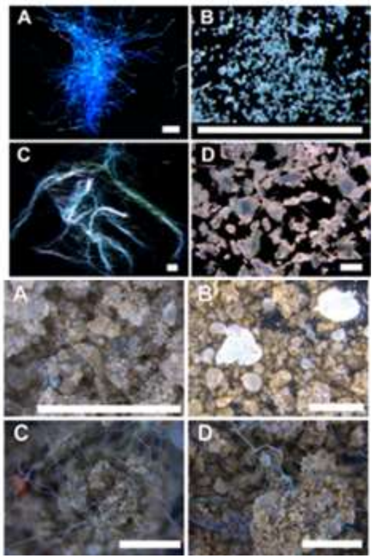
(Lwanga et al. 2016, Ramadass et al. 2016; Rillig et al. 2017; Prata 2018).



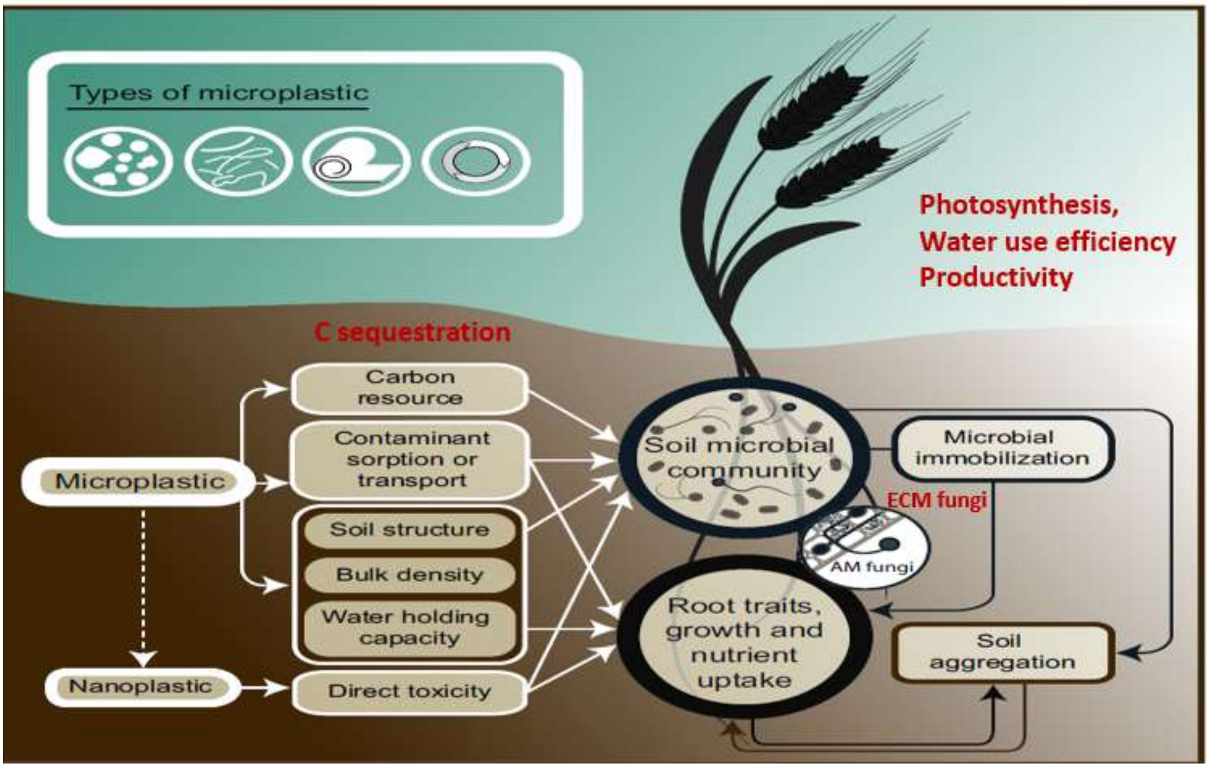
Effect on soil properties – bulk density

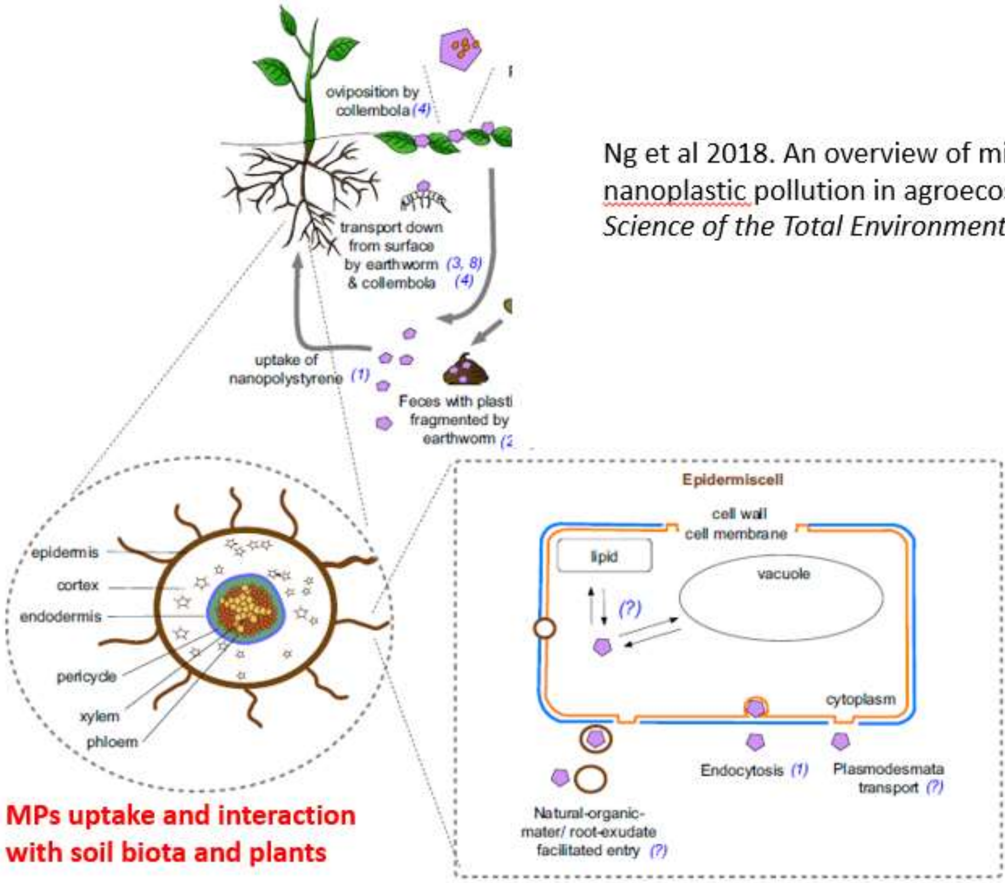
Microplastics altered fundamental properties of the soil biophysical environment with consequences for functional changes in soils (Machado et al., 2018).





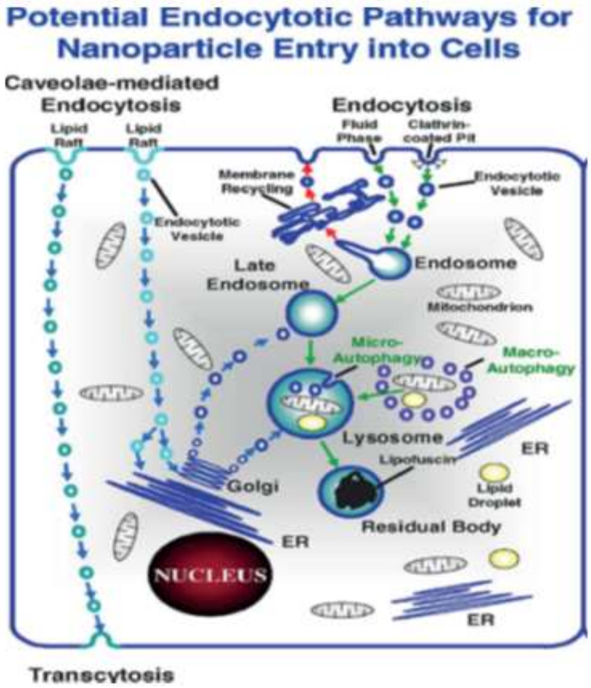
Microplastic effects on plants





Ng et al 2018. An overview of microplastic and nanoplastic pollution in agroecosystems. *Science of the Total Environment* 627.

Pathways for endocytosis in the cell

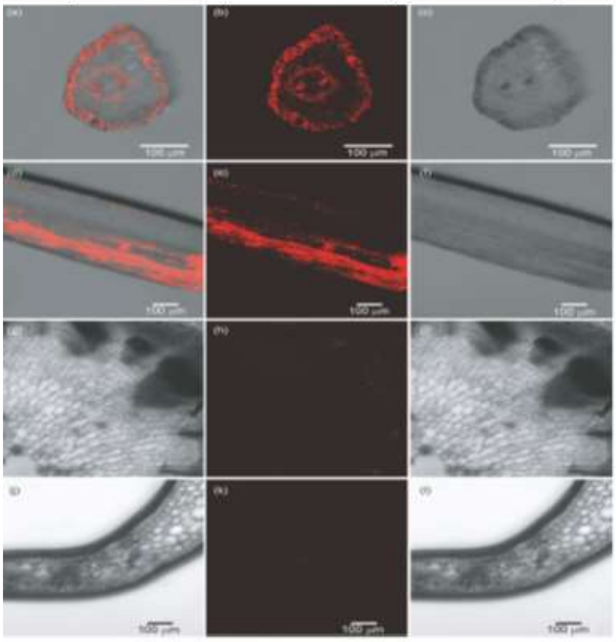


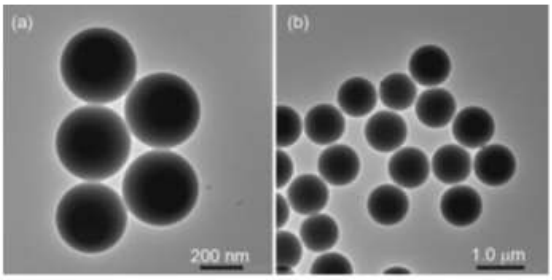
Endocytosis via clathrin-coated pits (receptor mediated) or uncoated pits (fluid phase) transfers materials to the lysosomal degradative compartment, while caveolar endocytosis can result in translocation to the endoplasmic reticulum (ER), Golgi or through the cell by trancytosis

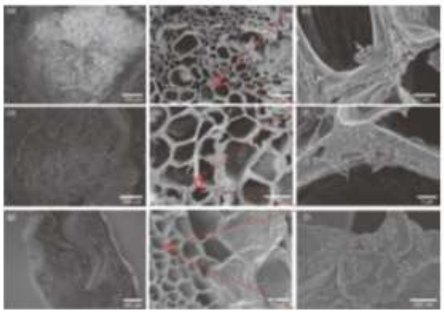
(Shin and Abraham 2001; van der Goot and Gruenberg 2002)
modified by Moore 2006.

Uptake and distribution of MPs in plant

Uptake and accumulation of microplastics in an edible plant
(Li et al. 2019, *Chin Sci Bull*, 64: 928–934)







KNOWLEDGE GAP

- Almost no terrestrial studies have been done to mirror marine findings
- Insufficient understanding of the dynamics and fate of microplastics (MPs) in soils, and the consequences on plants and soil biota.
- So far, studies on the ecological impact of MPs in soils are mostly at organismal level. What impact at higher biological organization levels (e.g. population)?
- Nonlinear or non-sigmoidal dose-response relationships are common, such as the U-shape or inverted U-shaped responses. Any hormetic effect of MPs on plant and soil biota?

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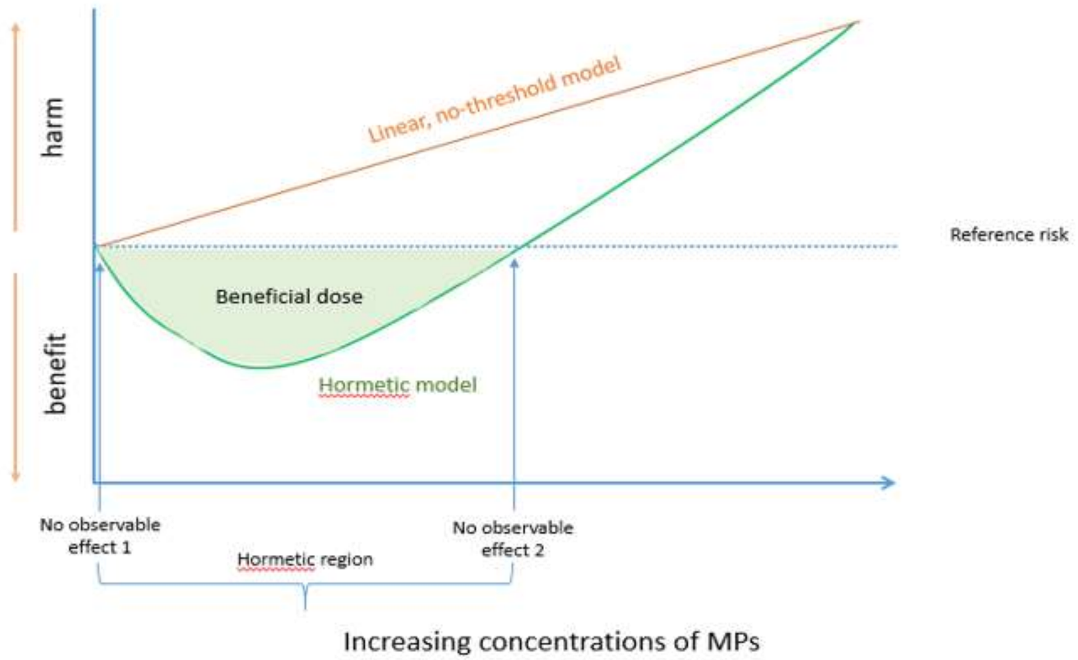
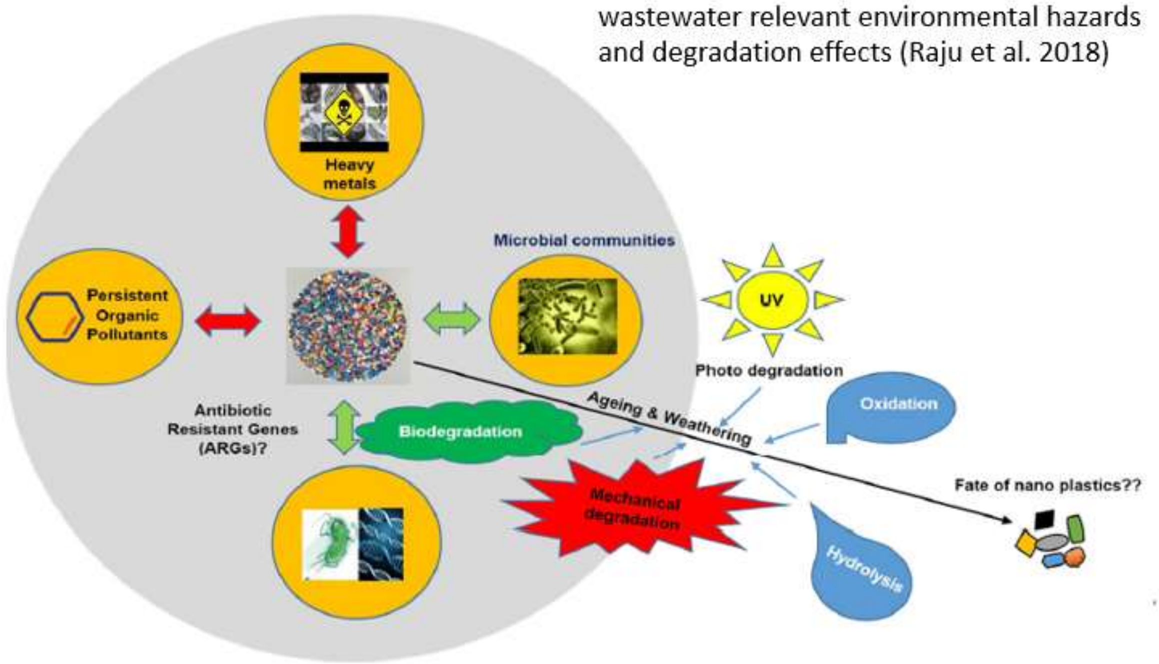
Hormesis of MPs?

U-shape or inverted U-shaped responses.



Interactions of MPs with adsorbed chemicals

Interaction of microplastics with wastewater relevant environmental hazards and degradation effects (Raju et al. 2018)



FUTURE RESEARCH

- Effects on other organisms such as **plants, invertebrates, insects, and microorganisms** need to be urgently considered.
- Recent studies have focused on PE fragments and spheres. To simulate practical and realistic situations, **various sizes, shapes, compositions, and origins of plastics** are needed.
- We need to consider various scenarios that can occur in real environments, such as **trophic transfer and generational effect**.
- We also have to consider **additives of plastic products** (plasticizers, retardant, antioxidants, and photostabilizers) and **adsorbed chemicals (ee.g. antibiotics)** in the soil environment.

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Acknowledgements

- **Prof Yongming Luo and Organizing Committee** of the MPs Conference for kind invitation and support.

For more info: jianming.xue@scionresearch.com

Thanks!

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DO MICROPLASTICS AFFECT PRODUCTIVE SOIL SYSTEMS?

Helena Ruffell [AD], Sally Gaw [A], Brett Robinson [A], Olga Pantos [B], and Grant Northcott [c]

[A] University of Canterbury, Christchurch
[B] Institute of Environmental Science and Research, Christchurch
[C] Northcott Research Consultants, Ltd

[D] Corresponding author email: helena.ruffell@pg.canterbury.ac.nz

ABSTRACT

Microplastics are plastic particles less than 5 mm in diameter. They result from fragmentation of plastic products or are purposefully produced e.g. as abrasives for commercial cleaning and personal care products.[1] Microplastics also include synthetic fibres released to the environment through the washing and general wear of synthetic textiles.[2]

It has been suggested that wastewater treatment plants (WWTPs) are a significant source of microplastics into aquatic and terrestrial environments. This first study (MSc) has increased the understanding of whether WWTPs are a significant source of microplastics to the environment in the Canterbury region, with concentrations detected up to 2.4 particles/L and 2.1 particles/L respectively in influent and effluent.

Plastics are widely used primarily in agricultural / horticultural settings, like the use of plastic mulch sheeting to prevent weed growth and reduce the need for pesticide use. Compost produced from municipal green waste collections and biosolids from wastewater treatment plants applied as soil conditioners may contain traces of microplastics and are also considered a source of microplastics to the terrestrial environment.

This second study (PhD) will investigate the behaviour, fate, and effects of microplastics in productive soil systems, with investigation of the interactions with common horticultural chemicals and contaminants and microbial communities.

[1] H. Leslie, *Inst. Environ. Stud.* **2014**.

[2] M. Browne, P. Crump, S. Niven, E. Teuten, A. Tonkin, T. Galloway, R. Thompson, *Environ. Sci. Technol.* **2011,** *45,* 21.

Microplastics in wastewater, biowaste and productive soil systems

Helena Ruffell

Supervised by

Professor Sally Gaw, Professor Brett Robinson

(University of Canterbury)

Dr Olga Pantos

(The Institute of Environmental Science and Research, Christchurch)

Dr Grant Northcott

(Northcott Research Consultants Ltd)

Microplastics

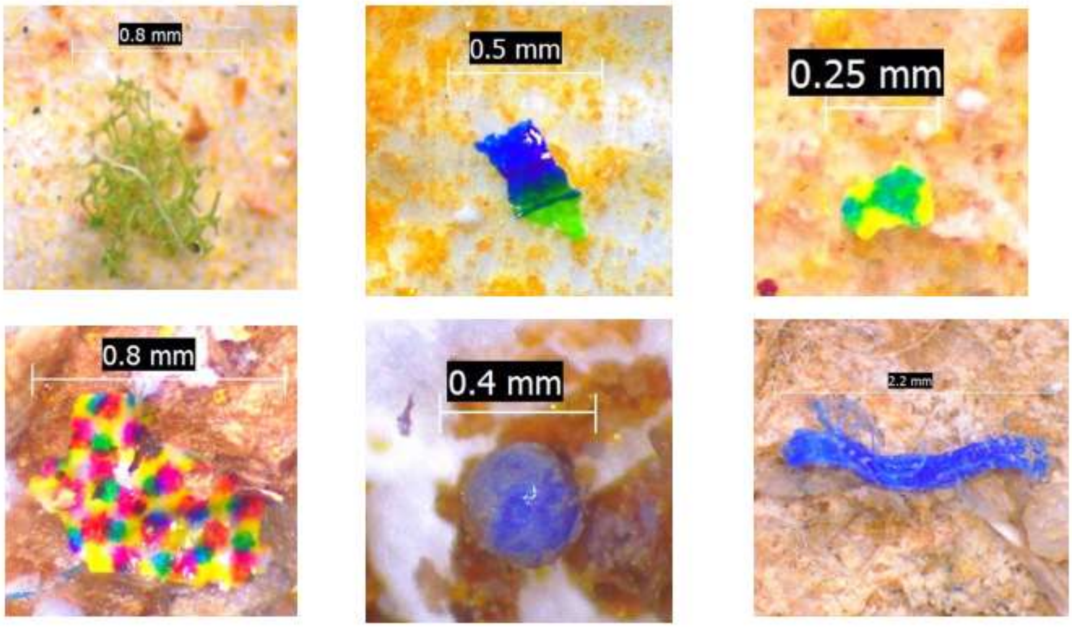
- Smaller than 5 mm
- Primary – purposefully produced
- Secondary – degradation of larger pieces

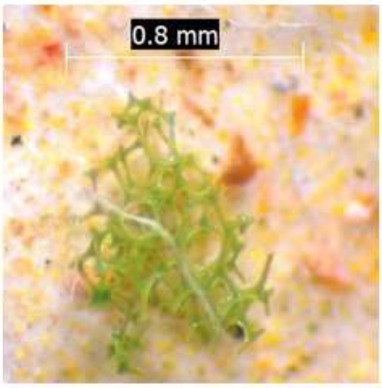

Justin Hofman

Sampling

- 4 WWTPs – Kaiapoi, Christchurch, Lyttelton, Governors Bay
- First study: Influent and effluent, Weekend and weekday of June
- Second study: Effluent in June, August, October, December

Sampling of WWTPs

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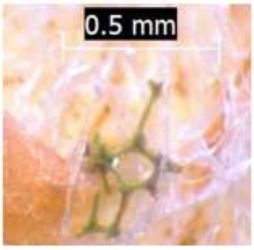
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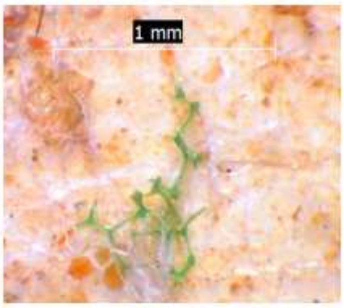
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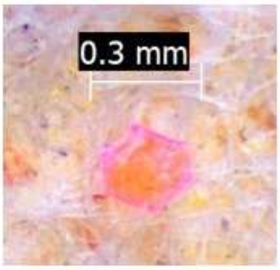
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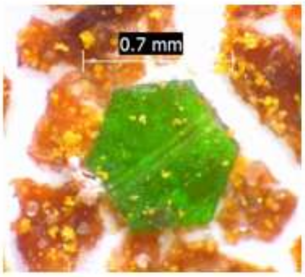
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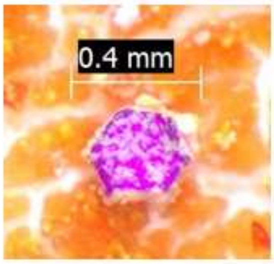
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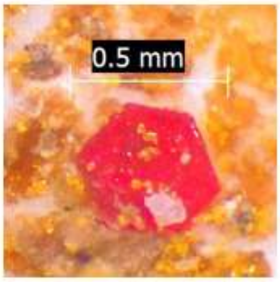
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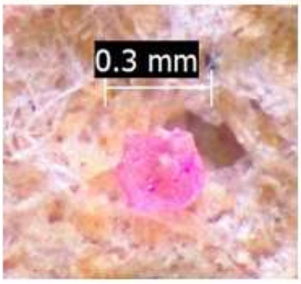
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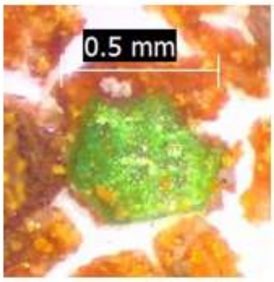
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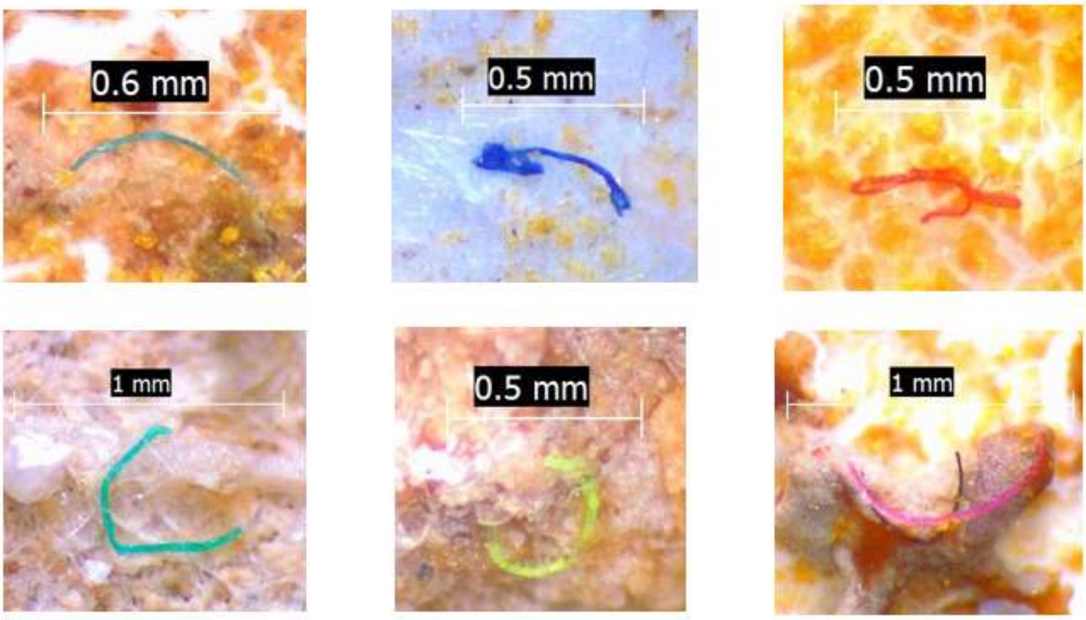
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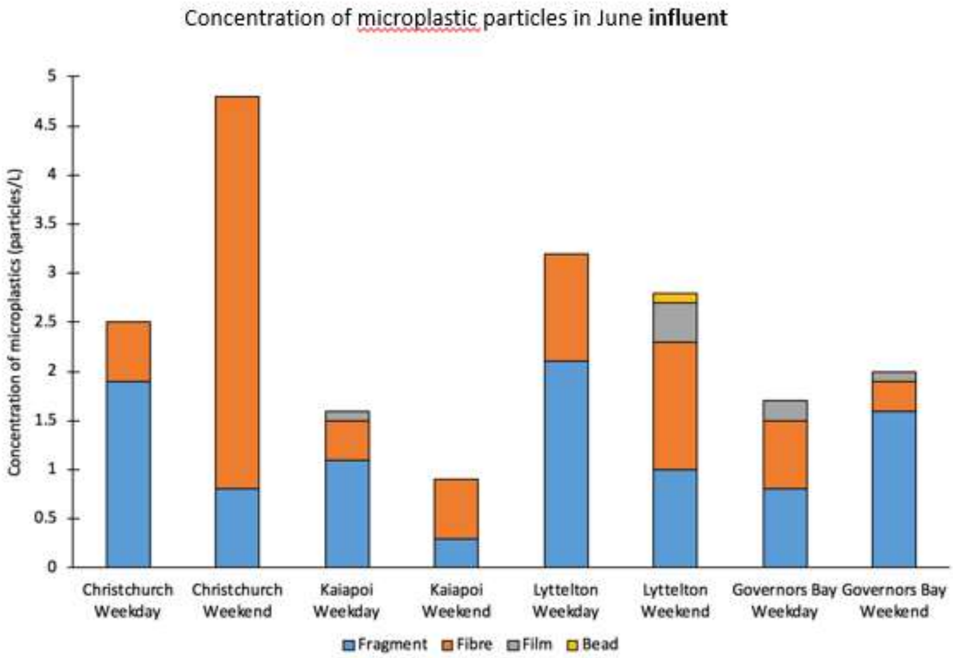
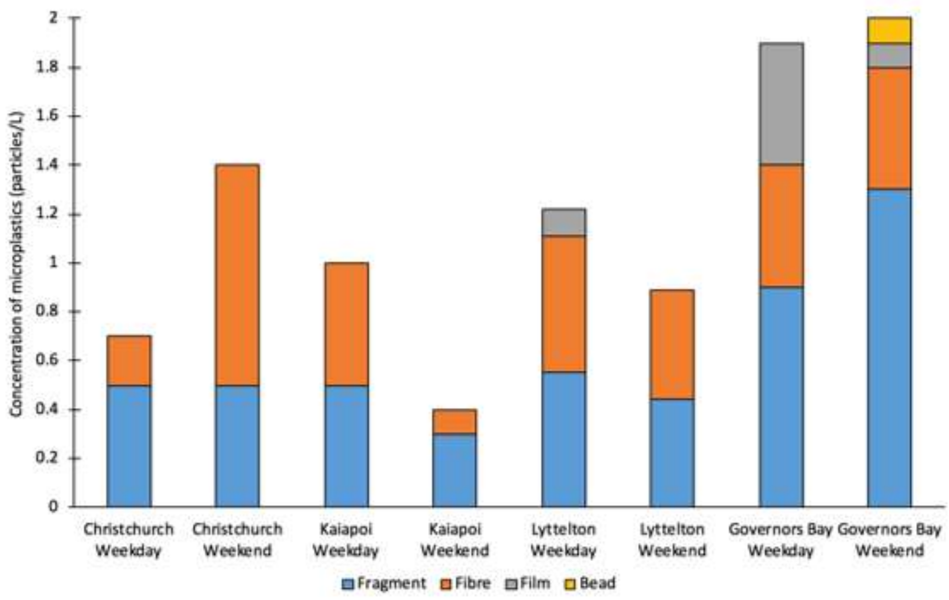
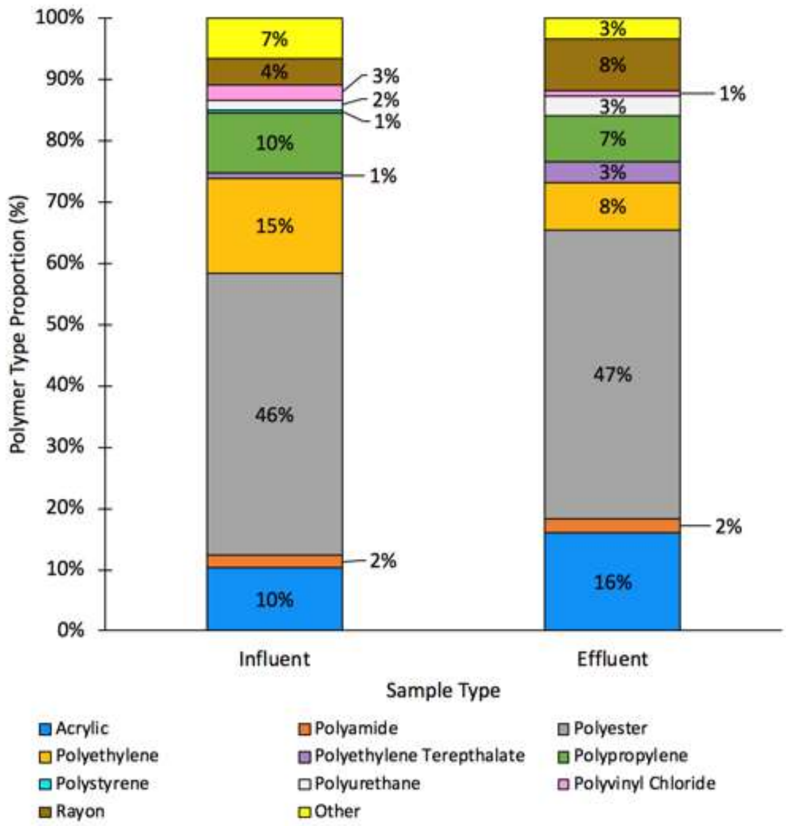

Concentration of microplastic particles in June **influent**
Concentration of microplastics (particles/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Christchurch Weekday
Christchurch Weekend
Kaiapoi Weekday
Kaiapoi Weekend
Lyttelton Weekday
Lyttelton Weekend
Governors Bay Weekday
Governors Bay Weekend
Fragment
Fibre
Film
Bead

Concentration of microplastic particles in June **effluent**



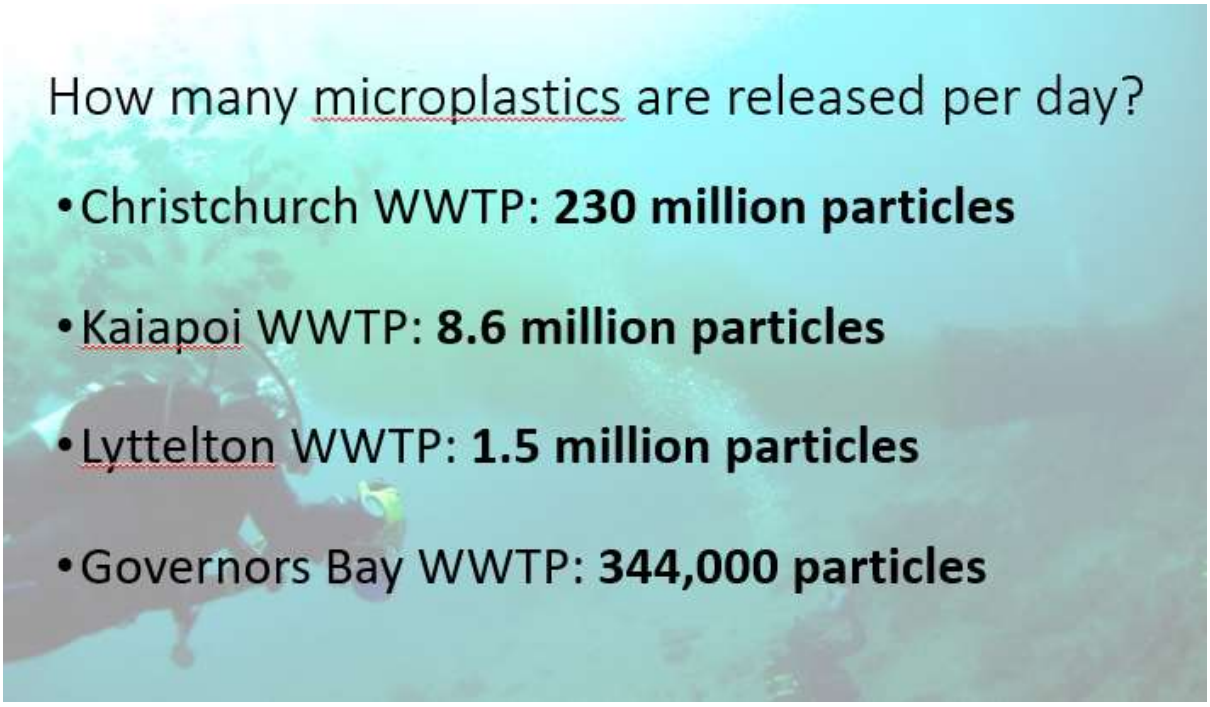
Polymer type proportion of microplastics in June **influent** and **effluent**

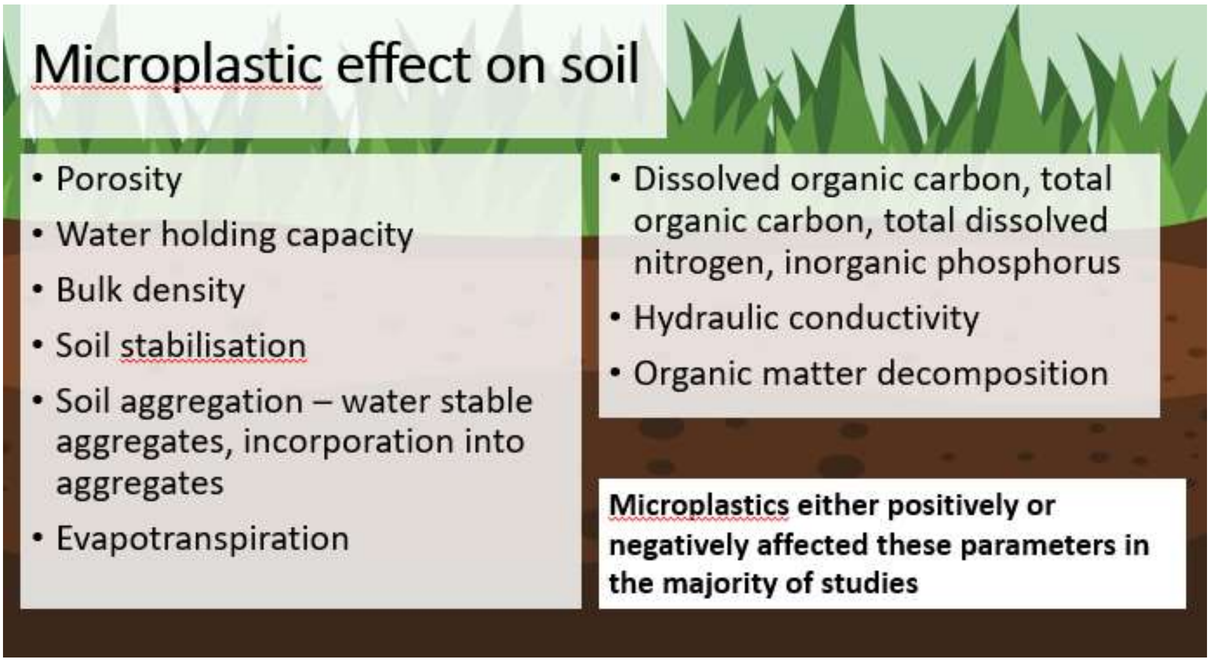


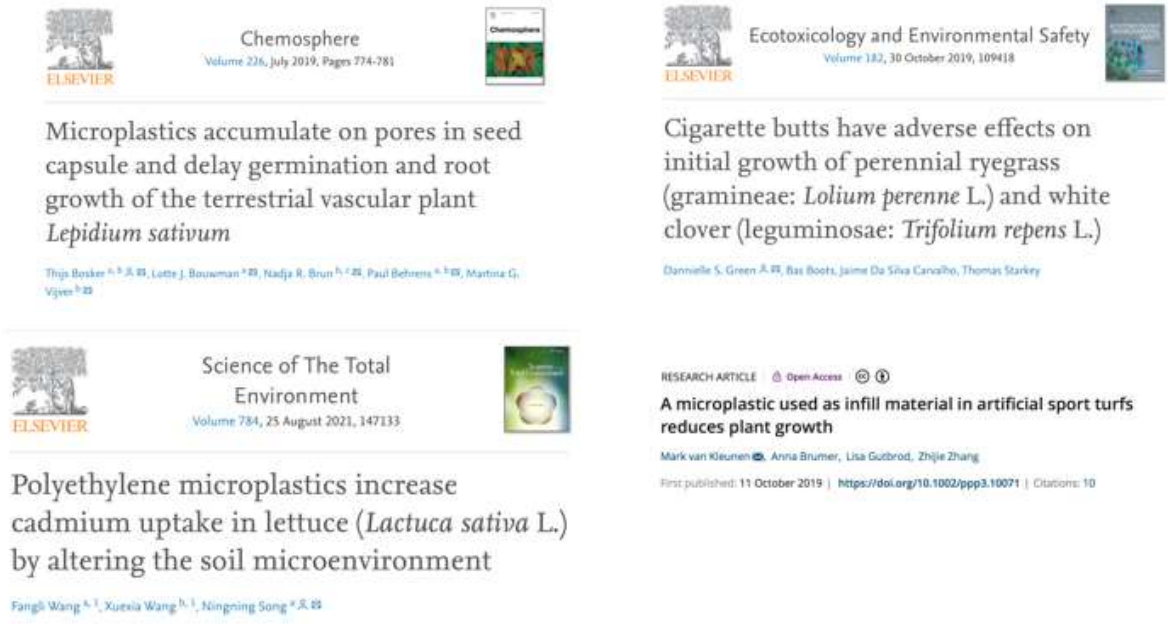
How efficient are WWTPs at removing microplastics?

- Christchurch: 72%
- Kaiapoi: 47%
- Lyttelton: 67%
- Governors Bay: ???

How many microplastics are released per day?


How many microplastics are released per day?
• Christchurch WWTP: 230 million particles
• Kaiapoi WWTP: 8.6 million particles
• Lyttelton WWTP: 1.5 million particles
• Governors Bay WWTP: 344,000 particles


Microplastic effect on soil
• Porosity
• Water holding capacity
• Bulk density
• Soil stabilisation
• Soil aggregation – water stable aggregates, incorporation into aggregates
• Evapotranspiration
• Dissolved organic carbon, total organic carbon, total dissolved nitrogen, inorganic phosphorus
• Hydraulic conductivity
• Organic matter decomposition
Microplastics either positively or negatively affected these parameters in the majority of studies


Chemosphere
Volume 226, July 2019, Pages 774-781

Microplastics accumulate on pores in seed capsule and delay germination and root growth of the terrestrial vascular plant *Lepidium sativum*

Thijs Bosker [a, b], Lotte J. Bouwman [a], Nadja R. Brun [b, c], Paul Behrens [a, b], Martina G. Vijver [b]

Ecotoxicology and Environmental Safety
Volume 182, 30 October 2019, 109418

Cigarette butts have adverse effects on initial growth of perennial ryegrass (gramineae: *Lolium perenne* L.) and white clover (leguminosae: *Trifolium repens* L.)

Dannielle S. Green, Bas Boots, Jaime Da Silva Carvalho, Thomas Starkey

Science of The Total Environment
Volume 784, 25 August 2021, 147133

Polyethylene microplastics increase cadmium uptake in lettuce (*Lactuca sativa* L.) by altering the soil microenvironment

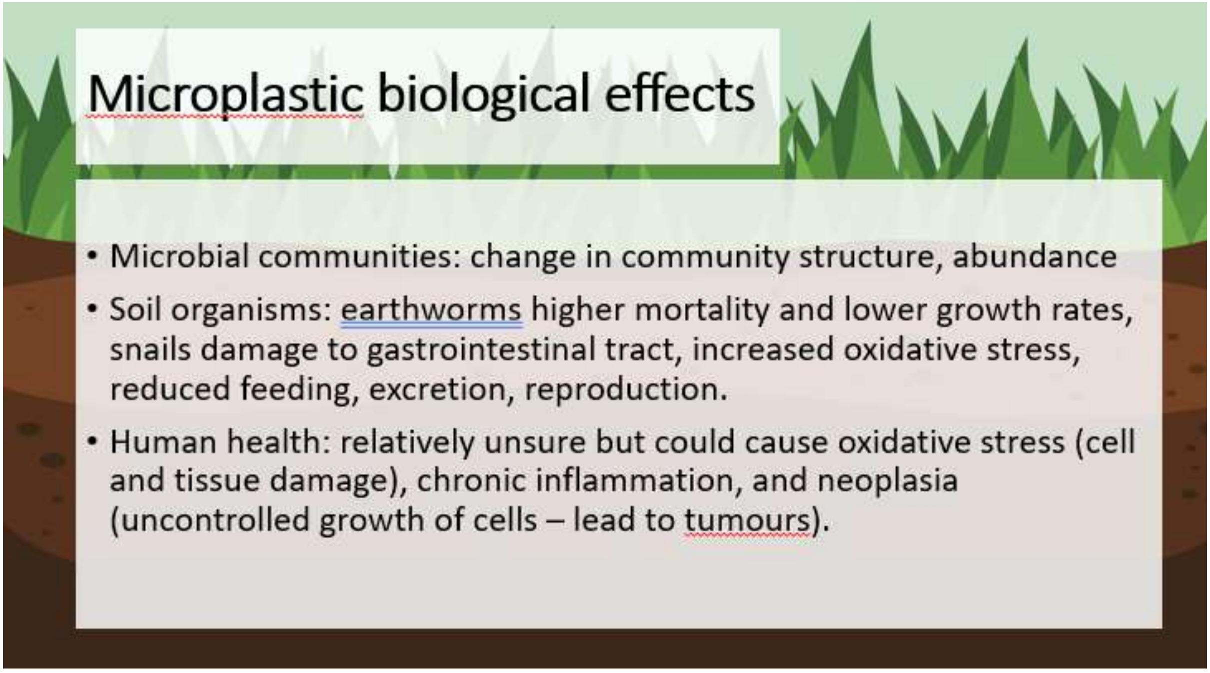
Fangli Wang [a, 1], Xuexia Wang [b, 1], Ningning Song [a]

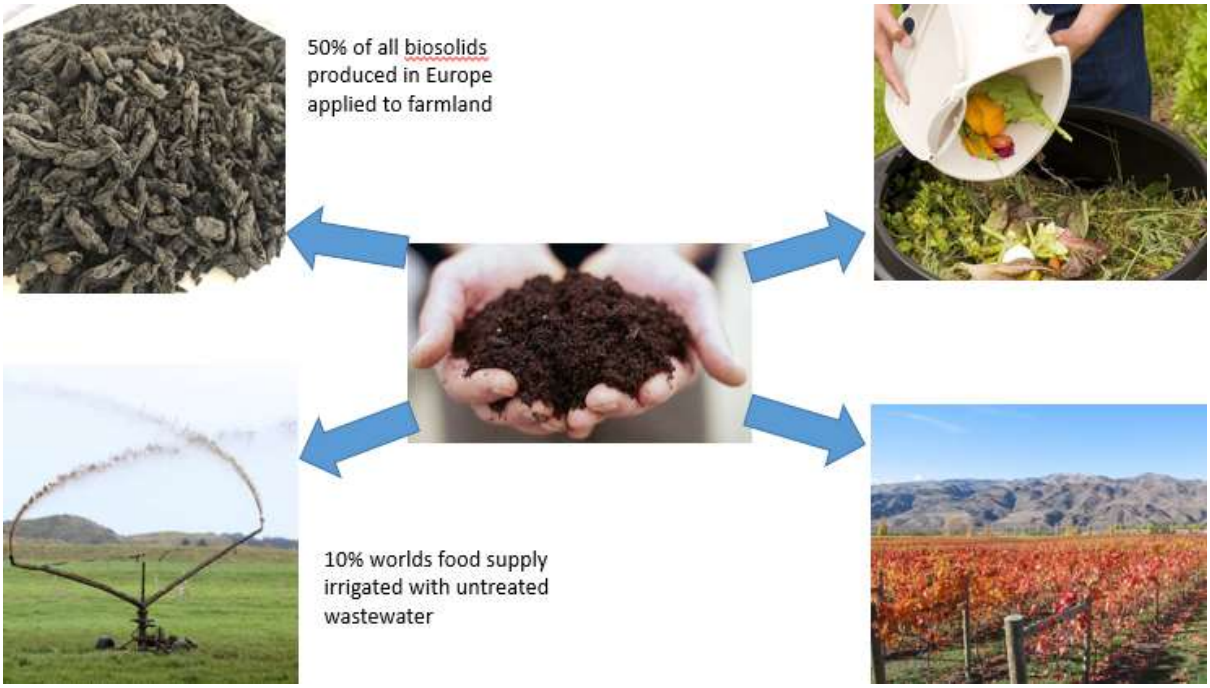
RESEARCH ARTICLE | Open Access

A microplastic used as infill material in artificial sport turfs reduces plant growth

Mark van Kleunen, Anna Brumer, Lisa Gutbrod, Zhijie Zhang

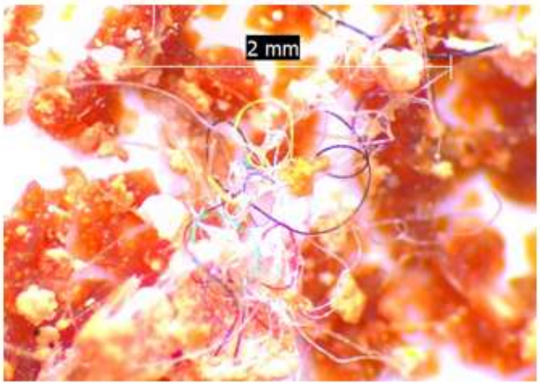
First published: 11 October 2019 | https://doi.org/10.1002/ppp3.10071 | Citations: 10

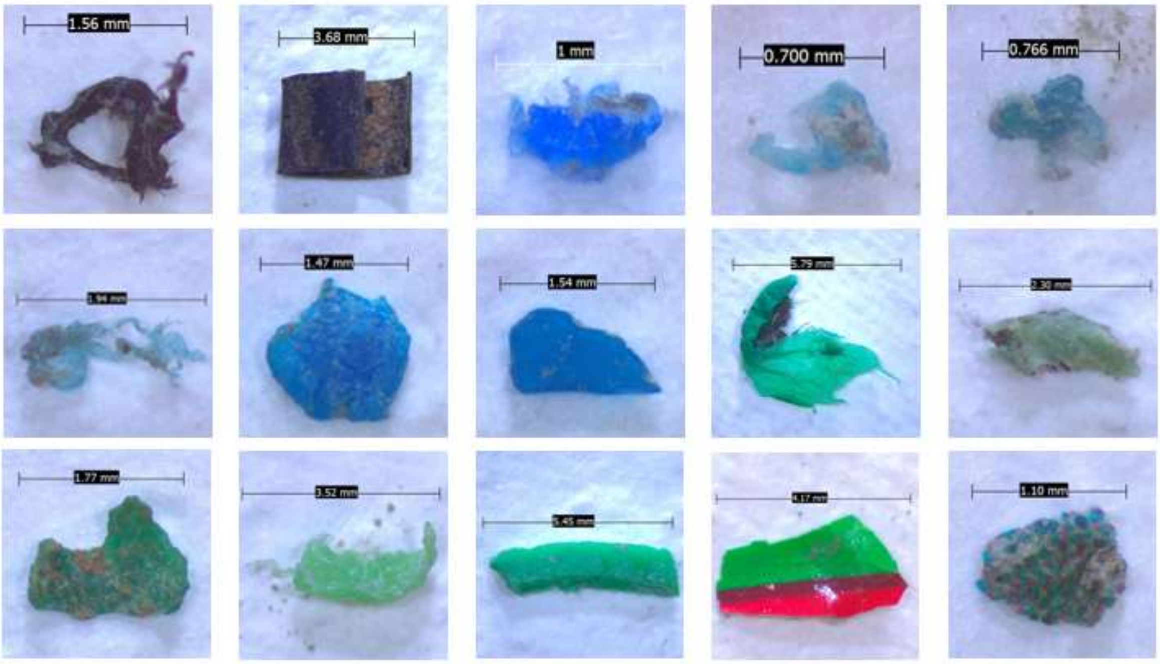



50% of all biosolids produced in Europe applied to farmland
10% worlds food supply irrigated with untreated wastewater

Project aims:

- How much plastic is present in each medium?
- How does microplastic behave in soil?
- What are the impacts of plastic in soil?




1.56 mm
3.68 mm
1 mm
0.700 mm
0.766 mm
1.47 mm
1.54 mm
1.77 mm
3.52 mm
1.10 mm


Acknowledgements
• Sally, Olga, Brett, Grant
• Dr Louise Weaver, Bronwyn Humphries, Dr David Wood, Bridget Armstrong (ESR)
• Rob Stainthorpe, Matt Polson, Matt Cockcroft, Chris Grimshaw, Nick Oliver, Rob McGregor (University of Canterbury)
• Mike Bourke (CCC), Rob Frizzell (Waimakariri District Council)
• MBIE, The Brian Mason Trust, ESR, The Evan's fund
• The Land Treatment Collective for the student conference scholarship
UC
UNIVERSITY OF CANTERBURY
AIM²
Aotearoa Impacts & Mitigation of Microplastics
MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
BRIAN MASON
SCIENTIFIC & TECHNICAL TRUST
E/S/R
Science for Communities

NEW ZEALAND-WIDE VERMICOMPOSTING OF MUNICIPAL BIOSOLIDS AND ORGANIC WASTE

Michael Quintern [AB], and Charlotte Robertson [B]

[A] Noke Ltd., PO Box 347, Seventh Avenue, Tauranga 3140, New Zealand

[B] Corresponding author email: michael@mynoke.co.nz

ABSTRACT

Industrial scale vermicomposting of municipal biosolids has become commercially and economically viable in New Zealand and has grown steadily since 2008. Approximately 35,000 t of municipal biosolids were vermicomposted in 2020 from Hamilton, Taupo, Rotorua, Te Puke, Tokoroa, Turangi, Maketu, and other cities. New vermicomposting sites will be established in 2021 to double vermicomposting capacity by the end of 2021.

Currently municipal biosolids are vermicomposted by blending with pulpmill solids. Services are therefore concentrated in the Central North Island. To roll out this service New Zealand-wide the vermicomposting technology requires adaptation to various climates such as winters in the alpine regions and drought conditions. A substitute for pulpmill solids as a carbon source has been found and successfully trialled achieving Aa-grade 'standard' vermicast.

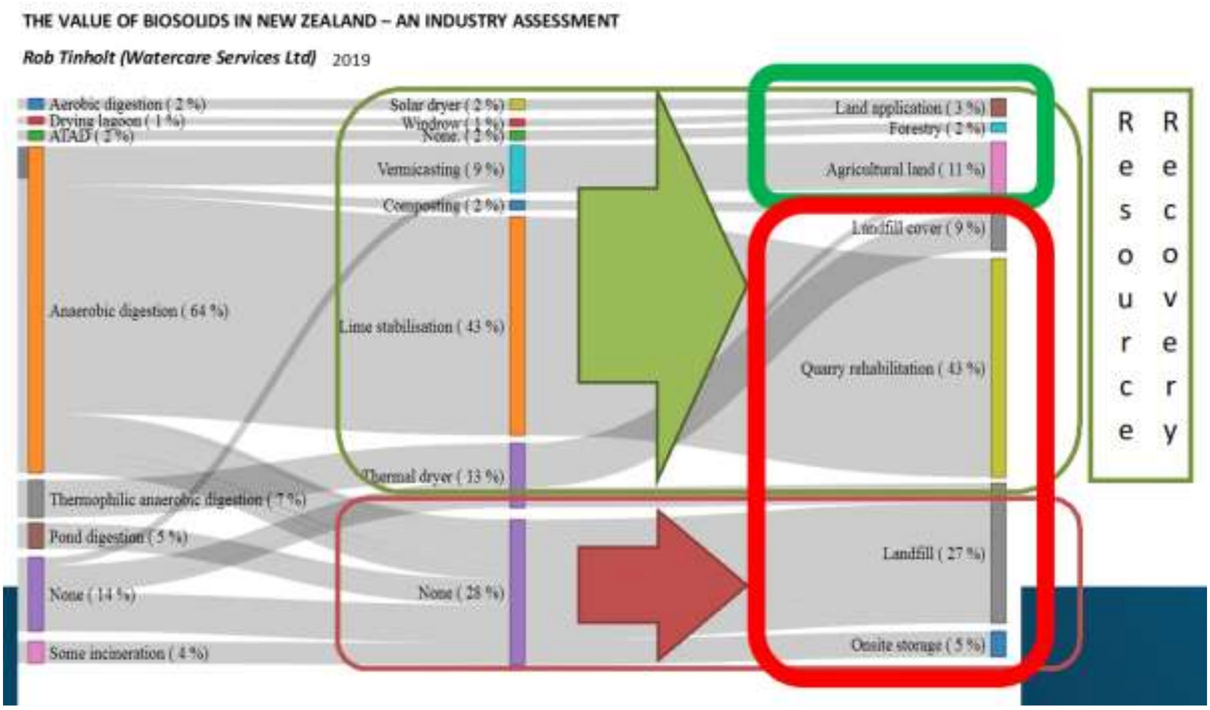
Several years of trials confirm that paper waste, cardboard, food waste, and other fibrous organic wastes can be used as carbon sources for vermicomposting when combined with municipal biosolids and other industrial sludges.

Vermicomposting must be integrated with land management to mitigate environmental risks and reducing costs for infrastructure and for operation. The technology is fully scalable and can be operated regionally. This optimises beneficial utilisation of desludging oxidation ponds in rural areas New Zealand-wide.

Keywords: biosolids, organic waste, vermicomposting, food waste, paper waste, decentralised operation

New Zealand-wide Vermicomposting of Biosolids and Organic Waste

Michael Quintern and Charlotte Robertson, Noke Ltd.


THE VALUE OF BIOSOLIDS IN NEW ZEALAND – AN INDUSTRY ASSESSMENT
Rob Tinholt (Watercare Services Ltd) 2019
Aerobic digestion (2 %)
Drying lagoon (1 %)
ATAD (2 %)
Anaerobic digestion (64 %)
Thermophilic anaerobic digestion (7 %)
Pond digestion (5 %)
None (14 %)
Some incineration (4 %)
Solar dryer (2 %)
Windrow (1 %)
None (2 %)
Vermicasting (9 %)
Composting (2 %)
Lime stabilisation (43 %)
Thermal dryer (13 %)
None (28 %)
Land application (3 %)
Forestry (2 %)
Agricultural land (11 %)
Landfill cover (9 %)
Quarry rehabilitation (43 %)
Landfill (27 %)
Onsite storage (5 %)
Resource Recovery


2501 Orchard


JCB
strautmann
verti-mix
2000
Double
JCB


MYNOKE
MYNOKE


MYNOKE


Google Earth


Google Earth


Google Earth


Google Earth

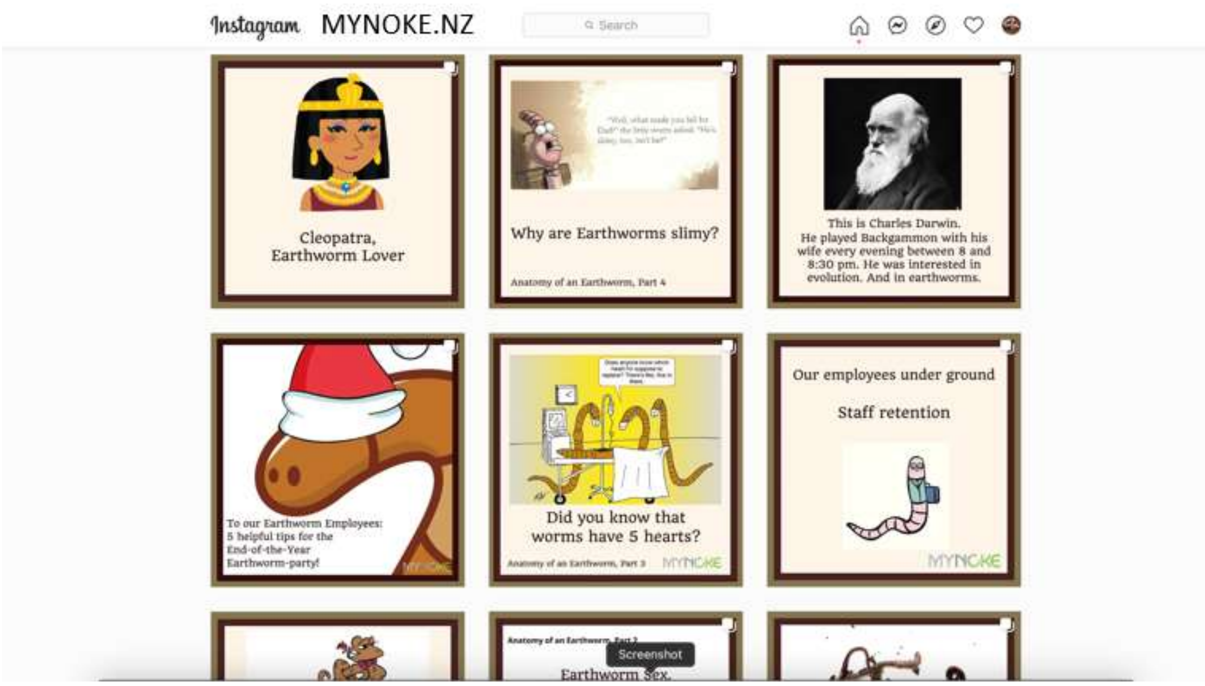

Google Earth
Image © 2021 CNES / Airbus


MYNOKE


smart
DELI
203131
FAST FRY


MYNOKE


MYNOKE PARTNERS
Hamilton City Council
Te kaunihera o Kirikiriroa
GREAT LAKE TAUPŌ
Taupō District Council
Western Bay of Plenty District Council
South Waikato District Council
NAPIER CITY COUNCIL
Te Kaunihera o Ahuriri
RUAPEHU DISTRICT COUNCIL
BAY OF PLENTY REGIONAL COUNCIL TOI MOANA
Fonterra
Dairy for life
Oji Fibre Solutions
OJI
Beyond the Boundaries
Kinleith Mill
Tasman Mill
WPI
forestry timber pulp
PAN PAC
PAN PAC FOREST PRODUCTS LIMITED
Zespri Kiwifruit
MIRAKA
nurturing our world
SEEKA
KIWIFRUIT INDUSTRIES LIMITED
T&G
Lakeweed
Harvesters & Contractors
Lakes & Waterways Consultants


Instagram MYNOKE.NZ
Search
Cleopatra,
Earthworm Lover
Why are Earthworms slimy?
Anatomy of an Earthworm, Part 4
This is Charles Darwin.
He played Backgammon with his wife every evening between 8 and 8:30 pm. He was interested in evolution. And in earthworms.
To our Earthworm Employees:
5 helpful tips for the End-of-the-Year Earthworm-party!
Did you know that worms have 5 hearts?
Anatomy of an Earthworm, Part 3
MYNOKE
Our employees under ground
Staff retention
MYNOKE
Screenshot
Earthworm Sex.

MYNOKE®

Organic Waste Collection
& Earthworm Products

REDUCING N LEACHING FROM EFFLUENT DISPOSAL LAND BY APPLYING VERMICAST FROM BIOSOLIDS

Charlotte Robertson [AB] and Michael Quintern [A]

[A] Noke Ltd., PO Box 347, Seventh Avenue, Tauranga 3140, New Zealand

[B] Corresponding author email: charlotte@mynoke.co.nz

ABSTRACT

Biosolids do not belong in the landfill!

Since 2009, Noke Ltd. has been taking biosolids from Waikato and Bay of Plenty councils, combining them with hemicellulose fibre and feeding the mixture to compost worms at industry scale. The end product is soil-like vermicast that meets Grade Aa (NZWWA 2003) for safe application to productive land.

Vermicast is a stable humus, renowned as a soil conditioner. Application of vermicast improves soil functions such as water and nutrient holding capacities, increases microbiological diversity and abundance, and directly benefits plants by stimulating root development and supporting immunity. International studies demonstrate that vermicast increases yield, nutrient uptake and can reduce nutrient losses from soils. In addition, by promoting root growth, vermicast increases carbon sequestration in topsoils.

A case study is proposed for the Taupo WWTP effluent irrigation site. Harvested pasture is exported to remove N and P from the site. In the case study, vermicast will be applied annually to irrigated land at 0, 10 and 20 t FM/ha. Soils, pasture production, nutrient uptake and export will be monitored to determine the effects of vermicast on N and P uptake to mitigate losses of these major nutrients from wastewater effluent to groundwater.

Keywords: biosolids, vermicast, nutrient uptake, nitrogen leaching, irrigation, effluent block

Can we reduce nutrient losses using vermicast from municipal biosolids?

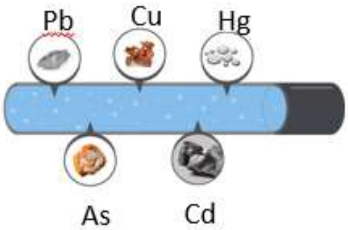
Charlotte Robertson and Michael Quintern
charlotte@mynoke.co.nz

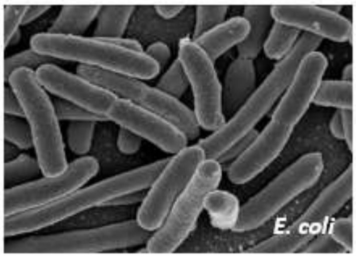
MYNOKE

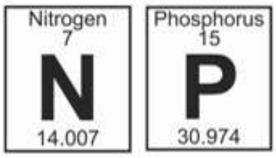
Municipal biosolids
DO NOT
belong in the landfill.

Municipal biosolids basics

1. Contaminated
2. Sludge
3. Nutrient-rich
4. Always being produced
5. **<u>Are vermicompostable</u>**



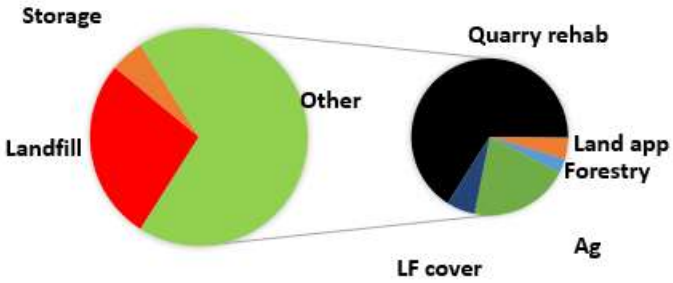




Vermicast

= worm poo

Fate of NZ municipal biosolids

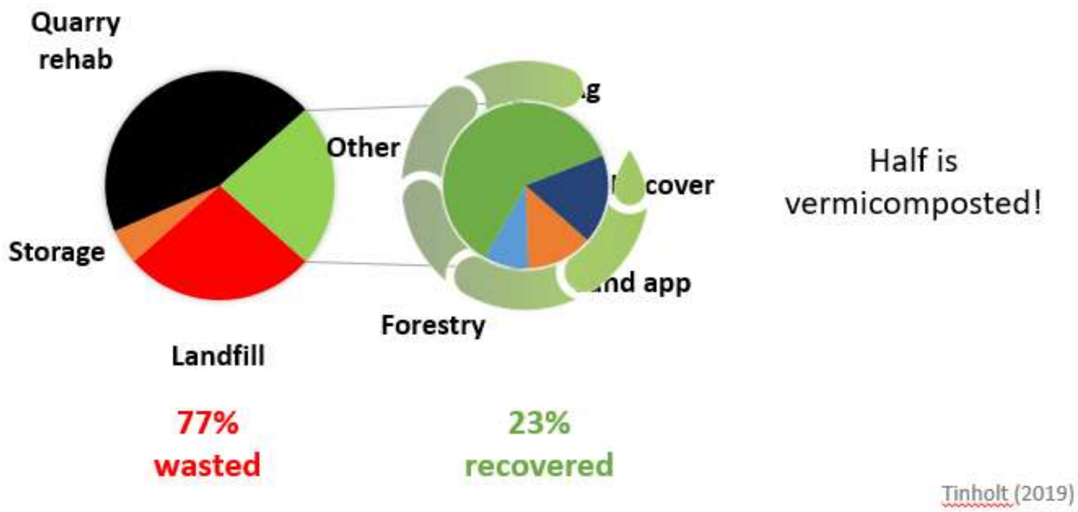


32% wasted

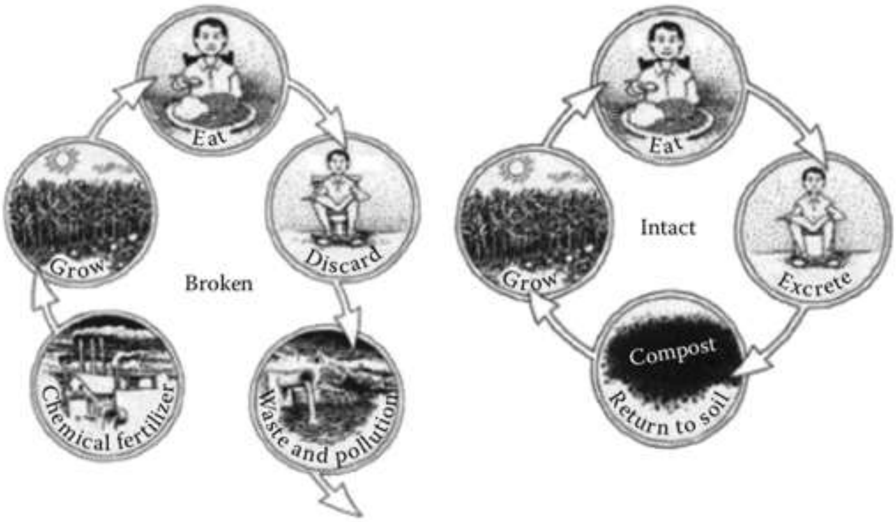
68% recovered

Tinholt (2019)

Fate of NZ municipal biosolids



Food production



Vermicomposting biosolids

- Destroys pathogens
- Reduces heavy metal concentrations
- Immobilises nutrients
- Stabilises carbon
- Reduces original volume by 80%
- Eliminates odours
- Produces vermicast

Benefits of vermicast

- Soil health and function
  - Organic matter
  - Beneficial soil microbes
  - Earthworms
  - Water storage
  - Nutrient management
- Plant health and production
  - Yield increase: 26% (Blouin et al. 2019)
  - Root development: 27% (Blouin et al. 2019)
  - Drought resilience
  - Nutrient uptake
  - Pest and disease resistance

Carbon and nitrogen

People represent carbon (C), tennis balls represent nitrogen (N)

High C:N

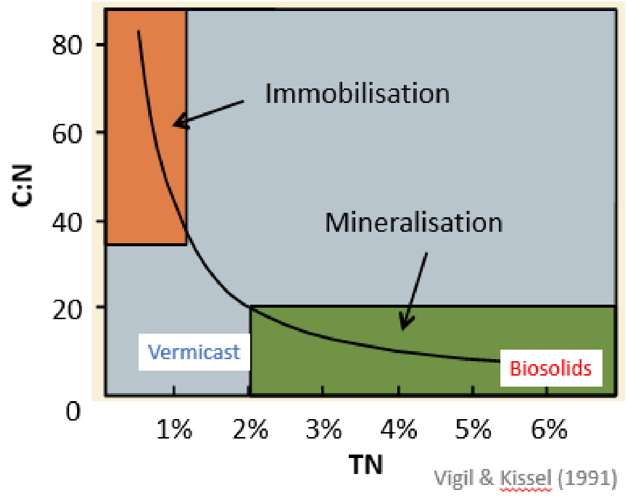
Low C:N

Vermicast and nitrogen

- Vermicast is a soil conditioner <u>not</u> a fertiliser

Sample	**TN**	**C:N**
TDC biosolids	6.0%	7.2
MyNoke Vermicast	1.2%	14.6

Vermicast is **stable**.



Vigil & Kissel (1991)

Trial proposal

- 0, 10 and 20 t/ha FM vermicast
- Monitor:
  - Pasture yield
  - Pasture N and P uptake
  - Soils (especially N, P, C)
  - Rooting depth
  - Leachate volume and concentration

Topsoil only   Topsoil + MyNoke vermicast

Can we reduce nutrient losses using vermicast from municipal biosolids?

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LAND TREATMENT – HEADING TO THE END OF THE ROAD?

Simone Stoove [AB] and Azam Khan [A]

[A] Pattle Delamore Partners Limited, 235 Broadway, Newmarket, Auckland

[B] Corresponding author email: simone.stoove@pdp.co.nz

ABSTRACT

In the 30 years since the formation of the Land Treatment Collective in New Zealand, expectations, technical research and operational practices in the implementation of land treatment systems in New Zealand have evolved. There is a realisation of growing considerable environmental pressure as society's focus changes, and increased expectations on the regulators to manage effects on receiving environment, especially freshwater.

A recent example being the National Policy Statement for Freshwater Management and canvassing of the motivations to bring in wastewater discharge standards signals the tightening controls to put in place allow for healthy freshwater. Both pose a possible challenge to suitability of land treatment if nutrient limits cannot be met when other competing land use practices are undertaken in parallel.

By undertaking a comprehensive review of the past LTC conference outcomes, a number of themes have emerged that provides a framework for future examination of the key issues in order to meet the tightening regulations. The themes generally align to assessment of directly land applied contaminant and its effects, broader environmental issues, social/cultural acceptance against direct improvement of land productivity.

Generally, the review found the following changes over time:

- 1990s' the focus tended to be on feasibility and technical issues.
- 2000's, while technical issues persist, the focus shifts to responding to societal pressures, nitrogen leaching, regulatory processes, frameworks and public acceptance.
- 2010's, there was a further movement towards the social and cultural focus.

Despite evolving social pressure, the technical issues for land treatment still persist as there is an evolving focus on treating wastewater before they re-enter the environment, and in recent years an emerging view of integrated management between wastewater and natural processes that impacts directly on groundwater and surface water.

This paper sets the historical development of knowledge base and probes into the emerging challenges that land treatment may face over the next decade.

1

Land Treatment – Heading to the End of the Road?

SIMONE STOOVÉ, AZAM KHAN

solutions for your environment

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Where has regulation taken us?

2

New Zealand Government

National Policy Statement for Freshwater Management 2020

August 2020

- Land treatment systems satisfy recognized cultural values and provide reuse of nutrients
- Drive toward land disposal consents
- Nutrient leaching identified as ongoing issue within the LTC
- NPSFM 2020 placing increased stress on land treatment activities to limit nitrogen leaching

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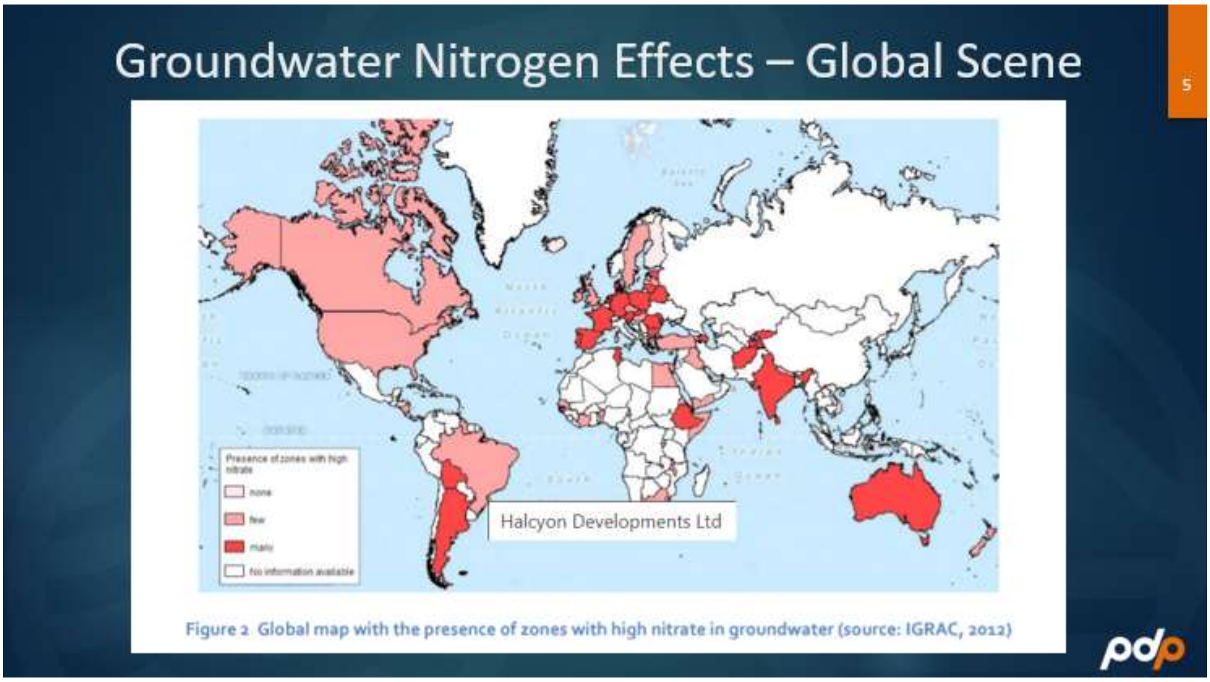
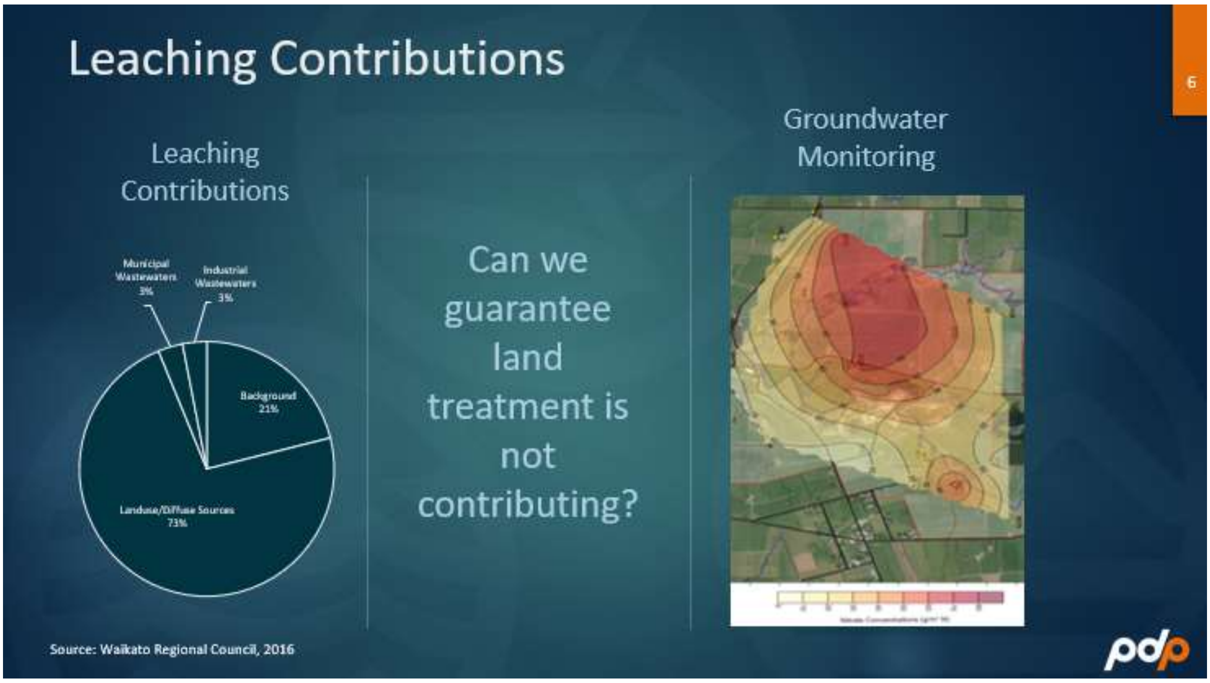
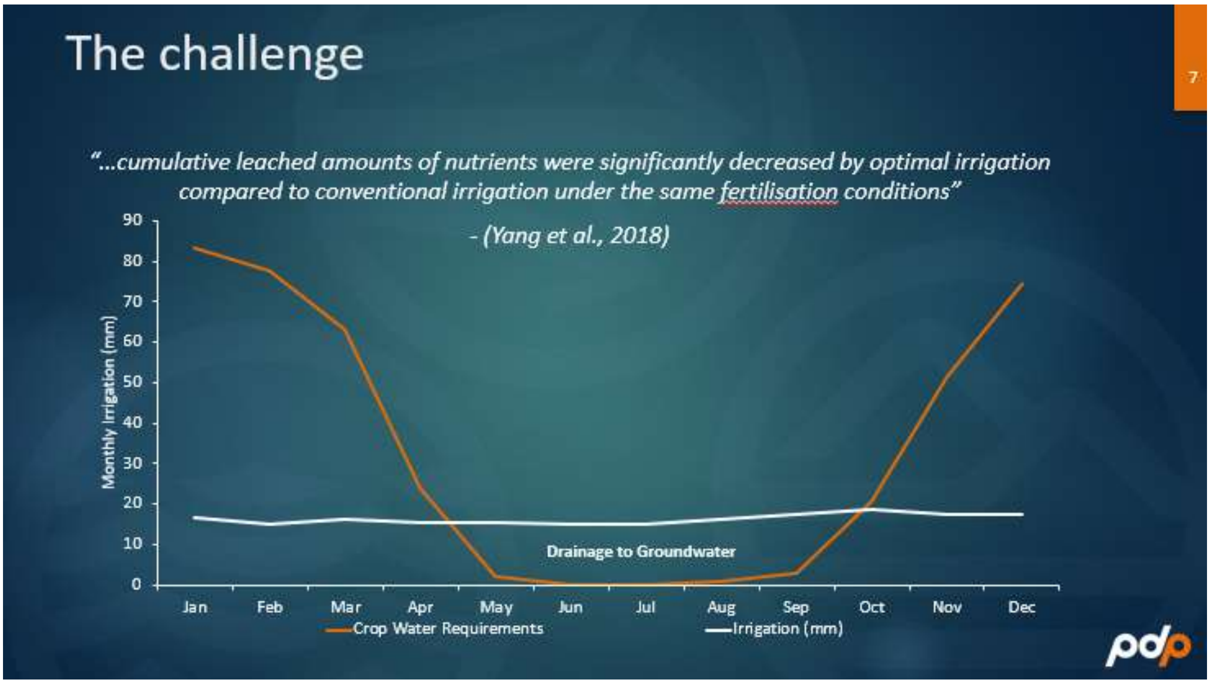
Is this the end?
Fonterra discharging nitrogen-heavy water onto 'ghost farms'
Environmental failure over nitrates could 'ruin' Christchurch drinking water
NEW ZEALAND / ENVIRONMENT
Warning over high nitrate levels in rural Hawke's Bay water
NEW ZEALAND / HEALTH
Health expert renews call for study on nitrates in drinking water
Is NZ's drinking water dangerous? Major international study links nitrates with bowel cancer
NEW ZEALAND
Gastro outbreak: Mushroom farm linked to previous water contamination
pdp


Regional Pressures on Nitrogen Management
High Risk – Nitrate levels exceed drinking water maximum allowable values
Moderate Risk – Levels below drinking water levels
Low Risk – Levels that can have an impact on aquatic life
Urea
Ammonia
Nitrite
Nitrate
pdp


Groundwater Nitrogen Effects – Global Scene
5
Presence of zones with high nitrate
none
few
many
No information available
Halcyon Developments Ltd
Figure 2 Global map with the presence of zones with high nitrate in groundwater (source: IGRAC, 2012)
pdp


Leaching Contributions
6
Leaching Contributions
Municipal Wastewaters 3%
Industrial Wastewaters 3%
Background 21%
Landuse/Diffuse Sources 73%
Can we guarantee land treatment is not contributing?
Groundwater Monitoring
Source: Waikato Regional Council, 2016
pdp



The challenge
7
"...cumulative leached amounts of nutrients were significantly decreased by optimal irrigation compared to conventional irrigation under the same fertilisation conditions"
- (Yang et al., 2018)
Monthly Irrigation (mm)
90
80
70
60
50
40
30
20
10
0
Drainage to Groundwater
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Crop Water Requirements
Irrigation (mm)
pdp

The challenge
8
• Wastewater managers have generally recognised leaching vulnerability in land treatment
• Nutrient application timing
• Deficit irrigation
• Year-round application does not allow for these management strategies
• Land treatment in vulnerable periods contributes nutrients to groundwater and surface water
pdp

Pasture Response to Nitrogen

9

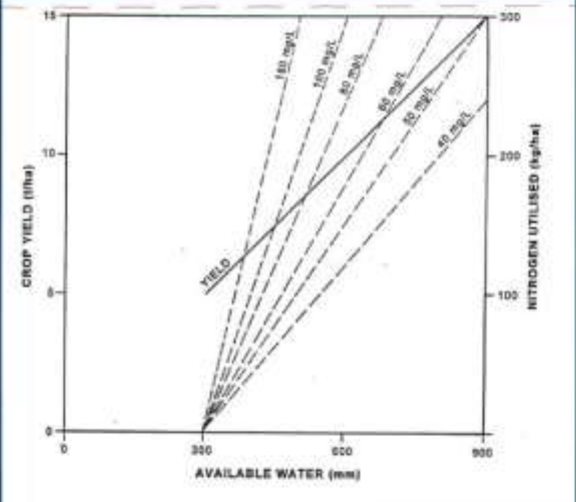
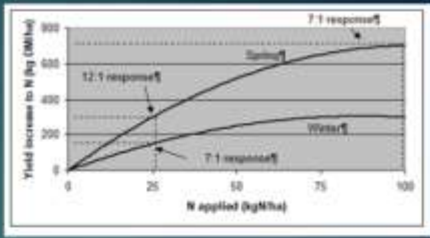


Figure B-6.1 Crop Yield and Nitrogen Uptake for Different Levels of Irrigation



- Optimise water requirements and nitrogen concentrations and crop yield.

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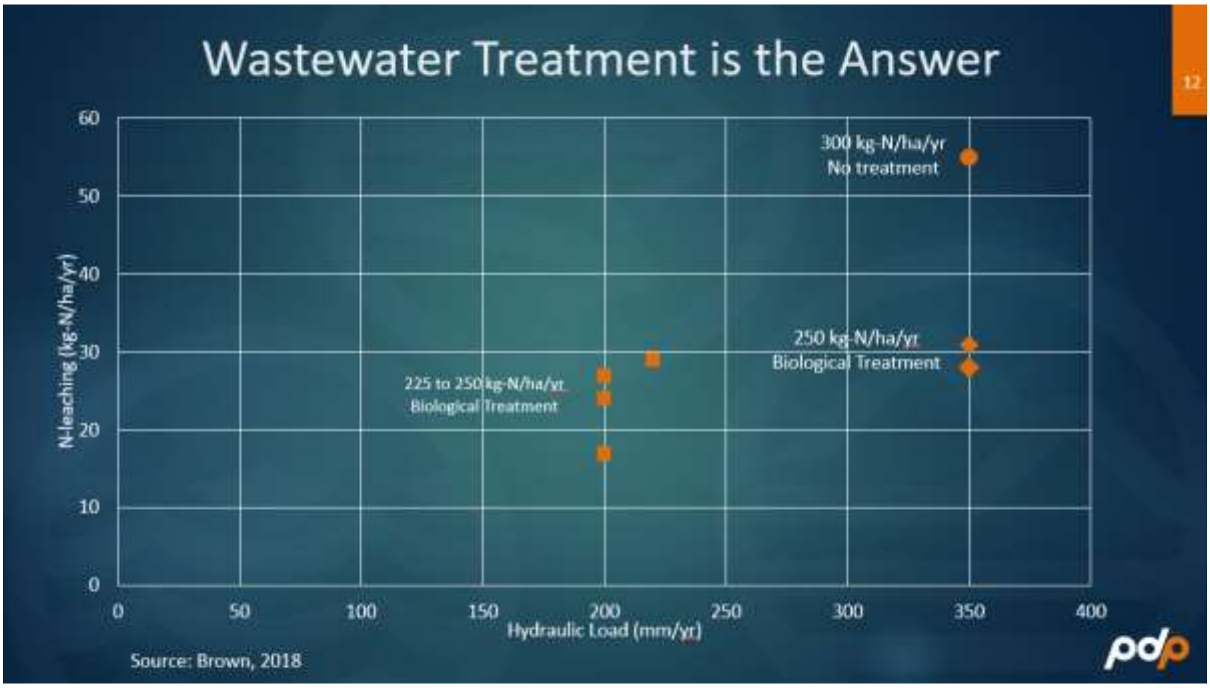
Where is our future going?

10

- Is non-deficit irrigation contributing to high groundwater nitrate levels?
- What will be the effects on the environment and human health?
- What is the next step forward in terms of land treatment sustainability?

pdp


Wastewater Treatment is the Answer
11
NEW ZEALAND
Fonterra looks at better wastewater treatment to cut nitrate levels
10:15 am on 10 February 2021
Share this
pdp


Wastewater Treatment is the Answer
12
300 kg-N/ha/yr
No treatment
250 kg-N/ha/yr
Biological Treatment
225 to 250 kg-N/ha/yr
Biological Treatment
N-leaching (kg-N/ha/yr)
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
400
Hydraulic Load (mm/yr)
Source: Brown, 2018
pdp


Are we heading to the end of the road? Or just a U-turn?
13
Is the current approach to land treatment contributing to the groundwater deterioration around the country?
Do we need to change the approach to land treatment?
Clearer regulatory framework for nitrogen leaching
pdp

NITROGEN LEACHING CONSTRAINTS FOR LAND TREATMENT SYSTEMS

Alana Bowmar [AB], Simon Greening [A], and Azam Khan [A]

[A] Pattle Delamore Partners Limited, PO Box 9528, Newmarket, Auckland 1149

[B] Corresponding author email: Alana.Bowmar@pdp.co.nz

ABSTRACT

Degradation of water quality in many catchments is now largely attributed to diffuse agricultural sources. This drives regulators to consider nitrogen leaching from land systems, as a key diffuse source of nitrogen into surface waters. Agricultural practices: especially as they increase in intensity contribute to increased nitrogen leaching.

The mechanisms for limiting nitrogen leaching from agricultural land have been implemented in some catchments in New Zealand, through relevant regional planning. However, in many catchments these regulatory controls are not yet in place or not enforced.

This can present an interesting challenge for land treatment operators. Nitrogen leaching limits are enforced on land treatment systems through consent conditions; however, permitted nitrogen leaching from the underlying agricultural activities are not established. Consequently, management of land treatment systems to meet nitrogen leaching limits is challenging, when the underlying farming activities vary year to year without an effective limit.

This paper examines a case study where nitrogen leaching was the key control on the land treatment system. Issues faced by the operators will be presented, including considering if consent conditions limiting nitrogen leaching for land treatment on third-party farms make the consent inoperable.

Methods to separate the land treatment from the underlying farming activities will be outlined. These methods can improve land treatment outcomes for regulators, consent holders and operators; by providing certainty in the environmental outcomes, and operational requirements to achieve compliance for land treatment systems.

Keywords: land treatment; nitrogen leaching; consent condition

Nitrogen Leaching Constraints for Land Treatment Systems

PRESENTED BY ALANA BOWMAR

solutions for your environment

1

Overview

2

- Background
  - Land treatment positives and negatives
  - Issues with nitrate pollution
- Current management practice
- Consent conditions
- Case study
- Proposed solution
- Conclusion

Background – Land Treatment

3

- More sustainable alternative to:
  - Water take (ground/surface) for irrigation
  - Synthetic nitrogen fertilisers (sourced from non-renewable natural gas)
  - Mined non-renewable phosphorus
- Attenuate a wide range of contaminants in the soil/water/farm system:

  "About 260 chemical and microbiological indicators were analyzed… concentrations of nitrate-N, boron, chloride, were elevated… the spray field operation was highly effective in removing most studied organic wastewater and pharmaceutical compounds and microbial indicators".

  – Katz *et. al.* (2009)

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Background – Nitrate

4

- Nitrate pollution is harming us and our environment.
- Land treatment systems regularly have nitrate beneath them.

  "Monitoring results indicate that the irrigation has caused the shallow groundwater to become significantly contaminated… nitrate-N concentrations average 50 g/m³"

  "Monitoring of groundwater bores within the irrigation area identifies that groundwater nitrate concentrations occur in excess of this limit [NZDWS]"

Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study

pdp

Background – Nitrate

5

- Nitrate pollution is harming us and our environment.
- Land treatment systems regularly have nitrate beneath them.

"Monitoring results indicate that the irrigation has caused the shallow groundwater to become significantly contaminated... nitrate-N concentrations average 50 g/m³"

"Monitoring of groundwater bores within the irrigation area identifies that groundwater nitrate concentrations occur in excess of this limit [NZDWS]"

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Current Practice

6

- Management of nitrogen effects in consents is varied:
  - Nitrogen loading limits
  - Monitoring and Farm Management Plans or Nutrient Management Plans
  - Modelled leaching limits

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Resource Management Act (1991)

7

108AA Requirements for conditions of resource consents

(1) A consent authority must not include a condition in a resource consent for an activity unless—

  (a) the applicant for the resource consent agrees to the condition; or

  (b) the condition is directly connected to 1 or both of the following:

    (i) an adverse effect of the activity on the environment:

    (ii) an applicable district or regional rule, or a national environmental standard; or

  (c) the condition relates to administrative matters that are essential for the efficient implementation of the relevant resource consent.

(2) Subsection (1) does not limit this Act or regulations made under it.

(3) This section does not limit section 77A (power to make rules to apply to classes of activities and specify conditions), 106 (consent authority may refuse subdivision consent in certain circumstances), or 220 (condition of subdivision consents).

(4) For the purpose of this section, a district or regional rule or a national environmental standard is **applicable** if the application of that rule or standard to the activity is the reason, or one of the reasons, that a resource consent is required for the activity.

(5) Nothing in this section affects section 108(2)(a) (which enables a resource consent to include a condition requiring a financial contribution).

Section 108AA: inserted, on 18 October 2017, by section 147 of the Resource Legislation Amendment Act 2017 (2017 No 15).

Retrieved on 3 May 2021 from https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM7471372.html#DLM7471372

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Case Study

8

- 600 – 700 ha land treatment system
- Elevated nitrates in groundwater and daylighting into a small impacted stream

  "Monitoring of groundwater bores within the irrigation area identifies that groundwater nitrate concentrations occur in excess of this limit [NZDWS]"
- Restrictive nitrogen leaching limits reducing over time
- Spans over 10 third-party owned and operated farms
- Non-compliances

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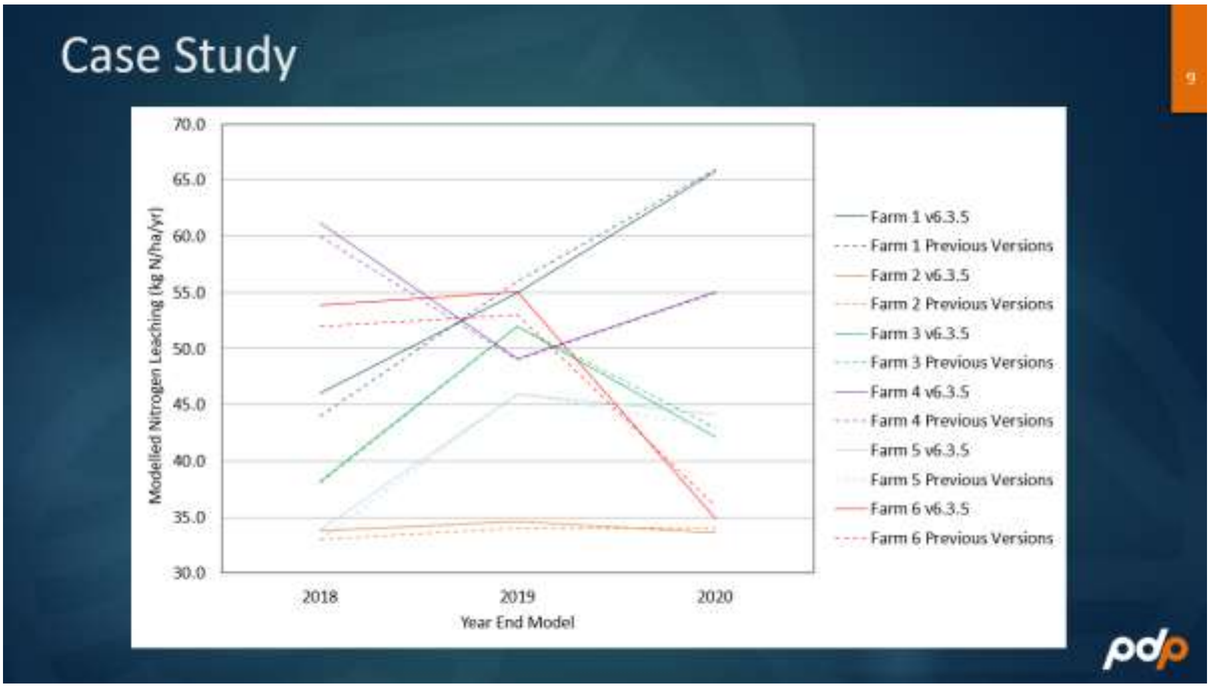
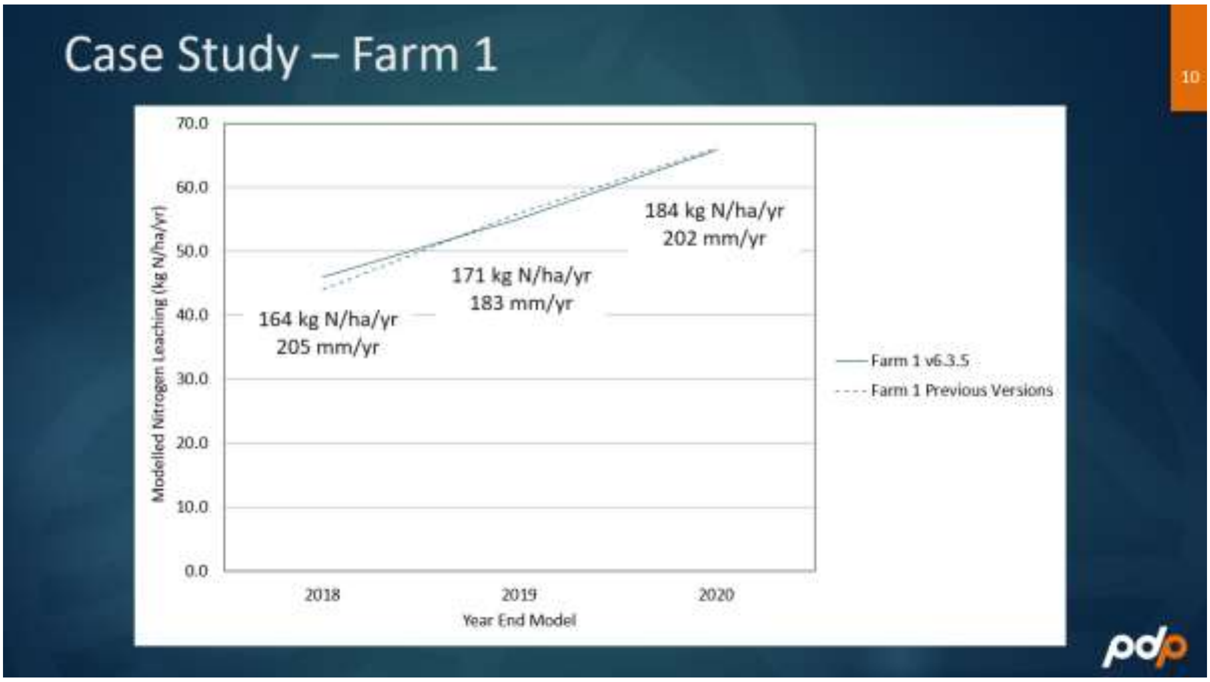
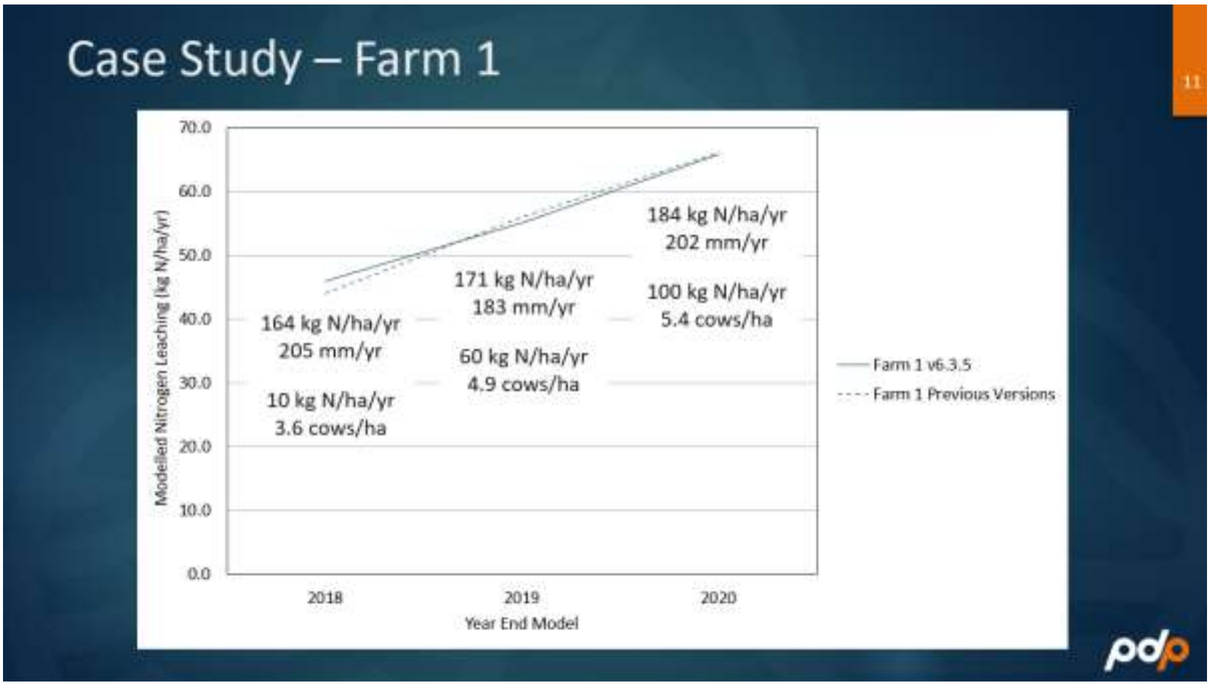
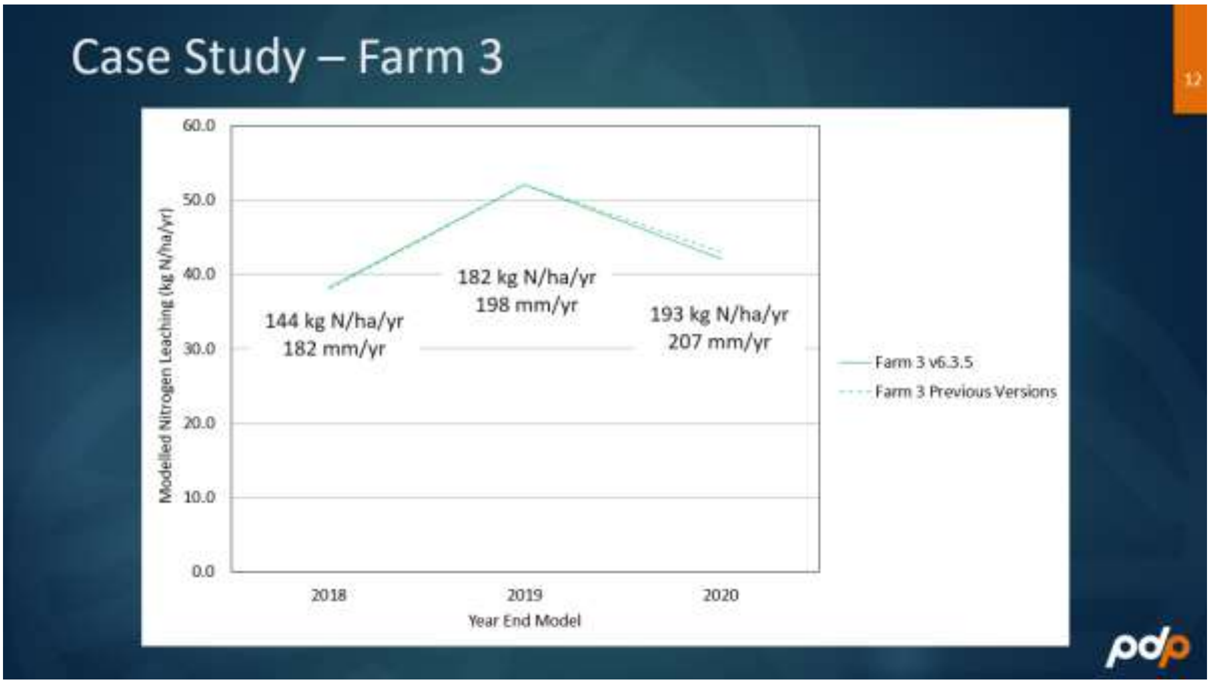

Case Study
9
Modelled Nitrogen Leaching (kg N/ha/yr)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
2018
2019
2020
Year End Model
Farm 1 v6.3.5
Farm 1 Previous Versions
Farm 2 v6.3.5
Farm 2 Previous Versions
Farm 3 v6.3.5
Farm 3 Previous Versions
Farm 4 v6.3.5
Farm 4 Previous Versions
Farm 5 v6.3.5
Farm 5 Previous Versions
Farm 6 v6.3.5
Farm 6 Previous Versions

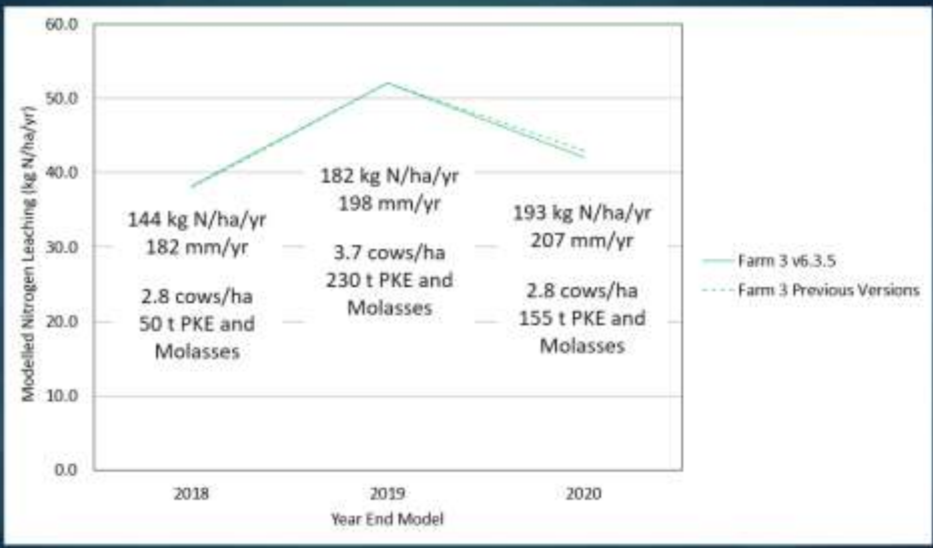

Case Study – Farm 1
10
Modelled Nitrogen Leaching (kg N/ha/yr)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
184 kg N/ha/yr
202 mm/yr
171 kg N/ha/yr
183 mm/yr
164 kg N/ha/yr
205 mm/yr
2018
2019
2020
Year End Model
Farm 1 v6.3.5
Farm 1 Previous Versions


Case Study – Farm 1
11
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Modelled Nitrogen Leaching (kg N/ha/yr)
184 kg N/ha/yr
202 mm/yr
171 kg N/ha/yr
183 mm/yr
100 kg N/ha/yr
5.4 cows/ha
164 kg N/ha/yr
205 mm/yr
60 kg N/ha/yr
4.9 cows/ha
10 kg N/ha/yr
3.6 cows/ha
Farm 1 v6.3.5
Farm 1 Previous Versions
2018
2019
2020
Year End Model
pdp


Case Study – Farm 3
12
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Modelled Nitrogen Leaching (kg N/ha/yr)
182 kg N/ha/yr
198 mm/yr
144 kg N/ha/yr
182 mm/yr
193 kg N/ha/yr
207 mm/yr
Farm 3 v6.3.5
Farm 3 Previous Versions
2018
2019
2020
Year End Model
pdp

Case Study – Farm 3

13



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Solution

14

- Conditions:
  - Nitrogen leaching target
  - Report on any exceedances and explain the cause
  - Any exceedance greater than 10% requires a mitigative response
  - Any exceedance as a 3-year rolling average greater than 15% is a non-compliance
  - Mechanism to change the nitrogen leaching target following Overseer updates
- We replaced one simple one line condition with six wordy conditions
- A LOT more reporting
- Any environmental improvement?

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Concluding Questions

15

- Are nitrogen leaching limits on land treatment systems enforcable and valid?
- Do they result in better outcomes?
- Is there an easier way?

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WASTEWATER BEST PRACTICABLE OPTION. LIFE FOR THE PNCC WWTP BEYOND 2022

Melaina Voss [ABC]

[A] Palmerston North City Council, The Square, Palmerston North, NZ

[B] Stantec, 118 Fitzherbert Ave, Palmerston North, NZ

[C] Corresponding author email: melaina.voss@pncc.govt.nz

ABSTRACT

Historically, our rivers have been the preferred environment for local authorities to discharge treated wastewater to. Palmerston North Council currently discharges the city's wastewater entirely into the Manawatu River and always has. However, the message seems clear from regulatory authorities, stakeholders and the community, 'business as usual' will no longer work. The life-supporting capacity of our rivers must not be adversely affected and instead improvements must be made. Over the past 5 years, 3 local authorities within the Horizons Region, have moved their wastewater out of our rivers and onto land.

Today we are working in changing legislation that seeks actions by authorities to protect and enhance our waterways. But what are the alternatives? A city the size of Palmerston North would require it's urban footprint in land area to discharge its wastewater 97% of the time. Equally, we are required to protect the regions high quality soils.

By June 2022, Palmerston North City Council's journey to deliver the Best Practicable Option for the city's wastewater, must land. Significant investment in the cities wastewater treatment has been identified, but at what cost? This presentation will explore the options and challenges from environmental, policy and stakeholder perspectives.

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Today

- Context
- Challenges
- Options Development & Assessment Process
- Engagement & Collaboration
- Q & A

2

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Palmerston North City Council's 'Best Practicable Option': Context

Commitments, Timeframes & Context

3

What is 'Best Practicable Option'?

- **Condition 23B of the Existing Resource Consent**
  - Receiving environment sensitivity
  - Effects on the environment
  - Financial Implications
  - Technology & Innovation
  - Minimise adverse effects on the life supporting capacity of the Manawatu River
  - Meeting environmental policy, standards and targets
- **Resource Management Act**
  - Purpose & Principles
  - Part 2 & Sections 104, 105 and 107

Life Supporting Capacity of Waterways

Periphyton growth has been increasing in rivers around New Zealand over the past 15 years. The National Policy Statement for Freshwater Management 2020 (NPS-FM) requires councils to improve degraded water bodies and ecosystems by monitoring and managing nitrogen and periphyton levels.

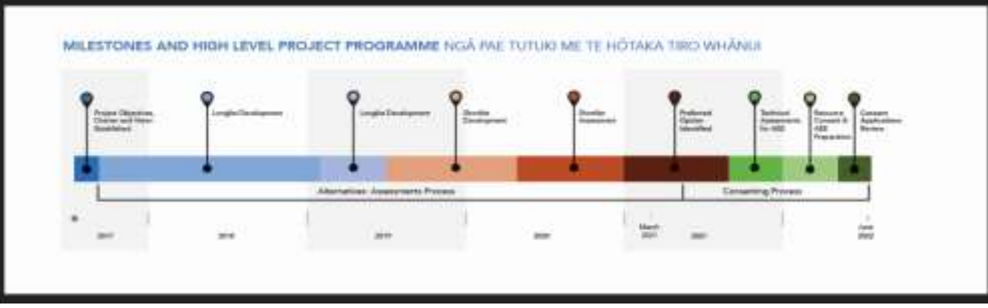
Early on, the Council confirmed that business as usual 'the current operation', could no longer continue

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Why a Resource Consent for BPO?

In 2012, Horizons Regional Council raised concerns the city's wastewater discharge was having an adverse effect on the life supporting capacity of the Manawatu River.

- In 2013, Council agreed to apply for a new consent by 2022.
- The new consent must be for the 'Best Practicable Option'.
- The 'BPO' process must commence by 2017 with an option identified by 2021.



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NATURE CALLS: A BPO FOR PALMERSTON NORTH

Challenges

Governance, Regulation, Policy & Community Expectations

7

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Palmerston North

Growth

A population of 90,000 expected to grow to 130,000 in 30 years time

An urban centre of 3,500ha surrounded by Class 1 soils, agriculture, ranges and 3smaller local councils

Horizons Regional Council

All the city's wastewater is treated at Totara Road WWTP and discharges to the Manawatu River.

Current Dry Daily Flow is 22,000m³/day expected to increase to 28,000m³ in 35 years

8

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Governance & Policy

- **3 Water Reforms**
  - Safe
  - Better Environmental Performance
  - Accountablility
  - Affordable
- **RMA & Policy Changes**
  - National Policy Statements
  - New Legislation
  - National Environmental Standards
  - One Plan Changes
- **Local Government Reform**

9

Values & Expectations

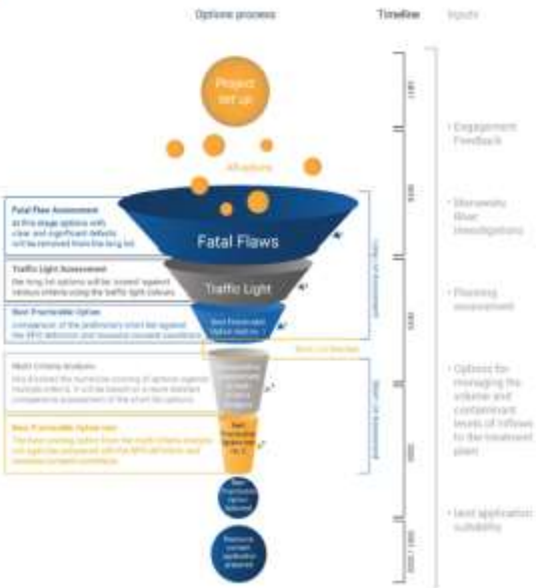
Communities and stakeholders are impacted by this project in varying ways. There is a need to engage wide enough to identify what this means

- Iwi and hapu
- Community values & priorities
  - Affordability
  - Environment
  - Long term solution
- Stakeholder Groups
  - Agriculture & Rural Community
  - Environmental Groups
  - Commerce
- Coastal villages
- Down River Communities

Options Development & Evaluation

An Overview

NATURE CALLS: A BPO FOR PALMERSTON NORTH



BPO Methodology

- Project Objectives
- Assessment Criteria
- BPO 'Test'
- Collaborative Workshops involving Iwi, Councillors and key stakeholders
- Engagement Feedback

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NATURE CALLS: A BPO FOR PALMERSTON NORTH

Values based Assessment Criteria

- Aligned with Council Policies and Strategies
- Used in Traffic Light & MCA process
- Engagement with Community & Stakeholders

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NATURE CALLS: A BPO FOR PALMERSTON NORTH

14

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Reducing Wastewater @ Source

How to?

- Residential wastewater reduction
- Trade Waste Customers management at source
- Planned approach to reducing stormwater infiltration

Tool to model how effective reduction at source can have on future flows and loads

15

NATURE CALLS: A BPO FOR PALMERSTON NORTH

Discharge to Land

- **Identify Treatment processes suitable for land discharge**
- Identifying & managing adverse effects
  - Heavy & prolonged rainfall
  - Climate Change
  - Adjoining land-use
  - Surface water protection
  - Bore & groundwater protection
  - Urban development
  - Land contamination
  - Operational effects (large scale)
  - Feasibility of Land aquisition
- Combined with other receiving environments

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NATURE CALLS: A BPO FOR PALMERSTON NORTH

Discharge to Surface Water

- NZ Best Practice for Wastewater Treatment
- Tangata Whenua Values
- Stakeholder and Community expectations
- Policy & Plans
- Managing adverse effects on the River:
  - River water quality
  - Mauri
  - Water supply protection
  - Ecology
- Riverbed composition
- Social and community impacts ie recreation and fishing
- Combined with other receiving environments

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Discharge to Ocean

- **Understanding the sensitivity of the recieving environment & correwsponding treatment regime necessary**
- **Identifying & managing adverse effects**
  - Water quality & ecology
  - Maori values & mauri
  - Aquaculture
  - Recreational, customary and commercial food gathering
  - Social and community
  - Climate Change
  - Adjoining Land-use
  - Archaeological features
  - Construction
- Combined with other receiving environments

Decision Making & Engagement

Governance, Iwi, Stakeholders & Community

NATURE CALLS A BPO FOR PALMERSTON NORTH

Governance

- Project Steering Group
- Iwi
- Council Officers
- Technical Advisors
- Terms of Reference
- Reporting to Council

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NATURE CALLS A BPO FOR PALMERSTON NORTH

Collaborative Workshops

Traffic Lighting, Multi-Criteria Assessment , briefings and workshops have occurred throughout the life of the Project.

Keeping technical experts, Council officers, Stakeholders and the Council's decision makers involved and accountable along the way.

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Engagement

Information

Booklets
Factsheets
Online
Hardcopies
In person with project team & councilors

Social

Social Pinpoint
Facebook
Youtube

Values

Engagement on values
Preference for options
Prioritisation of values
Compared with MCA process weightings

Website

Portal of information
Factsheets Access
Project history & updates

FOXTON WASTEWATER LAND TREATMENT CONSENTING AND CONSTRUCTION CHALLENGES AND LESSONS

Phil Lake [AB] and Hamish Lowe [A]

[A] Lowe Environmental Impact, PO Box 4667, Palmerston North 4442

[B] Corresponding author email: hamish@lei.co.nz

ABSTRACT

Foxton is a small Horowhenua town near the Manawatu River mouth. Its wastewater has been treated since 1976 in oxidation ponds that discharge into the adjacent Foxton Loop (a tributary of the Manawatu River which was the river channel prior to diversion works in 1942).

In November 2015 Horowhenua District Council (HDC) sought resource consents for constructing a land treatment system across 54 ha of nearby beef farmland. The consenting processes involved intensive scrutiny of the proposal and complex balancing of conflicting Regional and District Plan Policies and Rules. HDC needed to work with three iwi, each with different views and temporal connections to the land. The project also relied on supporting the farmer's interests and ensuring their continued co-operation with HDC.

Consents were granted in February 2019 with a 3-year construction deadline for ceasing the discharge to Foxton Loop. The 12 months since then have seen detailed designs generated, a construction programme developed, construction team appointed, and physical works commence.

Implementation has been challenging, especially with parties who were not involved in the consenting process and who introduce alternative design views. This required an iterative process to develop practicable solutions within the granted consenting framework.

This paper summarises the challenges and lessons from this complex project.

Foxton Wastewater Land Treatment

Consenting and Construction Challenges and Lessons

Phil Lake

Location

Location


Foxton Beach
Manawatu River
Foxton
Foxton Loop
Foxton
WWTP
Waitarere
Forest
Whirokino Cut
Manawatu River

Background

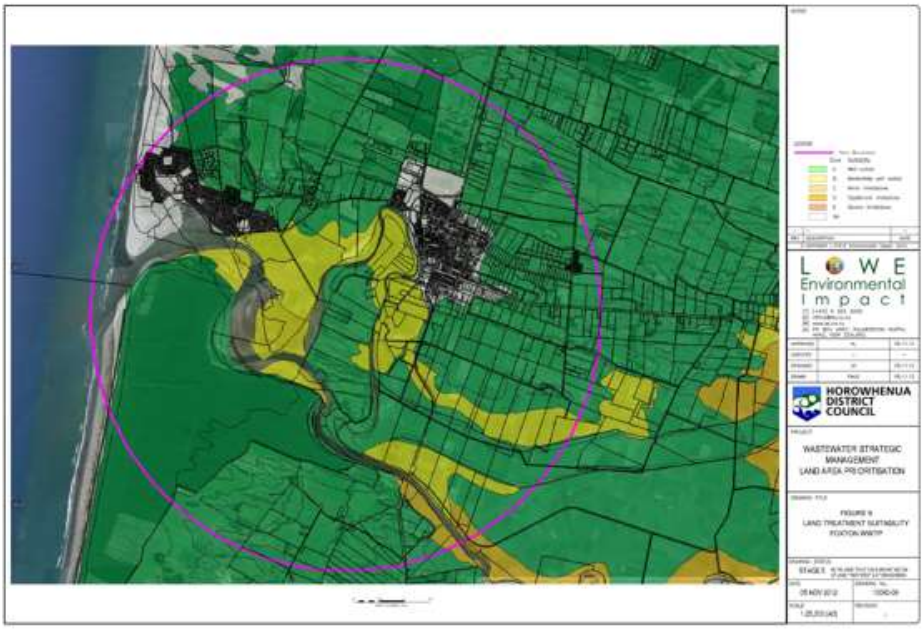
Foxton's Wastewater Treatment:

- WWTP (single pond) built at Matakarapa in 1976.
- Two maturation ponds added in 1993/94.
- Continuous discharges into Foxton Loop 3 km downstream of Foxton.

Background

- Discharge Consenting – Site Selection
  - 1998 consent required HDC to seek land discharge locations for future consents.
  - 2012 district-wide land treatment suitability study by LEI
    - GIS multi-criteria broad-scale assessment of whole district.
    - Considered options of suitability within 5 km of each WWTP.
    - Considered possible central site for all district discharges.
    - Land and soil properties ranked for suitability

Background



Background

- Discharge Consenting – Site Selection
  - Focus Group consultation during 2014 included:
    - Identification of the community's core values and aspirations;
    - High level identification and consideration of 22+ locations;
    - Desk-top feasibility studies of some potential discharge sites;
    - Refinement of preferred discharge site locations and costs;
    - Consideration of land discharge regimes and design concepts.
  - Based on Focus Group outcomes and feasibility studies, Matakarapa was selected as the best site in the area.

Background

Background

- Discharge Consenting – Application Timeline
  - 2015: Detailed site investigations and conceptual design.
  - 2015: Prepared and lodged consent application.

  - 2016: Consent application publicly notified.
  - 2016-19: Environment Court processing including direct negotiations with iwi and expert conferencing.

  - February 2019: Consents granted.
    - 3 years to implement:
      - Build storage pond;
      - Install 63 ha of irrigation;
      - Cease discharges to Foxton Loop.
    - 28 years for irrigation and intensive farming (irrigated beef).

LOWE Environmental Impact

Land Treatment Overview

- Irrigation avoids all culturally sensitive areas, kanuka, wetland, and drains.
- Three irrigation management units have application rates that reflect different soils and terrain.
- Build 50,000 m^3 of storage.
- Continue existing bull farming operation.

LOWE Environmental Impact

Consenting Challenges

- District Plan constraints:
  - District Plan maps of flood hazard are incorrect but rules restricting structures and earthworks still applied.
  - Entire site is Outstanding Natural Landscape.

- Unable to modify terrain from original contours;
- All irrigation posts needed to be under 3 m high;
- Considered visual effects of fenceposts and irrigation posts;
- Considered visual effects of greening of pasture from irrigation;
- No rules specific to kanuka but trees needed to be protected.

Consenting Challenges

- One Plan conflicts:
  - Wastewater discharges to land strongly encouraged but:
    - Nitrogen losses are tightly restricted by Table 14.2;
    - Irrigation of beef farms meets definition of intensive farming;
    - New intensive farms are difficult to consent due to conflicting rules and policies regarding nitrogen loss limits;
    - Irrigating areas of kanuka is a non-complying activity;
    - Existing pond seepage to groundwater requires consent;
    - Tension between increased contamination of groundwater and reduced contamination of surface water.

Consenting Challenges

- Overseer modelling:
  - Overseer model version updates increased predictions of nitrogen losses well beyond Table 14.2 limits.
  - One Plan and Table 14.2 had no mechanism for adjusting when Overseer updates changed its predicted losses for the same scenarios.
  - Conflict between principles of Overseer and its use as a regulatory and annual compliance tool.

Consenting Lessons

- Test case for application of One Plan rules and policies for new intensive farms and wastewater irrigation.
- Good things take time. Lots of patience and $$ too!
- Good consent outcomes rely on:
  - Thorough pre-application consultation/engagement;
  - Robust site investigations and technical documentation;
  - Robust design and technical backing;
  - Strong, unified team of experts;
  - Resolving opposition and concerns raised by iwi, submitters, and Council experts.

Construction Challenges

- Management of:
  - Uninterrupted wastewater treatment and farming;
  - Integrated design and operation;
  - Complex and fluid project team;
  - Iwi liaison and monitoring;
  - Materials supplies;
  - Timelines;
  - Costs.

Construction Lessons

- Invest time to:
  - Integrate design and operation;
  - Obtain different perspectives and expertise;
  - Explain reasons for decisions;
  - Gain common understanding;
  - Avoid conflicts;
  - Solve problems.

Simple win-win solutions are usually possible but may require several iterations of designs or discussions.

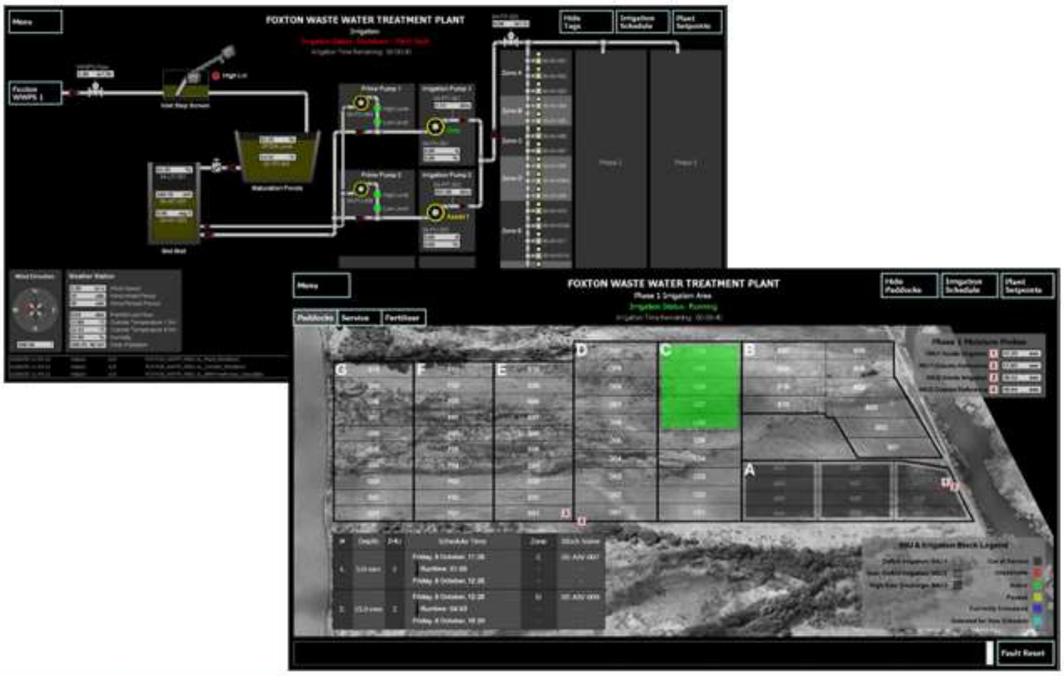
Construction Lessons

- Management of detail helps avoid cost escalation and delays (even without COVID disruptions)
- Smooth sailing is a bonus!

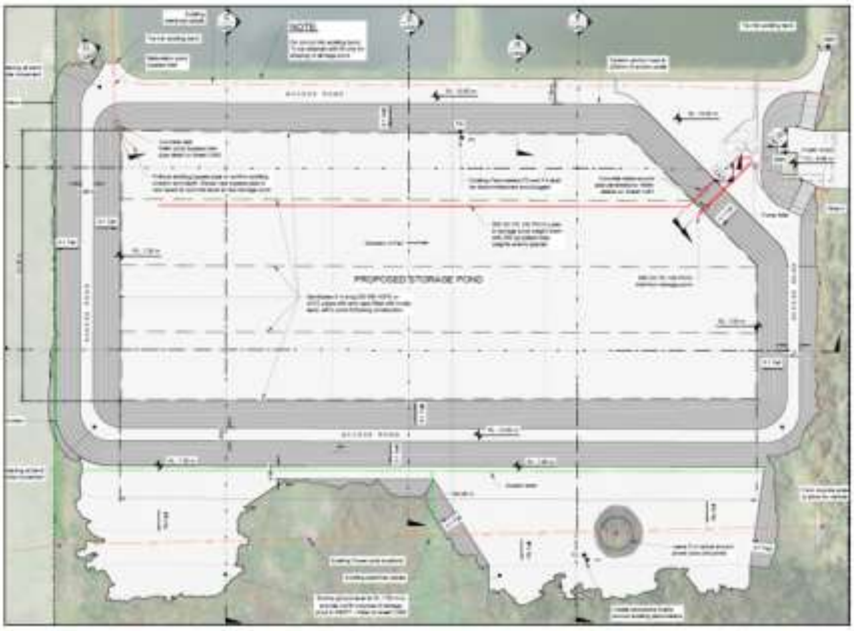
Completed Works

Pumps

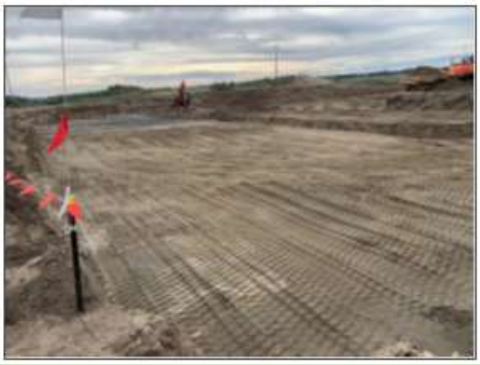
Computer Controls



New Storage Pond



New Storage Pond



Future Irrigation Areas

DEVELOPING A RESOURCE – BIOSOLIDS ANYONE?

Hamish Lowe [AC], Jennifer Prosser [A], Katie Beecroft [A], and Maria Gutierrez-Gines [B]

[A] Lowe Environmental Impact, Palmerston North, New Zealand

[B] Environmental Science and Research, Wellington, New Zealand

[C] Corresponding author email: hamish@lei.co.nz

ABSTRACT

More than 320,000 tonnes of wastewater treatment plant solids are produced every year in New Zealand. Most of this sludge ends up in landfills, which is not considered a long-term management option due to increased levies, space requirements and transportation distances. In addition, Government policy and community expectations now focus on the development of sustainable use options.

The MfE Waste Minimisation funded project "Collective Biosolids Strategy – Lower North Island" is taking a collaborative approach to the issue of sludge management. A collective of nine New Zealand territorial authorities are working in partnership to develop a regional biosolids strategy with a focus on beneficial end-use. The project focus is on smaller councils that may otherwise be unable to fund such investigations and/or solutions individually.

The feasibility of a selection of potential use option has been tested through on ground application (research trials) and desktop feasibility/cost analysis. Three research trials were undertaken:

- A large-scale biosolids composting trial;
- In laboratory testing of the feasibility for using biosolids in seedling growth media; and
- A grazing crop field trial using oats, Italian ryegrass and pasture.

The project also focused on exploring iwi and community views with regards to biosolids use.

This project has provided typically smaller communities a forum for discussion and identification of opportunities to work together on sludge management, and providing them the potential to collectively achieve outcomes that may not have been feasible individually. This paper presents a summary of the three-year project.

Keywords: Biosolids, cultural impact assessment, sustainable use, collective management

Developing a Resource

–

Biosolids Anyone?

Hamish Lowe

PRESENTATION OUTLINE

- Regional Biosolids Strategy (RBS) – Lower North Island
- Research trials and on ground application
- Biosolid variability

BIOSOLIDS – WHAT TO DO WITH THE POO?

- Large proportion of NZ WWTP solids goes to landfill;
- Current Government policy and community expectations focus on sustainable re-use;
- Landfilling no longer considered a viable long-term option;
- Biosolids can
  - Add valuable nutrients;
  - Improve soil moisture retention; and
  - Improve soil structure.
- Numerous re-use options for biosolids depending on quality/contaminants.

LOWE Environmental Impact

ACHIEVING SUSTAINABLE USE THROUGH COLLECTIVE MANAGEMENT

- The MfE Waste Minimisation funded project "**<u>Collective Biosolids Strategy – Lower North Island</u>**" is taking a collaborative approach to sludge management;
- 9 New Zealand territorial authorities working in partnership to develop a regional biosolids strategy, focusing on beneficial end-use;
- Focus on small councils that would be unable to fund such investigations individually;
- How did project come about?

MfE RESEARCH FUNDING PROCESS

- Waste minimisation fund (WMF)
  - Projects that promote or achieve waste minimisation;
  - Focus on waste reduction, reuse, recycling and recovery of waste;
  - Implementing new initiatives or significant expansion of existing activities;
  - Projects up to 3 years;
  - Shared funding/ cross-sectional collaboration is preferred; and
  - Projects $$$
    - Minimum $50,000
    - RBS $542,109 over three years
    - WMF contribution $433,689 (80%)

MfE RESEARCH FUNDING PROCESS

- Application process
  - Get support
    - Interested parties and potential financial contributions
    - Letters of support
  - Detailed budgets
  - Provide a strong statement of intent
  - Ability to quantify project benefit an advantage
- Reporting requirements
  - Initial project plan and additional yearly variations
  - Milestone reporting cycle – based on project plan
- Financial requirements
  - Detailed yearly budgets
  - Detailed evidence of spending with each milestone report
  - Financial contributions from WMF not reimbursed until after reporting cycle complete … can be drawn out.

PROJECT FOCUS

- Scale of the Problem.
- Potential Solutions
  - Working together
  - Regional strategy
- Alternatives to the Status Quo
  - Investigating end-use options
  - Field trials
    - Biosolids composting
    - Seedling growth trials
    - Grazing crop field trial
- Iwi and Community Engagement

PROJECT OVERVIEW

LOWE Environmental Impact

Three Primary Work Streams

Strategy Development

Outputs

- Report: Gap analysis; Desk top study.
- Report: Gap analysis; site visits and field investigations
- Report: Opportunities to Work Together.
- Report: Development of a Draft Strategy.
- Presentation: Biosolids end-use options for the lower North Island.

Biosolids Processing Trials

Outputs

Research reports:

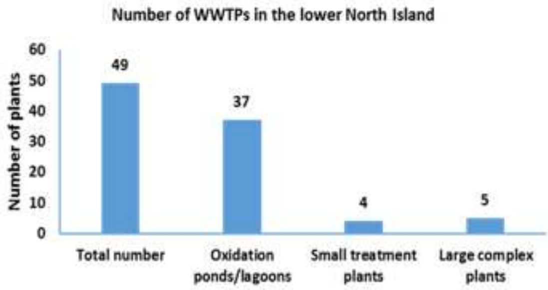
- Trial for assessing the reuse of biosolids as a growing substrate for nursery plants.
- Biosolids composting trial results
- Grazing crop field trial results

Iwi/Community Engagement

Outputs

- Report: Key insights and lessons learned.
- Developing a regional GIS map.
- Review: Assessment of cultural frameworks.

SCALE OF THE PROBLEM

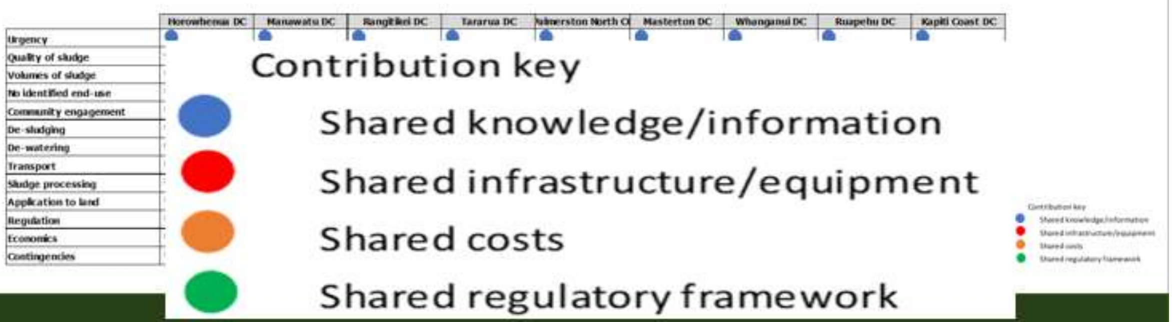


- Most sludge is landfilled;
- Significant volumes of sludge stored in oxidation ponds, and on site at WWTP – future liability; and
- Very little data exists on sludge quality.

L W E Environmental Impact

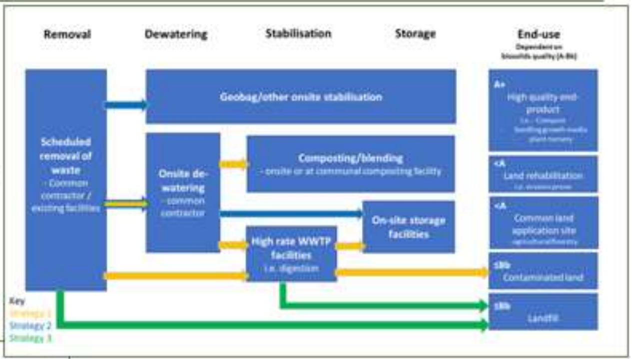
WORKING TOGETHER ON BIOSOLIDS MANAGEMENT

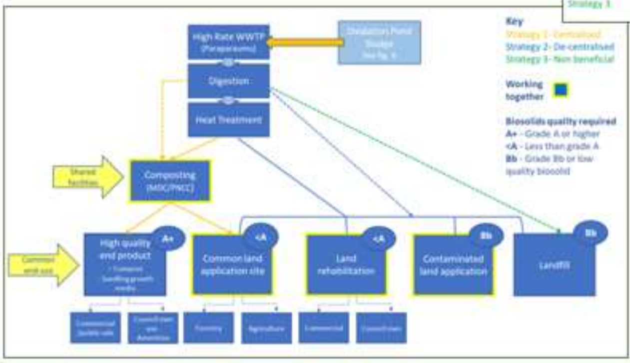
- Highlighted common problems and areas where councils could work together to manage sludge;
- Enabled dialogue/forum for discussion;
- Building of relationships; and
- Sharing of information;
- **Difficult to measure the success of these outputs.**



WORKING TOGETHER ON BIOSOLIDS MANAGEMENT

- Through discussion Strategies for collective management were developed - including specific details of how it applies to each district.





NOT ALL SLUDGE IS CREATED EQUAL

PNCC digester sludge

Tokomaru Geobag

PNCC Composted Biosolids

Auckland WWTP

- Options for re-use are dependent on quality of the sludge produced.

BIOSOLIDS PROJECT EXAMPLES

Whilst small scale experiment
useful, they do not alw
translate to the bigg

- Large scale field tria
  - Seedling trial;
  - Composting trial;
  - Massey field trial;

Maria's presentation

SEEDLING POT TRIAL

Plants grown in nurseries are well suited to using biosolids

- Not directly linked to human food chain;
- Commonly use growing media which requires frequent replacement;
- Slow growing plants benefit from slow release fertiliser such as biosolids; and
- Time between potting up seedlings and planting allow for further stabilisation.

TRIAL DESIGN

- Exposed seedlings to increasing conc. of biosolids mixed with mulched bark

CHARACTERISTICS OF FOUR SLUDGES AND BARK

- *value exceeds grade “a” and ** grade “b” biosolids.
- In most cases contaminants will be reduced to acceptable levels via blending

Properties	Units (dw)	PN	TOK	AKL	WHA	Bark Fines
Escherichia coli	MPN/g	<53	<30	5.7×10^4	<23	<38
Campylobacter sp.		Present	Absent	Present	Absent	Absent
Dry matter	%	34	61	20	79	47
Ash	%	61	92	28	25	42
pH		6.4	4.2	8.1	7.2	5.6
Electrical conductivity	mS/m	419	54.5	248	618	13.2
Organic matter	%	39	8.1	72	75	58
Total Organic Carbon	%	20	3.1	34	39	23
Total N	%	1.89	0.35	6.0	4.9	0.26
NH_4^+-N	mg/kg	6	240	12,500	3,700	6
NO_2^--N	mg/kg	<60	<1.0	<3	<1.0	<1.0
NO_3^--N	mg/kg	2400	3.2	<3.4	15.2	5.7
Ca	mg/kg	21,000	2,000	18,000	24,000	8,700
Mg	mg/kg	3,100	2,900	10,900	2,000	1,580
P	mg/kg	13,300	1,090	27,000	8,900	520
K	mg/kg	10,200	940	2,000	760	1,590
Na	mg/kg	1,550	108	720	4,200	300
Mn	mg/kg	350	240	139	1,170	165
As	mg/kg	11	5	5	5	2
Cd	mg/kg	0.51	0.028	0.81	0.39	<0.10
Cr	mg/kg	19	19	21	**17,300	6
Cu	mg/kg	61	*128	*240	*108	8
Pb	mg/kg	66	23	19.9	12.2	4.8
Ni	mg/kg	8	12	18	28	5
Zn	mg/kg	*300	175	*620	*380	41

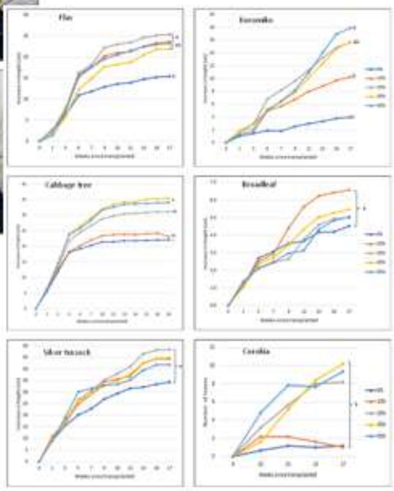
PN – Palmerston North composted biosolids, TOK - Tokomaru aged geobag biosolids, AKL - Auckland fresh biosolids, WHA - Whanganui fresh digested biosolids

MONITORING AND RESULTS

- All four biosolids improved plant growth
- When optimal concentration of biosolids is used plant height and biomass are increased between 2 and 10 fold

Six plant species used

- *Hebe stricta* (koromiko);
- *Poa cita* (silver tussock);
- *Corokia cheesemanii*;
- *Phormium tenax* (harakeke or NZ flax);
- *Griselinia* sp. (broadleaf); and
- *Cordyline australis* (Cabbage tree/ tī kōuka).



Growth of the species growing in increasing concentrations of biosolids from Palmerston North throughout the experiment. Results show averages. Different letters indicate significant differences between treatments in the last week of monitoring ($p < 0.05$).

BIOSOLIDS COMPOSTING TRIAL

- 12 compost rows incorporating three contrasting biosolids sourced locally
  - PNCC alum sludge;
  - PNCC digester sludge; and
  - Bunnythorpe oxidation pond sludge.

E. coli < 1 MPN after five months

BIOSOLIDS FIELD TRIAL

Trial aim

- Explore the use of biosolids as a soil conditioner for grazing crops.

Objectives are to determine:

- The impacts on soil fertility;
- The availability of nutrients for stock; and
- The growth response of winter grown crops.

TRIAL DESIGN

- Two sludge types, inorganic fertiliser and a no fertiliser control.
- Three crops:
  - Italian Ryegrass (seed)
  - Oats (seed)
  - Existing pasture

Both sludges would be Grade B and therefore require resource consent

Baseline data May 2019

Paramater	Unit	Pond Sludge	Digested Sludge	Soil
Organic Matter	g/100g dry wt	36.5	64	6.9
Dry Matter	g/100g as rcvd	8.15	15	75
Volatile Solids	g/100g dry wt	36.5	64	6.9
Ash	g/100g dry wt	63.5	36	93
Total Calcium	mg/kg dry wt	10750	15100	2500
Total Magnesium	mg/kg dry wt	2550	1720	830
Total Phosphorus	mg/kg dry wt	4650	16300	750
Total Potassium	mg/kg dry wt	1385	1200	540
Total Sodium	mg/kg dry wt	900	620	126
pH	pH Units	6.925	7.32	5.8
Total Nitrogen	g/100g dry wt	2.3	3.6	0.27
Ammonium-N	mg/kg dry wt	1260	6300	< 5
Nitrite-N	mg/kg dry wt	<7	< 4	< 1.0
Nitrate-N	mg/kg dry wt	<9.6	< 4.6	1.6
Nitrate-N + Nitrite-N	mg/kg dry wt	<7	< 4	1.6
Total Carbon	g/100g dry wt	19.4	29	3
Olsen P	mg/L	-	-	27
Exchangeable K	me/100g	-	-	0.32
Exchangeable Ca	me/100g	-	-	7
Exchangeable Mg	me/100g	-	-	0.89
Exchangeable Na	me/100g	-	-	0.14
CEC	me/100g	-	-	13
Total Arsenic	mg/kg dry wt	13.5	4	< 2
Total Cadmium	mg/kg dry wt	*1.895	0.73	0.16
Total Chromium	mg/kg dry wt	26.5	29	9
Total Copper	mg/kg dry wt	*220	164	4
Total Lead	mg/kg dry wt	68.5	33	7.2
Total Nickel	mg/kg dry wt	16	13	3
Total Zinc	mg/kg dry wt	*1035	680	27
Dehydrogenase enzyme	mg TPF kg^{-1} hr^{-1}	177.08	28.3	4.44
E. coli	MPN/g DW	*4.39 x 10^4	*1.76 x 10^7	*5.41 x 10^4

* exceeds limits for Grade A biosolid

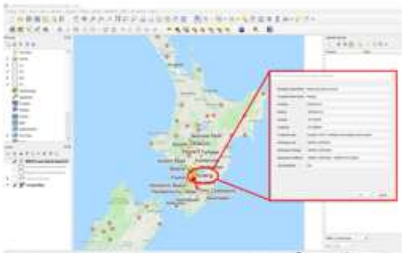
** exceeds limits for Grade B biosloids

RESULTS TO DATE

LOWE Environmental Impact

IWI AND COMMUNITY ENGAGEMENT

- Long-term, regional wide solutions for managing biosolids require the consideration of community and iwi views and values;
- The project has reviewed Cultural Health Indicators;
- Created a GIS tool mapping data on biosolids; and
- Developed a Cultural Health Index for composting of biosolids.



WHAT HAVE WE LEARNT

LOWE Environmental Impact

- Partners
  - Good – meeting and talking and better understanding
  - Bad - receive information and not pass on
- MfE
  - Good – positive about outcomes and objectives
  - Bad – changing staff, lack of knowledge, extensive reporting
- MfE Application Process
  - Long process
  - Milestone reporting

BIOSOLIDS GRADING

- Unrestricted use biosolids: Aa
- Restricted use biosolids: Ab, Ba, Bb.
- Non-grade sludge: Exceeds Bb

Location	Sludge/source	Grading	Notes
Foxton	Oxidation pond 1 - Facultative	Exceeds Grade Bb	- ↑ Zn, Cd, Cu. - ↑ *E. coli* - Sufficient plant available N and organic matter.
Foxton	Oxidation pond 2 - maturation	Grade Ab	- ↑ Zn, Cd, Cu. - ↑ Sufficient plant available N and organic matter.
Foxton	Oxidation pond 3 - maturation	Grade Ab	- ↑ Zn - ↑ Sufficient plant available N and organic matter.
Tokomaru	Geobag pond sludge	Grade Ab	- ↑ Cu - Sufficient N but low organic matter and high levels of silt/sand.
Shannon	Geobag pond sludge	Grade Ab	- ↑ Cu, Zn - Sufficient N but low organic matter and high levels of silt/sand.
Marton	Oxidation pond 1 – Facultative	Exceeds Grade Ab	- ↑ Zn, As, Cd, Cu, Hg - ↑ Sufficient plant available N and organic matter.
Marton	Oxidation pond 2 – maturation	Exceeds Grade Ab	- ↑ As, Zn, Cd, Cu - ↑ Sufficient plant available N and organic matter.
Masterton	Aged oxidation pond sludge	Grade Ab	- ↑ Cu, Zn - ↓ Nutrients offer little fertiliser value to soils.
Whanganui	Fresh digested sludge	Exceeds Grade Ab	- ↑ Cr Zn, Cu - ↑ Sufficient plant available N and organic matter.
Auckland	Fresh WWTP sludge	Grade Bb	- ↑ Zn, Cu. - ↑ *E. coli.* - ↑ Sufficient plant available N and organic matter.
Palmerston North	Composted biosolids	Grade Aa	- ↑ Sufficient plant available N and organic matter. - Predominant form or N is Nitrate
Palmerston North	Fresh digested sludge	Grade Bb	- ↑ Zn, Cu. - ↑ *E. coli.* - ↑ Sufficient plant available N and organic matter.
Palmerston North	Bunnythorpe – aged oxidation pond	Grade Bb	- ↑ Zn, Cu, Cd. - ↑ *E. coli.* - ↑ Sufficient plant available N and organic matter.

Key
No restrictions to use.
Land application would require restrictions/consent.
Not suitable for land application in present state.

MANAGING SLUDGE VARIABILITY

- Not all sludges equal
- Not all sludge from same site is equal
- Different management and grading possible

  Eg Foxton, Marton, Masterton

- What is the goal, do you treat worst case, or specific focus…..sampling regime?

TAKE HOME….

Reuse possible

- Done already in NZ
- Done internationally

There are unknowns

- Trial can help
- Experience of others can help

It will happen!!

Challenges

- Accepting new ideas – break the mould
- Regulatory environment – risk averse
- Cultural and community engagement – yucky
- Keeping staff engaged/focused/employed

Working together helps

- Just talking
- Sharing processes and knowledge
- Sharing resources
- There is a model for working together

ACKNOWLEDGEMENTS

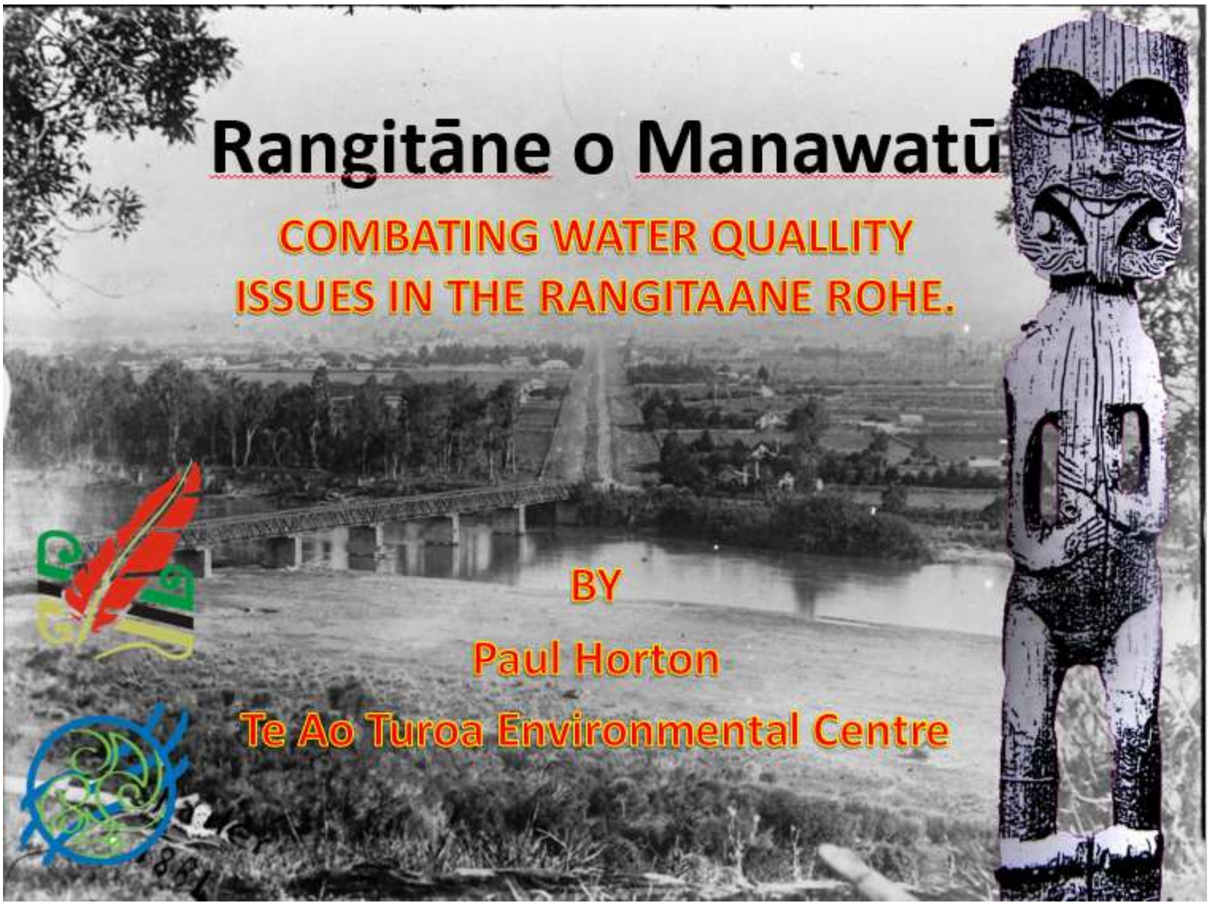
Ministry for the Environment, Massey University, Kapiti Coast District Council, Tararua District Council, Palmerston North City Council, Masterton District Council, Ruapehu District Council, Manawatu District Council, Rangitikei District Council, Whanganui District Council, Horizons Regional Council, Tanenuiarangi Manawatu Inc, The Centre for Integrated Biowaste Research.

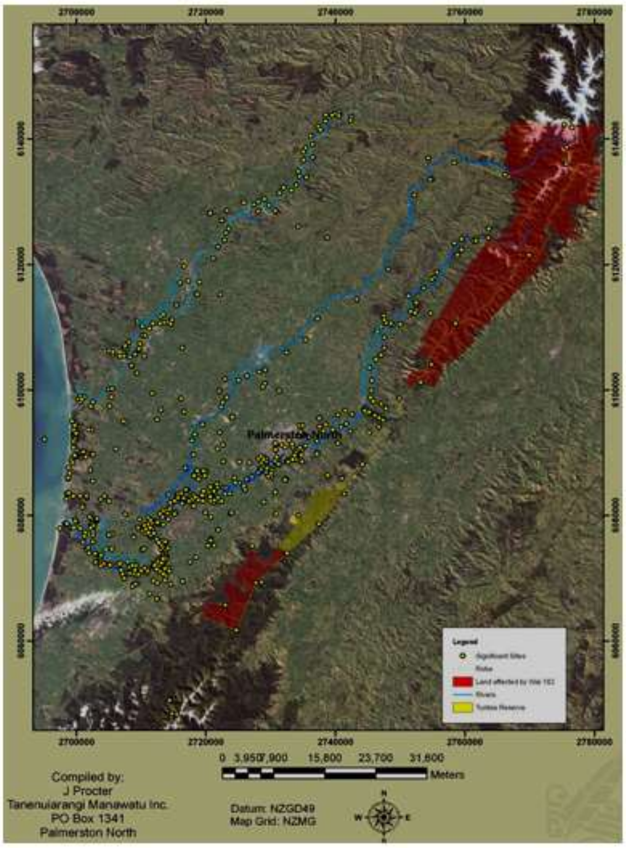
RANGITĀNE O MANAWATŪ- COMBATING WATER QUALITY ISSUES IN THE RANGITANE ROHE

Paul Horton [AB]

[A] Te Ao Turoa Environmental Centre

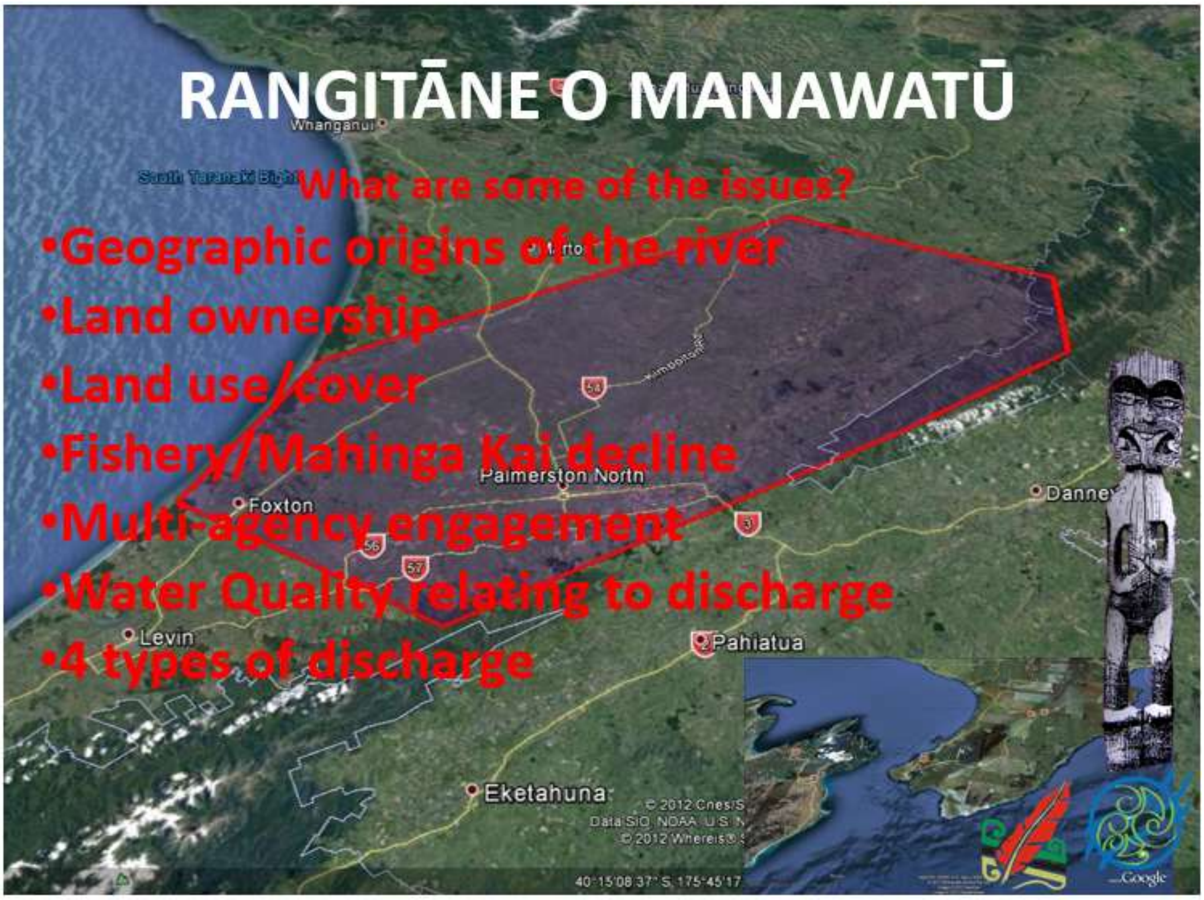
[B] Corresponding author email: paul@rangitaane.iwi.nz

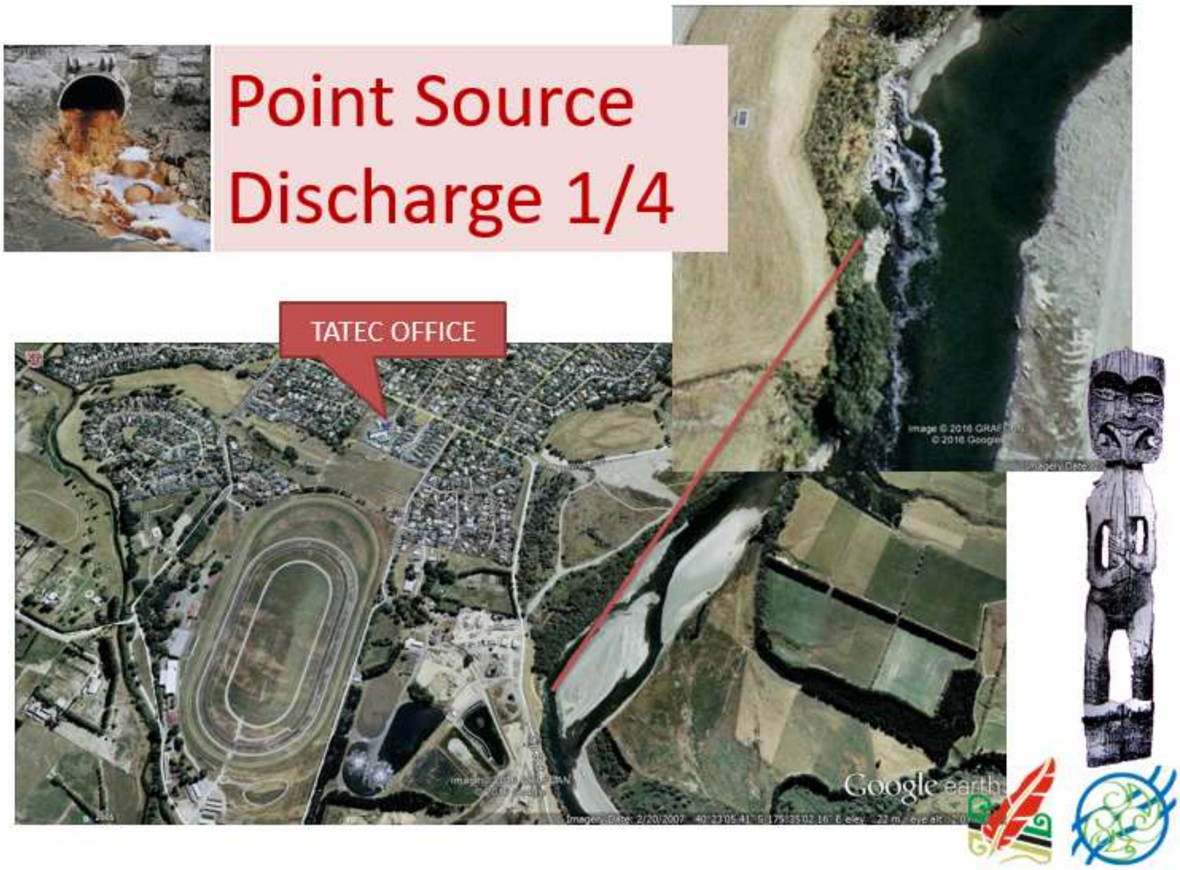




RoM Rohe

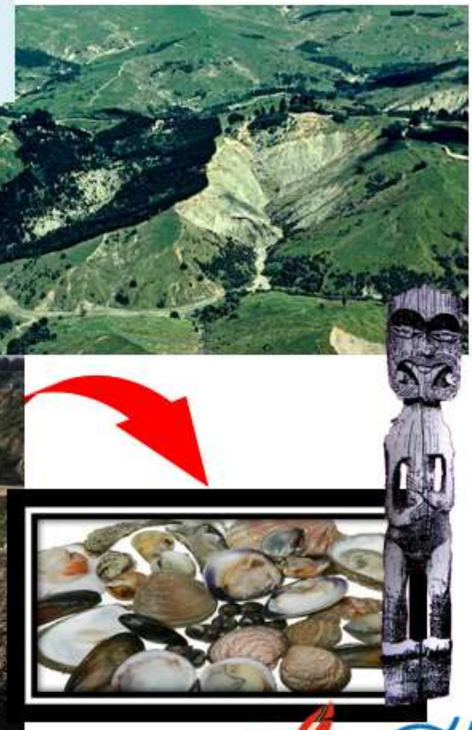
- Aprox 440,000ha
- 800 years occupation
- Present day 700+ waahe tapu (GIS)
- 6,000 RoM beneficiaries registered with Iwi Authotrity.
- 5 LTA's


RANGITĀNE O MANAWATŪ
What are some of the issues?
•Geographic origins of the river
•Land ownership
•Land use/cover
•Fishery/Mahinga Kai decline
•Multi-agency engagement
•Water Quality relating to discharge
•4 types of discharge
Whanganui
Palmerston North
Foxton
Levin
Pahiatua
Eketahuna

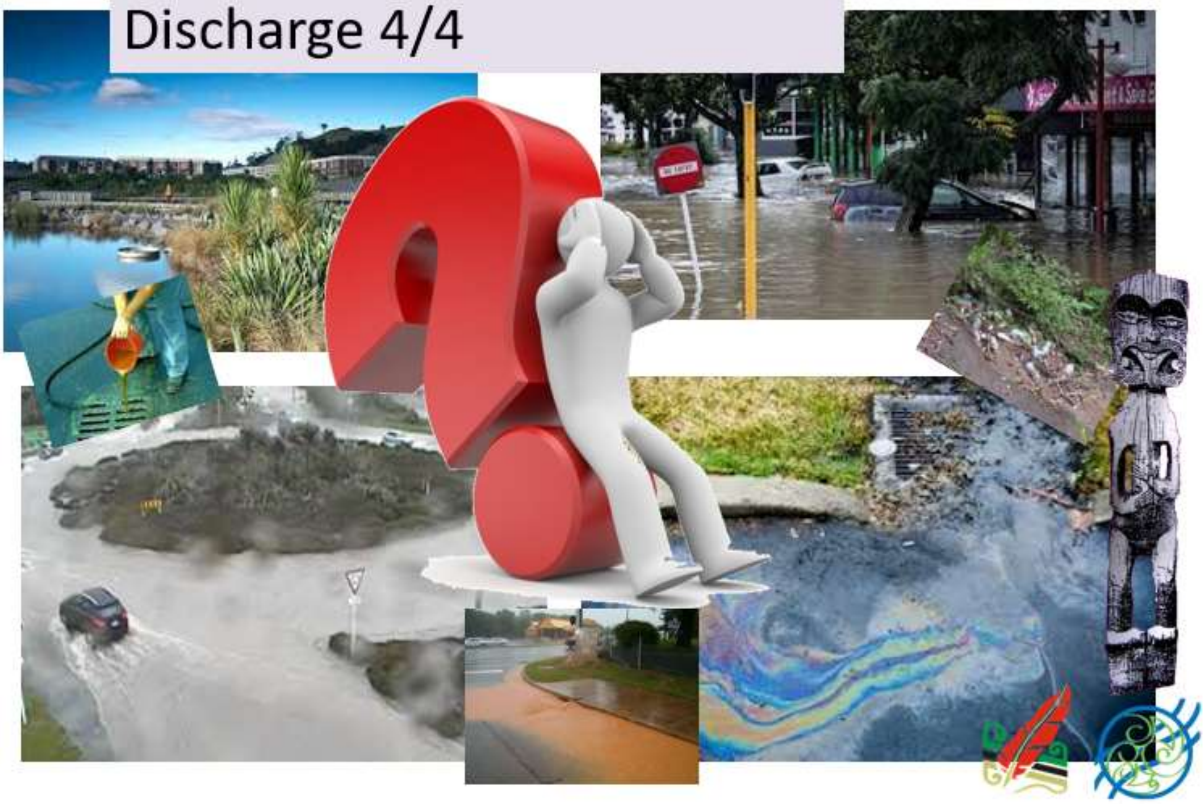

Point Source Discharge 1/4
TATEC OFFICE
Google earth

Diffuse Discharge 2/4

Nutrient Pollution Enriched Sediment Discharge 3/4



Urban Storm Water Discharge 4/4



RoM Settlement
Horizons One Plan
Registering our fresh and (marine) waterways under the MPI Kaimoana Fishery Regulations (*2010).

Planning and potential actions to improve water quality out to 2021

land irrigation sites in the RoM rohe

Foxton and Matakarapa
Shannon
Tokomaru
Waitarere*
Levin*

Shannon

8 years operation
Working Party
Cultural Health Monitoring
Harvest mahinga kai
Tuna whitebait fishery
Spoon bill
this year; Australasian Bittern sighting on farm

Tokomaru waste water plant 2021