The fate and impacts of terrestrial microplastics

Alix McDaid, Queen's University Belfast, PhD candidate
Supervisors: Prof. Gary Hardiman, QUB; Prof. Jaimie Dick, QUB; Dr. Gareth Arnott, QUB

Department of Agriculture, Environment and Rural Affairs
www.daera-ni.gov.uk

QUEEN'S UNIVERSITY BELFAST

Introduction

- Microplastics (MPs, < 5mm) threaten marine and freshwater ecosystems, but their effects on the terrestrial environment are under researched, especially in NI soil systems.
- Soil is important for nutrient cycling, carbon sequestration, water maintenance and filtration, biotic regulation, and biodiversity and habitat promotion.
- Healthy soil is vital for optimal crop health and pasture feeding for livestock.
- Of the research conducted so far, microplastics negatively affect soil properties and soil biota, but this field is still novel.
- Presently there is a knowledge gap in our understanding of how environmentally accurate concentrations of different MP types impact soil dwelling biota behaviour and animal physiology.

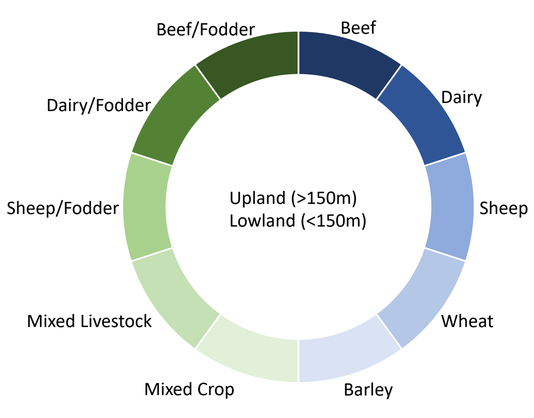
Research Aims and Objectives

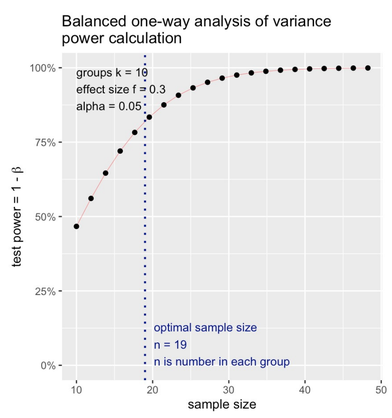
1. The concentration of MPs found in agricultural soils.
2. The types of MPs found in agricultural soils.
3. The impacts of MPs on the behaviour of soil biota.
4. The impacts of MPs on soil biota physiology and genomic perturbations with implications for livestock and human health.

Research Methods

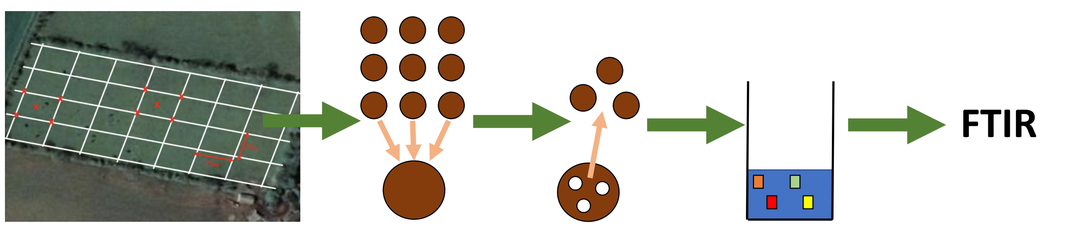
MP concentrations and types in NI agricultural soils

- Soil Samples being collected from 190 agricultural fields of varying land use:





- Field type based on NI Agricultural Census 2021 :largest sectors, increased output.
- Questionnaire to farmers re practices and methods: building database.

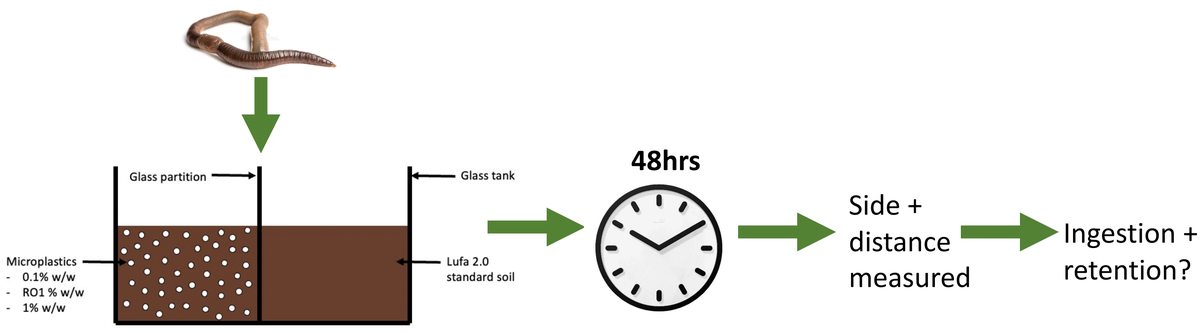


- Plastic type, morphology, size and colour will be determined.
- Average MP concentration (mg kg^{-1}) calculated.
- Concentrations can be compared between field types and elevation to understand which farms may be affected more.

MP effects on soil organism behaviour

- Earthworms play major role in soil structure, fertility and physical properties.
- Little to no research on predatory response and avoidance behaviour.
- *Lumbricus terrestris* - environmental indicator species will be used to assess impacts of various concentrations and types of MPs (determined in RO1) on these behaviours.

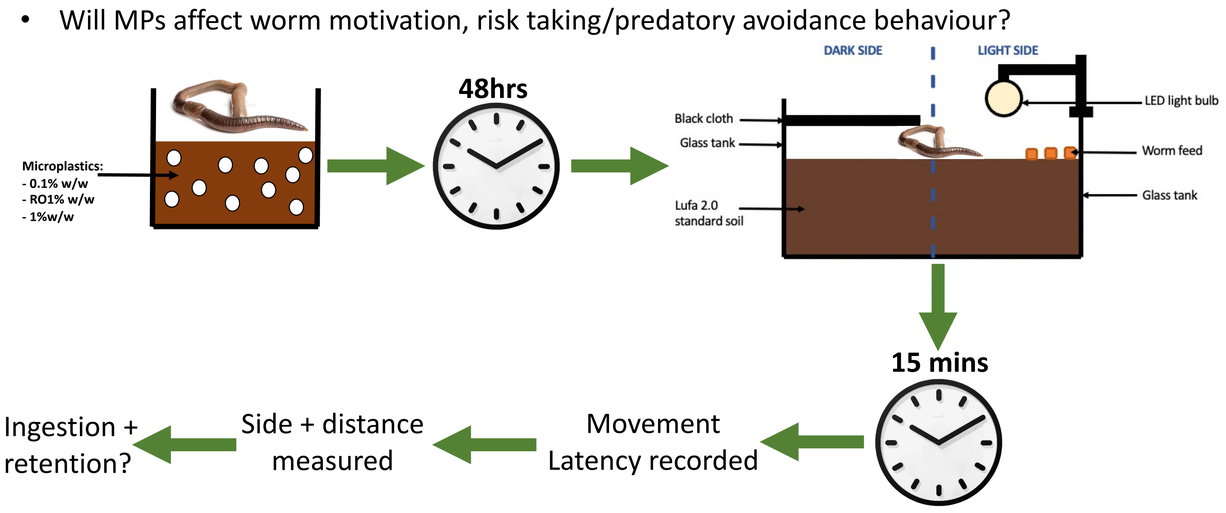
Avoidance Behaviour



- Calculate % avoidance.
- Compare MP concentrations and types.
- Model relationship between concentration and distance travelled.
- Freezing of worms for future analysis on MP ingestion and retention.

Predatory response behaviour:

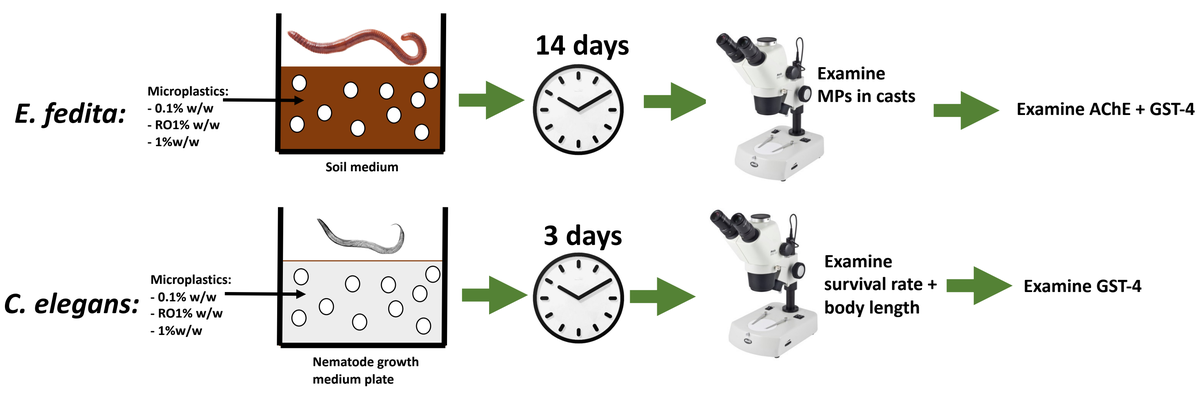
- Earthworms are negatively phototactic: a predator-avoidance strategy.
- Preyed upon in NI by the invasive alien species, New Zealand flatworm, *Arthurdendyus triangulates*.
- *L. terrestris* at risk of increased predation due to MP contaminated soil: could alter decomposition of organic matter and soil properties.
- Will MPs affect worm motivation, risk taking/predatory avoidance behaviour?



- High risk = food +bright light, low risk = no food + dark.
- Determine effects of MP treatments on risk choice.
- Examine effect of MP concentrations and types, and interaction effects.
- Freezing of worms for future analysis on MP ingestion and retention.

MP effects on soil organism physiology

- Effects of environmentally accurate concentrations and types of MPs on animal physiology not fully understood.
- *Caenorhabditis elegans* (Bristol N2 strain): sentinel species } Genome sequenced
- *Eisenia fetida*: environmental indicator species



- Oxidative stress and neurotoxicity will be measured by looking at acetylcholinesterase and glutathione S-transferase 4.
- Differentially expressed genes in both can be compared with the human genome and other organisms: determine which orthologs are impacted by MNP exposures.

Conclusions

- This project is the first to determine how much microplastics and the types that may be affecting soil biota, representative of environmentally relevant concentration for future studies. .
- It is important to recognise the effects on physiology and behaviour so that the impacts on the agricultural industry and human health can be better understood.
- The project findings can be used in future ecological risk assessments.
- This project will provide insights into real time health and environmental implications.

Acknowledgements

- Department of Agriculture, Environment and Rural Affairs
- Prof. Gary Hardiman, Queen's University, Belfast
- Prof. Jaimie Dick, Queen's University, Belfast
- Dr Gareth Arnott, Queen's University, Belfast
- Dr Eoghan Mánus Cunningham, University of Oxford
- Dr Andrew Crump, London School of Economics

Bibliography:

Blanchart, E., Albrecht, A., Alegre, J., Duboisset, A., Gilot, C., Pashanasi, B., Lavelle, P. and Brussaard, L., (1999) Effects of earthworms on soil structure and physical properties. *Earthworm management in tropical agroecosystems*, *5*, pp.149-171.
Chen, H., Hua, X., Li, H., Wang, C., Dang, Y., Ding, P. and Yu, Y. (2021) Transgenerational neurotoxicity of polystyrene microplastics induced by oxidative stress in Caenorhabditis elegans. Chemosphere, 272, p.129642.
Chen, Y., Liu, X., Leng, Y. and Wang, J. (2020) Defense responses in earthworms (Eisenia fetida) exposed to low-density polyethylene microplastics in soils. Ecotoxicology and environmental safety, 187, p.109788.
Department of Agriculture, Environment and Rural Affairs (2021*)* Provisional results of the June Agricultural Census 2021, *DAERA: NISRA*
Harper, E.H. (1905) Reactions to light and mechanical stimuli in the earthworm Perichaeta bermudensis (Beddard). *The Biological Bulletin*, *10*(1), pp.17-34.
Moore, J.P., Dynes, C. and Murchie, A.K. (1998) Status and public perception of the'New Zealand flatworm', Artioposthia triangulata (Dendy), in Northern Ireland. *Pedobiologia*, *42*(5/6), pp.563-571.
Sandhu, P., Shura, O., Murray, R.L. and Guy, C. (2018) Worms make risky choices too: the effect of starvation on foraging in the common earthworm (Lumbricus terrestris). *Canadian Journal of Zoology*, *96*(11), pp.1278-1283.
Syers, J.K. and Springett, J.A., (1984) Earthworms and soil fertility. In *Biological processes and soil fertility* (pp. 93-104). Springer, Dordrecht.Fründ, H.C., Butt, K., Capowiez, Y., Eisenhauer, N., Emmerling, C., Ernst, G., Potthoff, M., Schädler, M. and **Schrader, S. (2010)** Using earthworms as model organisms in the laboratory: recommendations for experimental implementations. *Pedobiologia*, *53*(2), pp.119-125.