Bioremediation of microplastics in Irish soils

Research project proposal (summer 1) Peter Dowling

Mankind is at an environmentally precarious point right now. Centuries of exploitation of the earth and overconsumption have had detrimental effects on our planet and our own health. One material that encapsulates the throw away culture we have now, is plastic. Plastics are incredible useful and important materials but are abhorrent for the environment, taking centuries to degrade and leaching harmful chemicals into our soil and water courses.

Common plastics are non-biodegradable as a result large quantities of plastic are accumulating in the environment, switching to biodegradable plastics will not help remove the plastics already in our soil and wate. Recycling plastics is difficult, people have a poor understanding of what is recyclable and not all plastics are equally recyclable. According to the EPA, in Ireland the recycling rate of plastic packaging is only 28% (1). When waste plastics are not correctly managed, they pollute our environment, one avenue of pollution is the generation of Microplastics.

The problem with Microplastics

Microplastics (MP) are fragments of any type of plastic less than 5 mm in length. They form when large pieces of plastic are weathered and broken down. While a whole plastic drink bottle is unlikely to enter the food chain, microplastics, from degraded larger plastics, have been found time and time again within soil and living organisms including humans (2,3) . build-up of these plastics within the food chain is detrimental to our health. For example, MP have been found to reduce viability of soil, leading to poorer crop harvest (4).

MP are easily transported by rainwater passing through soils, they then enter rivers and sea. Water suspended microplastics can be absorbed by many more organisms than microplastics trapped in soil. Therefore, there is a need to treat and remove these MP from soil before they enter our waterways.

What does this project propose?

This proposed research project will focus on categorising the MP concentration of soil samples from Ireland and the removal/degradation of MP within soil, this will be done by bioremediation. Bioremediation is the process of using microorganisms to treat and polluted or contaminated medium (water, soil, etc). Certain microbes can break down the bonds of certain synthetic polymers (plastics). Once in situ, it can become passive, requiring no electricity and very little maintenance. Keeping our freshwater systems free of MP is critical for the health of all organisms

Literature review

There is published work on the use of microbes for this purpose. A study from P. Masiá and colleagues (5) pointed at bioremediation as a promising strategy for MP removal from water treatment plants. Similarly, this 2021 (6) paper dealing with MP in the aquatic environment suggests bacteria as an effective and environmental remediation technique for MP. Both papers highlight the concern about MP within the food chain and the urgency in which it must be addressed.

However, these studies are treating MP as they enter the aquatic environment, and not at the source, in soil.

There is a gap in the literature surround bioremediation of plastics in soil. This is an important research opportunity surrounding the topic and can provide a possible solution to arrest MP before they enter the food system. There is a substantial lack of knowledge on the extent of MP in Irish soils. (Some work shows MPs in freshwater, EPA research 377 (7).)

Methodology and timeline

This project will take place over the summer of 2022. Microbes can take decades to fully breakdown substances and given the short time frame of this project, the main aim of this research proposal is to gather data on MP presence in Irish soils and propose some potential microbes that can counteract the MP.

The Lab studies will take place in the civil engineering lab in Trinity College Dublin.

(Week 1-2):

Objectives:

- To review the literature relevant to MPs sources in soils and bioremediation methods
- To identify farms for this study

Work:

- Relevant literature will be reviewed. Based on literature review and interview
- with farmers and relevant stakeholders (such as EPA and Teagasc), 3-6 farm sites will be identified for this study.

Deliverable:

- Farm sites identified for the study

(Week 3-4):

Objective:

- To quantify and characterise MPs in soils.

Work:

- Soil samples will be taken from farms.
- MPs in the soil samples will be quantified characterise by using Raman spectroscope and other equipment.

Deliverable:

- MPs concentrations in different farm sites

(Week 4-5):

Objective:

- To develop a MPs level map for Ireland.

Work:

- Based on the information collected in weeks 1-4, a map with MPs level will be produced.

Deliverable:

- Construct a MPs level map of Ireland

(Week 5-6):

Objective:

- To propose strategies to remove MPs from Irish farms.

Work:

- Based on the information collected in weeks 1 - 5, recommendations to remove MPs from Irish farms will be produced using suitable microbes.

Deliverable:

- Recommendation to protect Irish farms from MPs pollution

Expected results and contribution to body of knowledge

There is not much research quantifying MP concentrations and so this is an exciting opportunity to fill that research gap. Agricultural and industrial land, along with landfills will likely have a higher concentration of MP. Once the concentration is known of MP. Different microbes can be introduced to the sample. A successful project will conclude with a reduction of MP concentration throughout the samples.

The project will also add valuable data concerning MP in soil around Ireland.

Requirements

This project requires the use of a laboratory. Live bacterial cultures. Soil samples, and time. Soil samples will be gathered by myself. The laboratory used will be the soil lab, Simon Perry building and the environmental engineering lab, Watts Building.

A Ramen spectroscope will also be used analysing soil samples for MP.

No ethical approval or garda vetting required.

Supervisor

The supervisor for this project will be Professor. Liwen Xiao. Publishing many papers on the characteristics of MPs in soil and possible treatment options makes Professor Xiao the perfect supervisor for this topic.

Sources

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