Laidlaw research Project Reflective report: A study of Microplastics in Irish soil

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Introduction

The prompt for this research project was a simple observation of the sheer amount of plastic pollution on the grass and exposed earth which can be seen all over the country. It begged the question, *where will this plastic go?* Some will be collected, but some will also begin to degrade, and tiny particles will enter the earth and stay, effectively, forever.

Microplastics have become somewhat of a hot topic in recent years. Their emergence into the mainstream has skyrocketed awareness and discourse around them, prompting scientific paper after scientific paper and article after article. The effects of Microplastics (hereafter referred to as MP) on human health are still being uncovered however, many papers have linked disease, chronic illness, infertility, and other ailments to exposure to MP. One example is how MP can transport dangerous pathogens on their surface, increasing the mobility of pathogens in waterways and thus affecting more people.

At current, the literature centralises around MP in waterways and the marine environment. There is a large gap surrounding MP in soil. All water sources on earth are fed through rain, much of that rain runs over and through land before reaching the destined watercourse, with MP presences in soil there is a huge potential for relocation of these MP into the aquatic environment, where they become much more mobile.

Microplastics are any plastic particle less than 5mm in length. This investigation concerned MP between 0.1mm and above, analysing MP under 0.1mm proved challenging and out of the scope of this short project, it is still an area of interest.

Aim

The original idea of this project was to determine MP concentration in Irish agricultural soil, soil used to grow crops for consumption which could introduce MP into food chain. The final aim of this would be to formulate some mitigation measures and attempt to reduce these MP concentrations, using certain bacteria or enzymes. However, due to the short time allotted to this project the final aim could not be completed, and a streamlined project plan was developed.

A small pilot study, using only a small number of sites and samples was thought up. 5-6 sites would be sampled, and 3 samples taken from each site would be tested for MP concentrations. The study would also measure garden soils for MP as many more people are directly exposed to garden soil than to agricultural soil and for logistical reasons.

Methodology and challenges

As previously stated, much research has taken place MP in water and measuring concentrations, but very little work has been done on extracting MP from a soil matrix, this was the first challenge. Soil is a very complicated mixture. Made up of rock, plant and animal matter, water and other pollutants, it is a hard substance to isolate any one component from. I had to first come up with standardised procedure for MP extraction I could repeat for all my soil samples. After research of similar techniques and some trial and error the final procedure was developed and is outlined below.

1. Acquire soil sample. 10-15cm below surface, free from excessive organic matter (Sod, leaves, etc)
2. Dry sample in oven overnight at 110^{o}C.
3. Sieve dried sample with appropriate pore size. Stacked 5mm through 0.1mm sieves were used.
4. Separate main soil particles from MPs and Organic matter via density.
5. Filter Solution.
6. Remove Organic matter using digestive enzyme, Fenton's reagent. 2:1 ratio of H_2O_2 to FeSO4 Catalyst. Let react in loosely covered vial at 50^{0}C for several hours until all organic matter has been removed.
7. Remove particles for inspection and leave to dry
8. Use Raman spectroscope, visual means, or both to quantify remaining particulates.

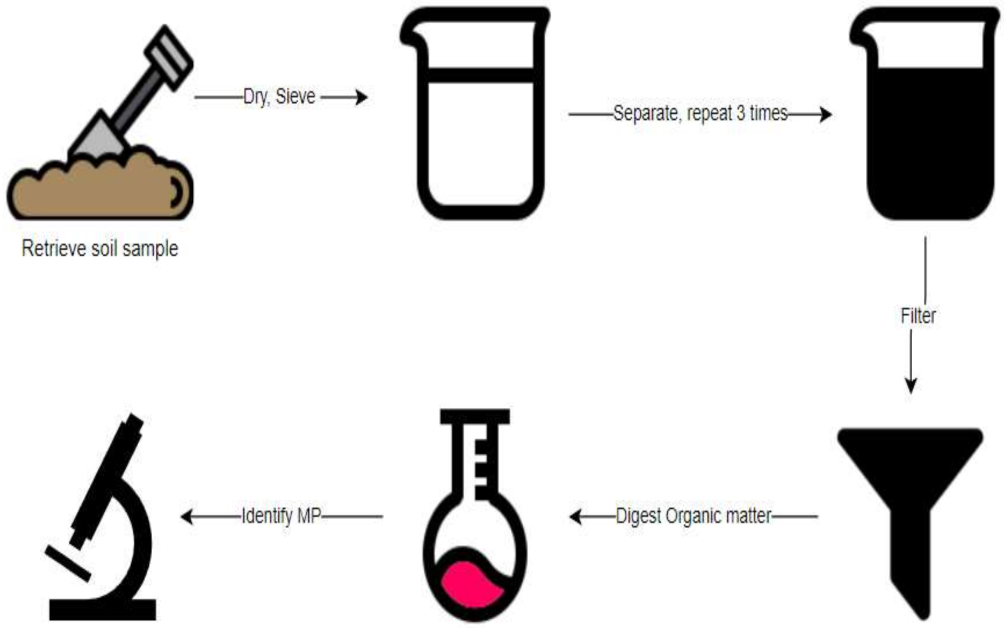

Figure 1: Method of MP extraction

The separation step proved more challenging than the others. The MP have a lower density than much of the soil which means, when placed in a dense solution (relatively, when compared to water) the MP particles will float to the top. The difficulty arose when much of the MP at the top of the solution was obscured by a lot of organic matter. Irish soil is very fertile and generally has a large amount of organic matter. The organic matter made MP identification and isolation much more difficult. This made the digestion stage very important.

The most challenging part of this process was identifying MP for Raman spectroscopy. Raman spectroscopy is a method of verifying whether a particle is a MP or not. Lots of particles that looked like MP were not and vice versa. This extraction of MP also had to be done largely by hand, picking out each particle one by one for testing. This limited how many samples I could process per day and added human error. Some particles were so small that they were impossible to grab with even the smallest tweezers in the lab. This problem was alleviated by using a valve which drained the fluid below the top layer, but still proved difficult as the small MP particles would adhere to the glass and be hard to pick off.

The context of this investigation was important, and so records of where each sample was taken from was kept. Coordinates are displayed. All samples were taken from Leinster, in the counties of Carlow and Dublin. All the samples were from brown earths. The process of collecting samples was enjoyable but did slow down the research and was an expense.

Results and findings

The aim of this project evolved through the time I spent researching and so the findings differed slightly from those I suspected. Raman spectroscopy was the only tool used in measuring the MP in this project. A Raman spectroscopy works by firing a laser at a particle, exciting the molecules of said particle, and by measuring that excitement it can determine what that molecule and subsequent particle is made from.

Agricultural investigation

A farm in Carlow was chosen for this investigation.

The field was recently harvested for barley and had been fertilised with cattle dung earlier in the year.

The dung had small pieces of low-density polyethylene (LDPE) sheeting from silage wrapping. This came from when the cattle would eat silage and accidentally consume some of the plastic wrapping. The plastic was seen on the surface of the field and some small pieces could be made out in the soil sample, this seemed very promising.

Figure 2 Silage wrapping can build up quickly on a farm and be expensive and difficult to dispose of

Sample table, coordinates, and soil type

No. Samples	Location	Soil type	Initial Observation
3	**52.809780, -6.883825**	**Brown earth, Agriculture**	**Little LDPE on surface, harvested recently**
2	**52.820584, -6.932998**	**Brown earth, Agriculture**	**Under grass, no plastic on surface**

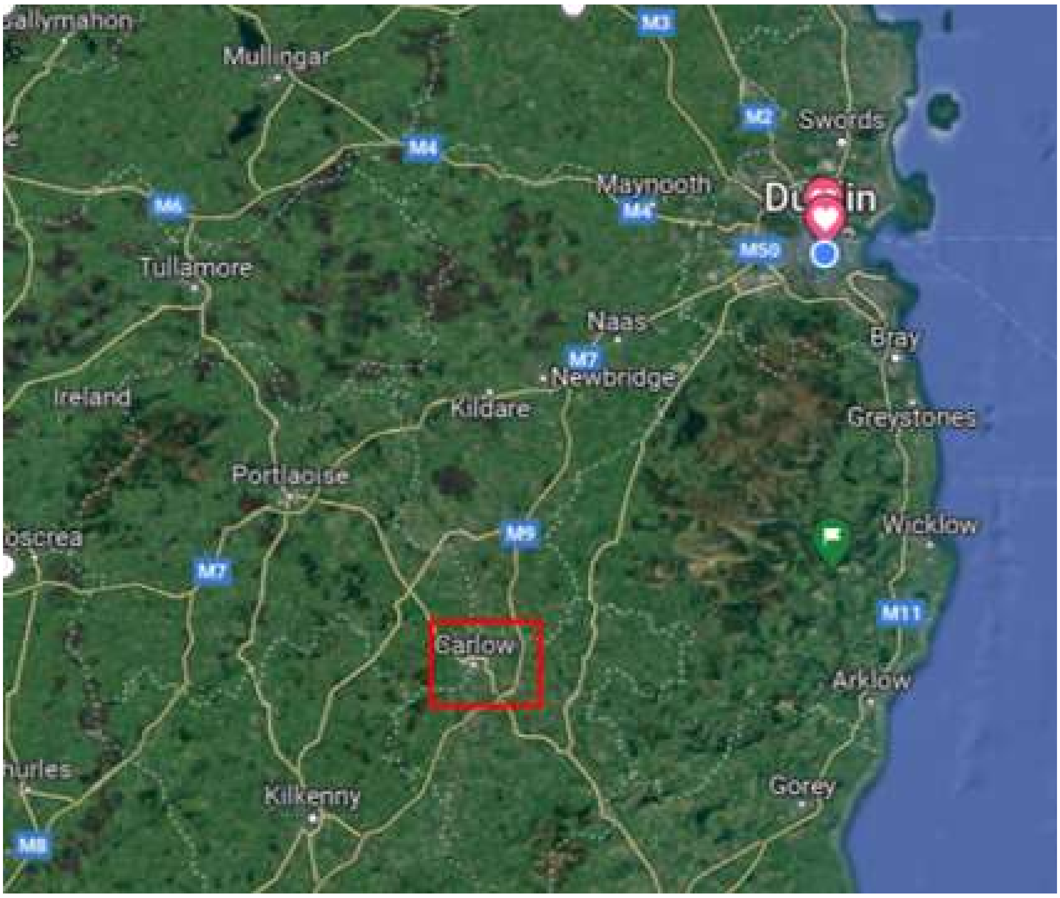

Figure 3 Location of farm

Figure 4: Field sampled highlighted

After completing the sample preparation steps there was a number of particles to be tested, shown below.

Figure 5: Some particles isolated from sample

From 100g of soil 9 particles were identified and removed, see figure 5.

Visual inspection indicated that some LDPE was present, No 1, No 8, No 9.

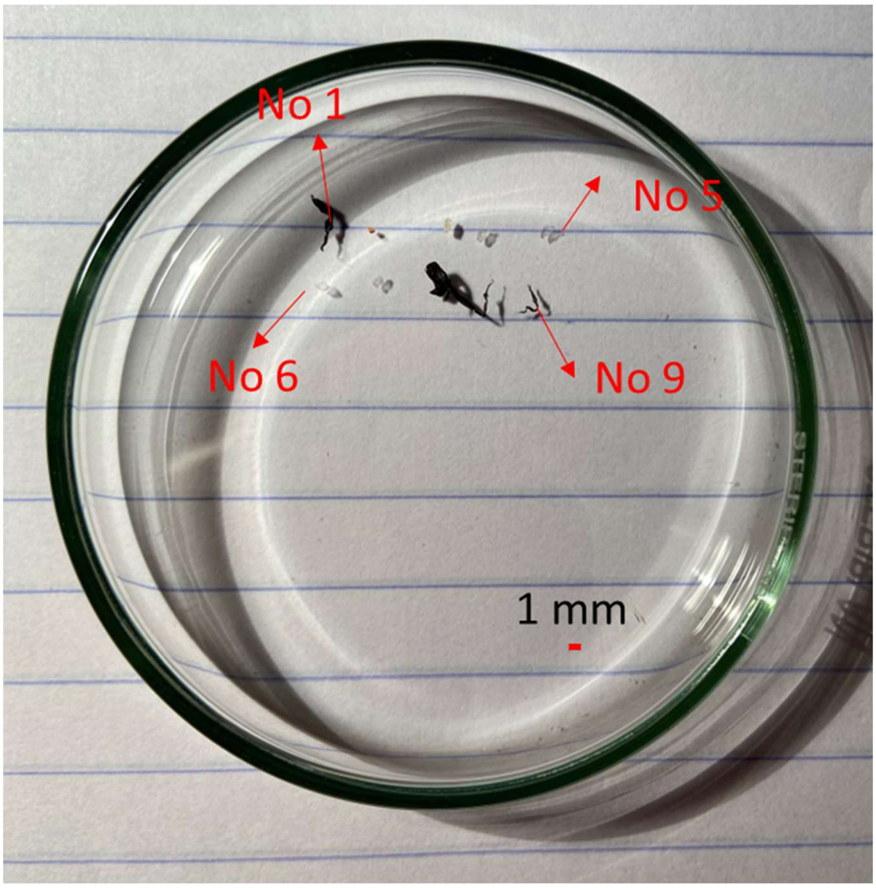

Figure 6

Raman results from farm soil, sample 2.

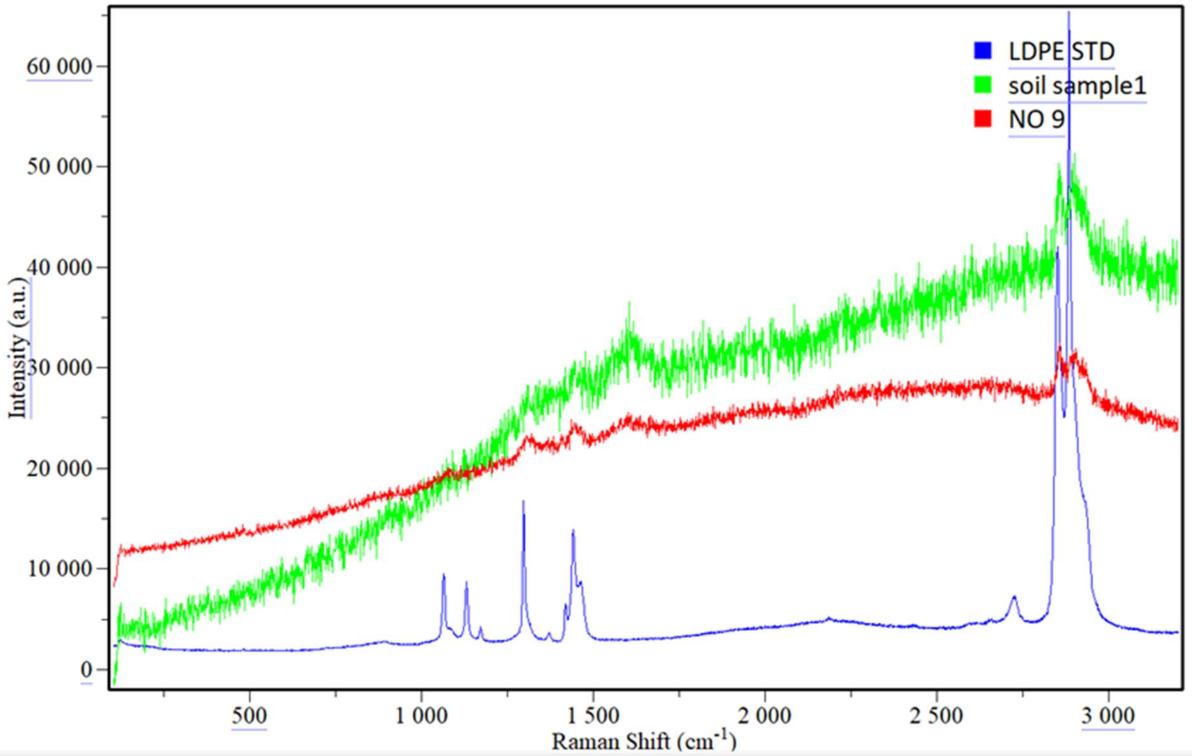

Figure 7

Raman results from farm soil, sample 1.

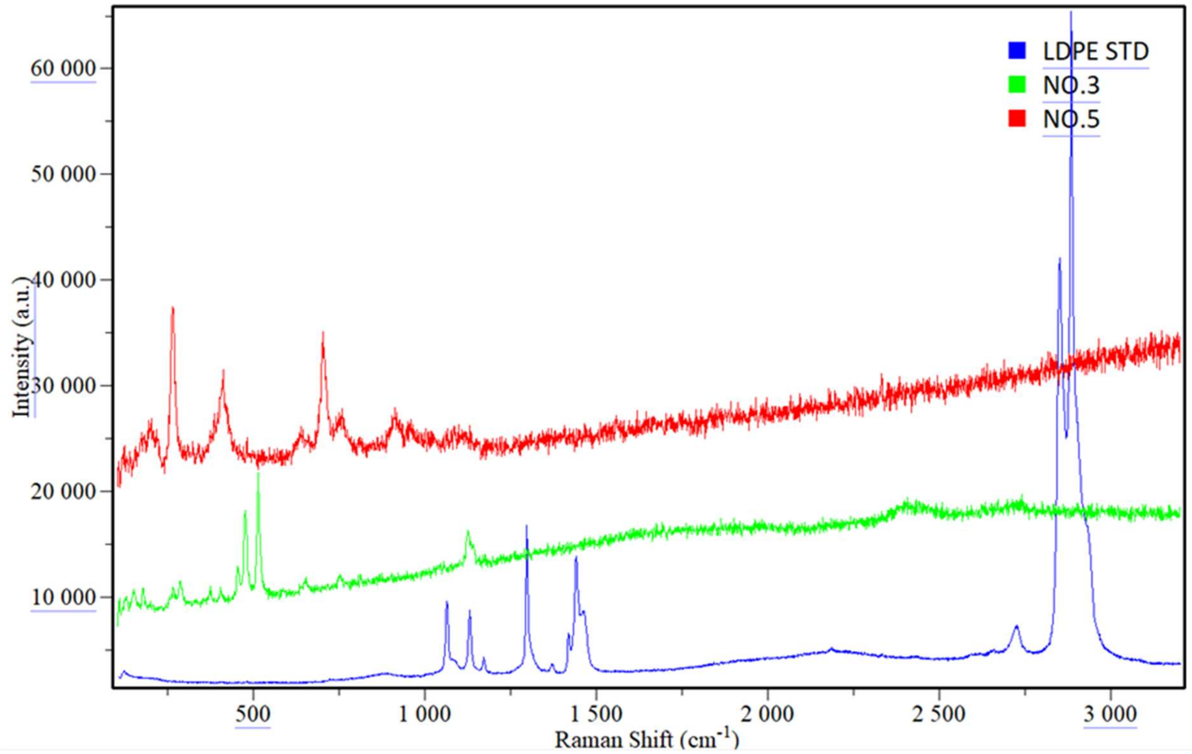

Figure 8

Despite the promising visual inspection, the Raman spectroscope indicated there was no MP present in the sample. The blue line above represents standard LDPE, if LDPE the particles should match the general shape of the blue line, rise where the blue rises and fall where it falls, however this is not the case. If figure 7 there is some corelation between the lines at 2800cm^-1 but the lines are distorted and full of noise. Likely caused by the soil still attached to the sample and the colour of the particles.

This agricultural soil seemed to have very low concentrations of MP and subsequent results reinforced that. This was not what I was expecting and proved challenging as I was unsure what the next step in the project should be, it was here I altered my strategy and decided to pursue soil MP in a slightly different context, domestic garden soil. Restructuring my project plan was not something I anticipated but it proved the right choice. Being able to adapt to results and challenges is something I made an effort to practice throughout this project.

Garden Soil Investigation

5 Gardens were selected, 2 in Dublin, 3 in Carlow.

Sample table

No. Samples	Location	Soil type	Initial Observation
3	53.256207, -6.172743	Brown earth, Garden	Under grass, no plastic on surface
3	52.809780, -6.883825	Brown earth, Garden	Little LDPE on surface
2	52.820584, -6.932998	Brown earth, Garden	Under grass, no plastic on surface
2	52.826601, -6.928942	Brown earth, Garden	Bare earth, Much plastic on surface
2	53.289151, -6.261615	Brown earth, Garden	Under grass, no plastic on surface

The following results are from location 52.826601, -6.928942.

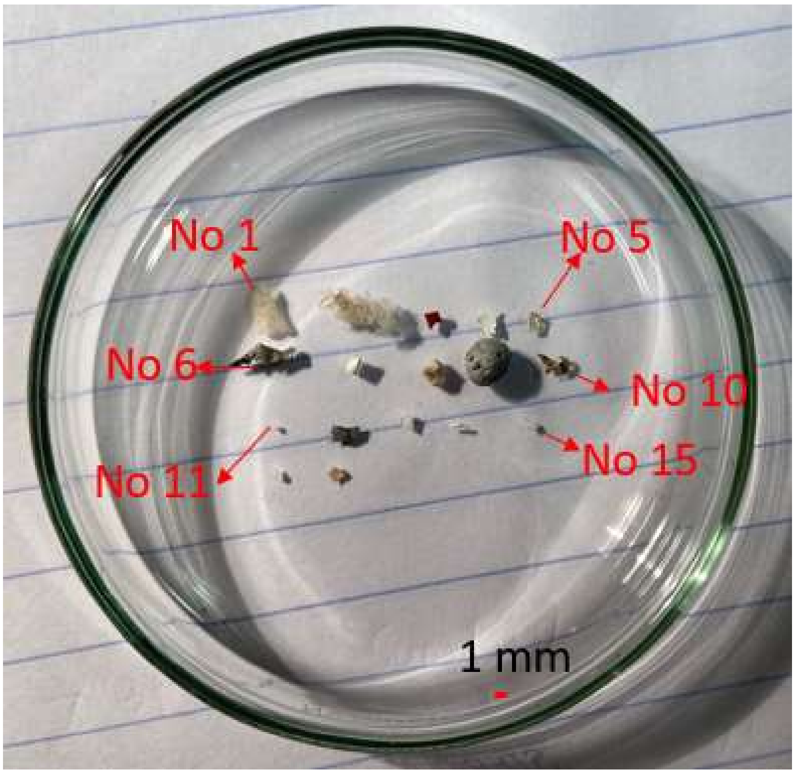

Figure 9

17 particles were obtained from one separation of this garden soil.

Ramen results from garden soil

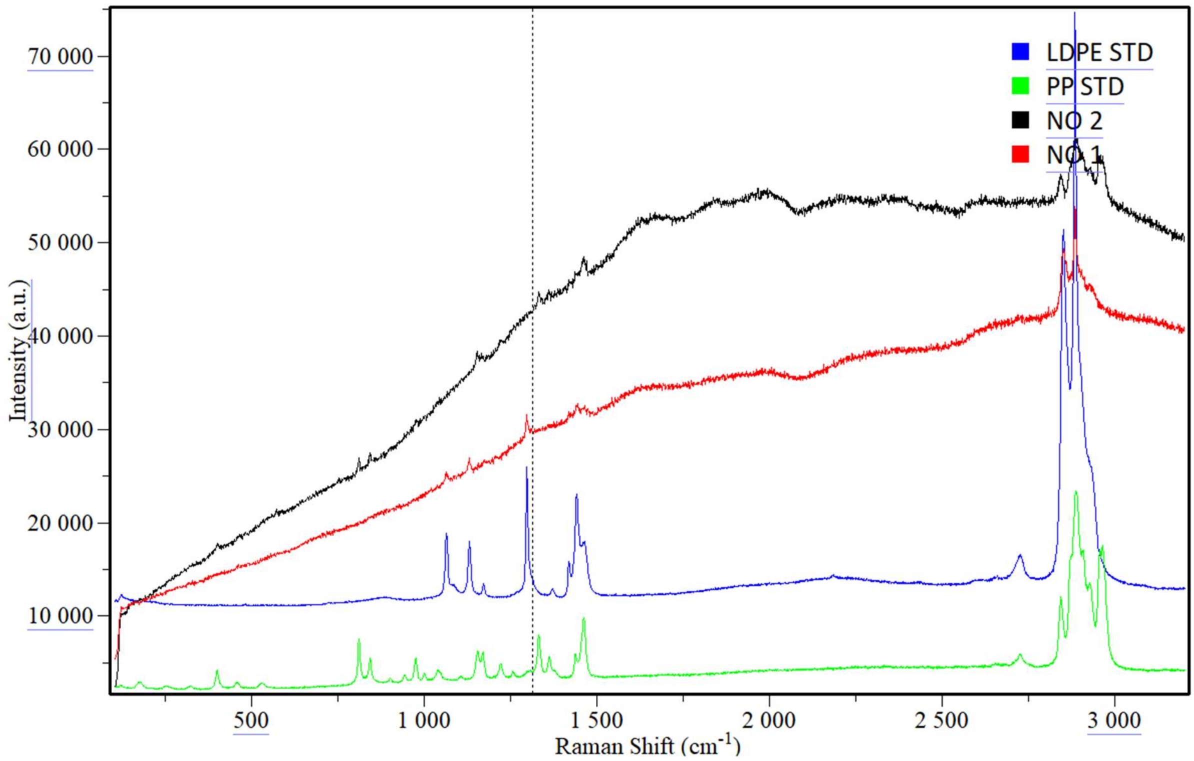

Figure 10: Raman spectrum of sample from 52.826601, -6.928942

Particle No	Raman result	Particle No	Raman result
1	PE	10	No raman spectrum
2	PP	11	PP
3	PP	12	No raman spectrum
4	PE	13	PE
5	No raman spectrum	14	PE
6	No raman spectrum	15	PE
7	PP	16	PE
8	No raman spectrum	17	No raman spectrum
9	No raman spectrum		

The results indicated that 10 MP were present, all either Polyethylene or Polypropylene. These particles are all above 0.1mm. The actual number of MP present is likely to be much higher.

25 MP were isolated from 50g of soil, this is approximately 500 particles per 1kg of soil.

These results indicate high MP concentrations. These samples were not collected at the surface and so it shows that MP are migrating own through the soil, with high concentrations to depths of at least 15cm.

The risk of human exposure to these MP is high, perhaps higher than in Agricultural soil. People spend much time in their gardens, gardening, children playing etc. Children could be especially at risk playing around or even ingesting MP contaminated soil. This final point shows the potential scope of this project. Highlighting the need for greater vigilance and care regarding MP exposure to children. The data shows that there is a large amount of MP can be ingested by children, further increasing their already high exposure to MPs.

Personal development

As a researcher this project has provided me with a lot of food for thought, what I feel I did right and what I can work on in the future. I found myself reflecting on some aspects of the project in particular.

I found communicating with people throughout the project to be very enjoyable. I had to deliver weekly reports on my progress at the lab meetings. I had to learn how to effectively communicate with many people whose first language was not English. Reflecting on this I have seen that communicating with people is something I really enjoy, and I should pursue more similar opportunities.

I found what I enjoy and what I don't. I found the lab and field work very enjoyable and rewarding. I cannot say the same for the reflection and self-analysis. I have realised though, that these are very important. Being able to reflect on your own experiences allows for greater self-improvement. Learning from your mistakes is vital, and something I now appreciate much more. In the past I feel I tended to shy away from thoughts about my own performance, perhaps thinking that how I felt was superfluous to the results of the project. I now realise the opposite is true.

Similarly, I found the same things above to be the parts of the project I had the easiest and hardest times completing. I enjoyed the lab and field work and easily learned how to complete that part of the project. The reflective report was more challenging to me. However, I believe after some time I have improved my self-reflection. And now see it as an important tool in self-improvement.

One aspect I wish to focus on more, is teamwork and collaboration. The scope of this project did not allow for much collaboration and teamwork between me and the other researchers. Of course, my supervisor provided a lot of invaluable information and resources. But in the future, I wish to be part of a more collaborative project. On reflection, I think this further highlights my enjoyment and affinity for working with others and communicative projects. As a result of the project being mainly solo work, I did not have any experiences of other leadership styles/techniques. This is another thing that, upon reflection, I would like to be exposed to. To find the style of leadership that you are best suited too I believe you should be exposed to as many as possible.

Conclusion and Future work

This Project proved challenging and very rewarding, I feel I accomplished my goal, ascertaining MP concentrations in a small sample group of Irish soils. The direction of this project evolved throughout my time researching. I am very excited to continuing working on thus topic as there is still a huge amount of work that can be done. I would like to explore mitigation measures in the future, such as bioremediation. Some enzymes have been shown to degrade certain plastics within soil. (1,2).

Bibliography

1. Masiá P, Sol D, Ardura A, Laca A, Borrell YJ, Dopico E, et al. Bioremediation as a promising strategy for microplastics removal in wastewater treatment plants. Mar Pollut Bull. 2020 Jul

2. Lu H, Diaz DJ, Czarnecki NJ, Zhu C, Kim W, Shroff R, et al. Machine learning-aided engineering of hydrolases for PET depolymerization. Nature. 2022 Apr