

**ASSESSING SOIL FOR MICROPLASTIC CONTAMINATION IN A SELECTED IRISH
POTATOE FARM IN KWEEN DISTRICT.**

KAPSIKORYA HILLARY

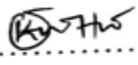
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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CHEMISTRY IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF
BACHELOR OF SCIENCE EDUCATION DEGREE OF BUSITEMA UNIVERSITY**

JUNE 2026

DECLARATION

I, Kapsikorya Hillary, declare that this project report titled “Assessing soil for microplastic contamination in a selected Irish potato farm in Kween district” is my own piece of work; it has never been submitted to any other university or institution of higher learning for the award of degree, diploma or certificate. All sources of information used in this report have been duly acknowledged by means of citations as per university policy.

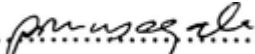
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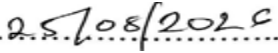
Date 25th/08/2026

APPROVAL

This research project has been submitted with the approval of the supervisor.

Mr. Musagala Peter

Signature ........

Date ........

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ABBREVIATIONS

FTIR Fourier Transform Infrared Spectroscopy

H₂O₂ Hydrogen Peroxide

ZnCl₂ Zinc Chloride

NaCl Sodium Chloride

NaI Sodium Iodide

PE Polyethylene

PP Polypropylene

PS Polystyrene

PET Polyethylene Terephthalate

PBT Polybutylene Terephthalate

MP Microplastic

NP Nanoplastic

MSW Municipal Solid Waste

GESAMP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

UV Ultraviolet

PyGC/MS Pyrolysis Gas Chromatography/Mass Spectrometry

CO₂ Carbon Dioxide

CH₄ Methane

N₂O Nitrous Oxide

PLA Polylactic Acid

PHA Polyhydroxyalkanoate

ABSTRACT

Microplastic (MP) contamination is increasingly recognized as a threat to soil health, yet data from low-resource agricultural regions remain scarce. This study assessed microplastic contamination in soils from Irish potato farms in Kween District, Uganda. Soil samples were collected from three distinct locations representing different potential contamination sources: an irrigation channel, a waste dump site, and where fertilizers are mostly used. Microplastics were extracted using density separation after oxidative digestion of organic matter with 30% H₂O₂. Extracted particles were identified by Fourier Transform Infrared (FT-IR) spectroscopy, and the resulting spectra were interpreted using a reference table of characteristic wavenumbers for common polymers (PE, PP, PS, and PET). All three samples contained microplastics, but each showed a different polymer type. The irrigated soil exhibited C=O carbonyl stretching (1716 cm⁻¹) and C–O ester stretching (1245 cm⁻¹), which can be attributed to Polyethylene Terephthalate (PET) contamination, likely from synthetic textile microfibers or bottle fragments transported by water. The dump soil displayed the characteristic CH₂ rocking doublet at 730 and 717 cm⁻¹, along with C–H stretches near 2920 and 2850 cm⁻¹, which can be attributed to Polyethylene (PE) contamination from fragmented agricultural films and general plastic waste. The fertilizer soil showed CH₃ rocking peaks at 997 and 972 cm⁻¹ and a CH₃ asymmetry band at 1458 cm⁻¹, which can be attributed to Polypropylene (PP) contamination probably originating from plastic fertilizer bags or polymer-coated fertilizers. These findings confirm that agricultural soils in Kween District are contaminated with microplastics, with polymer types reflecting local land use practices. The presence of PE, PP, and PET poses potential risks to soil structure, biota, and crop safety. This study provides essential baseline data to inform sustainable farming and waste management policies in Uganda

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Irish potatoes thrive in Kween District's high-altitude loamy soils (1,500–3,000 m) under cool temperatures (15–20°C) and reliable rainfall.

Microplastics are small plastic pieces <5 mm intentionally produced to be used in consumer products (e.g., as exfoliants in cosmetics) and in activities as abrasives (e.g., air blasting) (primary microplastics) or resulting from the fragmentation of larger objects (secondary microplastics). (Prata et al., 2019) and while this upper size limit is widely accepted, the lower size limit is still under scientific debate. Some groups, such as the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) include “particles in the nano-size range.” (Moller et al., 2020)

Frias and Nash proposed the following definition: “Microplastics are any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water”. We also distinguish between “large” microplastics (>500 μm –5 mm) and “small” microplastics (1 μm –500 μm). (Moller et al., 2020)

Plastic products have become an essential part of every human activity because of their light weight and suitability, thus becoming abundant in all sides of the economy. The increasing demand for plastics leads to increasing production and waste generation, which has created enormous problems, especially in the form of single-use plastics. Considering that the majority

of plastic waste is generated and emitted on land, it is rather surprising that microplastics research has only recently expanded to terrestrial ecosystems, where soils may be a significant long-term sink for microplastic particles. Especially urban and agricultural soils are assumed to be prone to microplastic contamination, as they are most exposed to human activities and therefore microplastic input pathways.(Moller et al., 2020)

In 2018, plastic production was 359 million tons, and its production is predicted to increase due to growing populations and increasing demands. The packaging sector is the main contributor to total global plastic waste, followed by textiles, consumer products and other sectors.

Municipal solid waste (MSW) generation is predicted to increase by 70% by 2050. Plastics in MSW are also increasing dramatically with the increasing use of plastic products, especially Single-use plastics. For example, in the United States of America, plastics in MSW went from 25.6 million tons in 2000 to 35.4 million tons in 2017. Canada produces about 3.3 million tons of plastic waste each year and sends 86% (2.8 million tons) to landfills.(Roy et al., 2022a).

1.2 Statement of the problem

Microplastics (<5 mm) are widely studied in marine systems but underexplored in terrestrial environments. Agricultural soils are increasingly contaminated via plastic mulch, irrigation systems, biosolids, and wastewater reuse. Soil contamination threatens soil health, crop productivity, food safety, and ecosystem services. The purpose of this research is to provide sufficient data on the sources, distribution, and long-term ecological impacts of microplastics in terrestrial environments, particularly in low-resource agricultural settings so as to inform effective mitigation strategies and policy interventions.

1.3 Objectives of the Study

The overall objective of the study was to assess the level of microplastic contamination in Irish potato growing fields in Kween district

The overall object will be achieved by the following specific objectives

- i) To determine the variation in microplastic contamination of soils from different origins using FT-IR spectroscopy.
- ii) To specify the specific polymer types of microplastics in various soil samples using FT-IR spectroscopy and reference data.
- iii) To ascertain the likely causes of microplastic contamination in different locations basing on data collected.

1.4 Justification of the Study

Microplastics disrupt Soil fealth and fertility by altering essential physical properties, such as decreasing bulk density and increasing soil porosity, which can lead to excessive water loss and erosion. They also interfere with the nitrogen cycle, reducing nitrogen availability for crops and increasing harmful ammonia emissions.

Accumulation in agricultural lands largely from plastic mulch, sewage sludge, and polymer-coated fertilizers inhibits root development and reduces crop yields hence affecting food security and productivity. Nano plastics can even penetrate plant roots and move into edible tissues, posing a direct risk to the human food chain.

MPs cause physical harm to vital soil organisms like earthworms and springtails, leading to gut inflammation, reduced reproduction, and increased mortality. They also fundamentally

shift microbial communities, potentially creating "plastisphere" hotspots for pathogens and antibiotic-resistance genes.

Due to their high surface area and hydrophobicity, microplastics adsorb and transport other hazardous chemicals, such as heavy metals (e.g., cadmium, lead) and pesticides, magnifying their toxicity in the soil ecosystem hence acting as a vector for toxic Pollutants.

Preliminary evidence suggests that microplastics can enhance greenhouse gas emissions (CO_2 , CH_4 , and N_2O) from the soil by accelerating the mineralization of organic matter and altering microbial metabolic rates hence changing the weather patterns.

Ongoing research is critical to developing eco-friendly alternatives, such as biodegradable mulch films (e.g., PLA, PHA), and implementing effective bioremediation strategies using specialized fungi or bacteria to mitigate existing pollution.

In conclusion, the study of microplastics in soil is justified by their persistence, accumulation and potential to disrupt soil structure, biological processes, agricultural productivity, food safety and human health.

Conducting this research will help to inform environmental sustainability, public health protection and policy formulation. It will also bridge existing knowledge gaps and support effective mitigation and remediation strategies.

1.5 Literature Review

1.5.1 Definition and various types of microplastics

The term “microplastic” refers to plastic particles between 1 μm and 5 mm in size that come in a variety of shapes, and polymer compositions, and can be classified by origin as primary (intentionally manufactured MPs) or secondary (MPs generated by the unintentional fragmentation of larger plastic items). Microplastics are heterogeneously mixed plastics that are less than 5mm in diameter, they include plastic fibers, granules, and fragments,

and they are considered to be emerging contaminants of concern (Yakovenko et al., 2025),(Guo et al., 2020)

Primary microplastics include pre-production plastic pellets and intentionally manufactured tiny plastic particles that are used in creating texture and friction for certain products. For example, microbeads are added to cosmetic products like toothpaste and facial scrubs, while microfibers are used in various household products and the textile industry.

Agricultural fertilizers are also known to carry microplastic additives such as microplastic fibers, microplastic fragments, microplastic beads and granules, foam particles that are spread into the environment, creating a higher concentration of microplastics in the soil. These microplastics make their way into the natural environments through water runoffs from rains, irrigation or regular water use and then disperse themselves in waterways to eventually reach the ocean.

However, most microplastics in the environment are secondary microplastics, which are the result of breakage and deterioration from bigger pieces of plastic in the environment. The fragmentation is caused by sun exposure and other environmental factors and leads to fragmented pieces that vary in size.

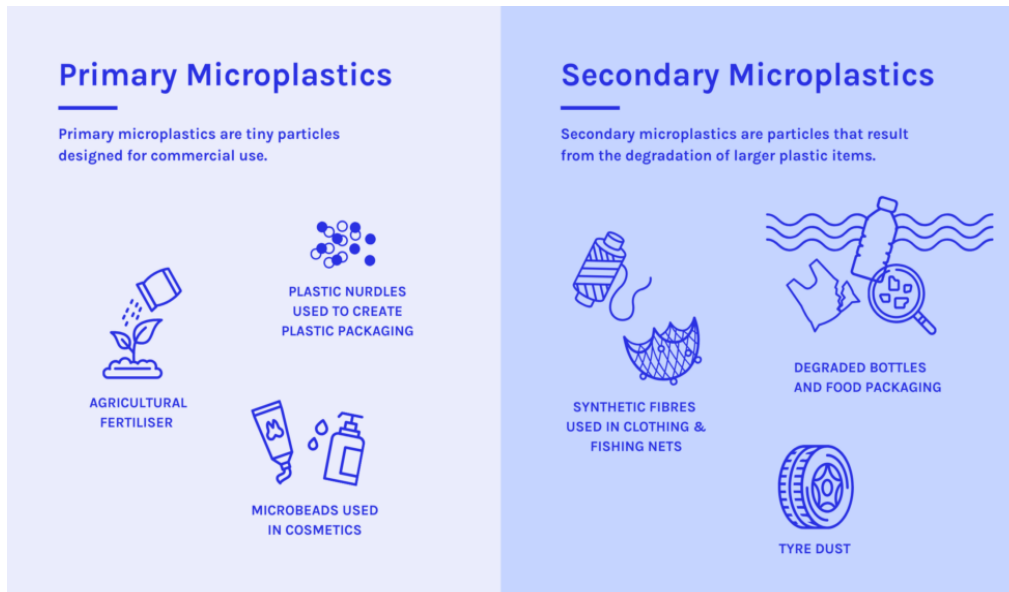


Figure 1: Illustration of the types of microplastics (Guo et al., 2020)

Based on the latest global estimate of microplastics, there are 93–236 thousand tons of microplastics floating on the ocean surface, which corresponds to as many as 51 trillion particles.(Guo et al., 2020)

1.5.2 Degradation, Sources, implications and migration pathways of MPs

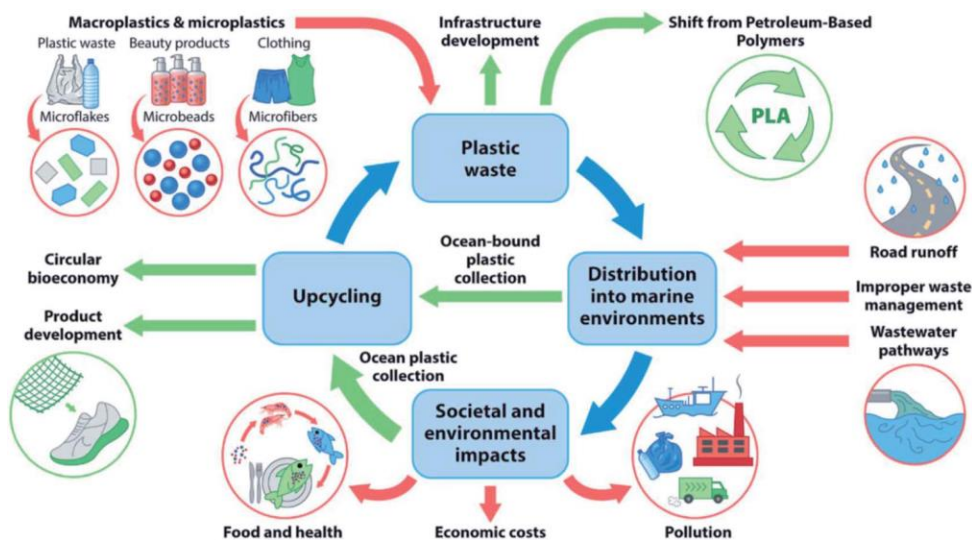


Figure 2: An overview of the sources of microplastics, their implications and migration pathways (Roy et al., 2022a)

Leaked or mismanaged plastics degrade into smaller fragments/particles in ecosystems over time.

Further degradation of MPs generates finer particles which are known as nano plastics (NPs).

MPs are found in water, soil, and air, which are hazardous to ecosystems as these particles are ingested by soil or marine biota, causing various health problems for them and contaminating food systems.

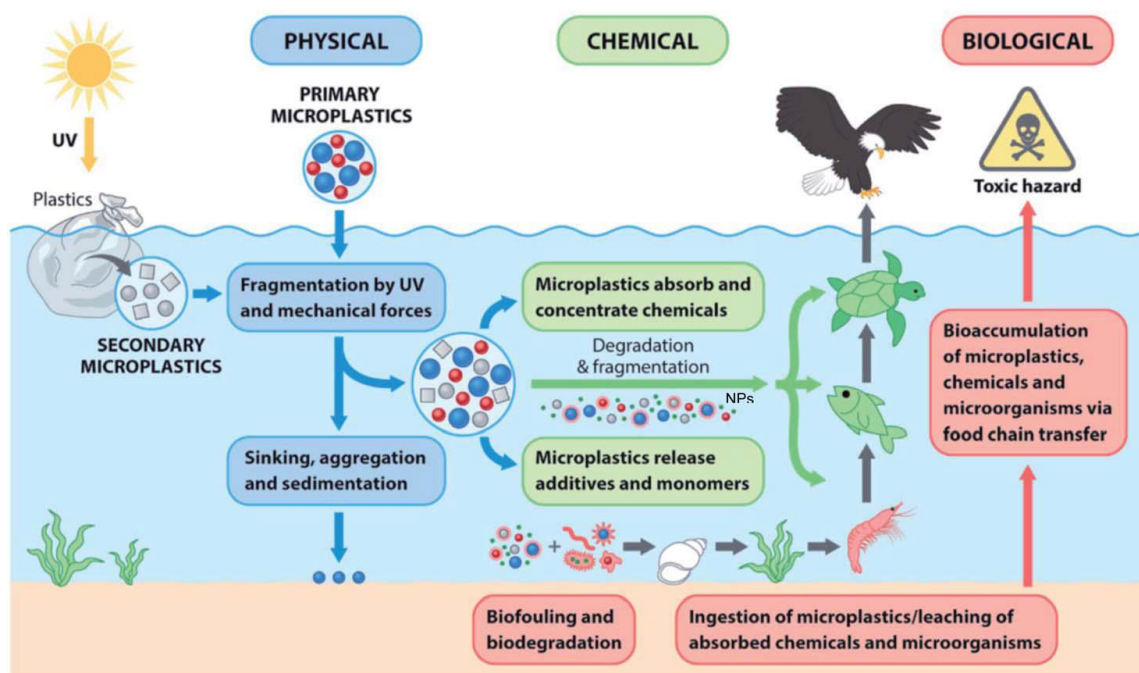


Figure 3: Schematic diagram of the degradation process of waste plastic (Roy et al., 2022a)

1.5.3 Common examples and sources of soil microplastics

The sources of microplastics are mainly classified as either primary or secondary microplastics. Primary microplastics are purposefully manufactured for specific applications, which include cosmetic abrasives, drug vectors, and industrial and engineering applications such as air blasting. These microplastics are usually difficult to remove using sewage disposal technologies and once

they enter wastewater; they will ultimately accumulate in the environment.

Secondary microplastics originate from larger plastics as they are progressively fragmented into smaller pieces by multiple, complex environmental conditions such as wind, waves, temperature, and UV light .(Guo et al., 2020)

Much different from the sources of microplastics in ocean, which mainly includes land-based sources (contributing~80%), costal tourism, recreational, commercial fishing (e.g., plastic fishing gear applications, etc., contributing~18%), marine vessels and marine-industries e.g. aquaculture, oil-rigs, etc., microplastics enter soil via multiple sources, including landfills , soil amendment, land application of sewage sludge, wastewater-irrigation , compost and organic fertilizer , residues of agricultural mulching films , tire wear and tear , and atmospheric deposition ,etc.(Guo et al., 2020),(He et al., 2018a)

Agricultural Films & Fragments: Degraded polyethylene (PE) mulch films, silage wraps, and protective greenhouse plastics are major sources in farming soils.

Sewage Sludge/Biosolids: Microfibers from synthetic clothing (polyester, acrylic) and fragments from wastewater treatment plants applied to fields.

Fertilizer Pellets: Coated, slow-release fertilizers that use plastic polymers as coating agents.

Tire Wear Particles: Fragments (elastomers) that accumulate near roadsides and in agricultural runoff.

Microbeads: Small, intentionally manufactured beads used in industrial abrasives.

Macro-plastic Breakdown: Weathered fragmented debris from plastic pots, irrigation pipes, and plastic twine.

1.5.4 Production and fate of microplastics

According to studies, by the end of 2015, all plastic waste ever generated from primary plastics had reached 5800 Mt, 700 Mt of which were PP&A fibers.

There are essentially three different fates for plastic waste.

First, it can be recycled or reprocessed into a secondary material. Recycling delays, rather than avoids, final disposal. It reduces future plastic waste generation only if it displaces primary plastic production, however, because of its counterfactual nature, this displacement is extremely difficult to establish. Furthermore, contamination and the mixing of polymer types generate secondary plastics of limited or low technical and economic value.

Second, plastics can be destroyed thermally. Although there are emerging technologies, such as pyrolysis, which extracts fuel from plastic waste, to date, virtually all thermal destruction has been by incineration, with or without energy recovery.

The environmental and health impacts of waste incinerators strongly depend on emission control technology, as well as incinerator design and operation.

Finally, plastics can be discarded and either contained in a managed system, such as sanitary landfills, or left uncontained in open dumps or in the natural environment.(Geyer et al., 2017)

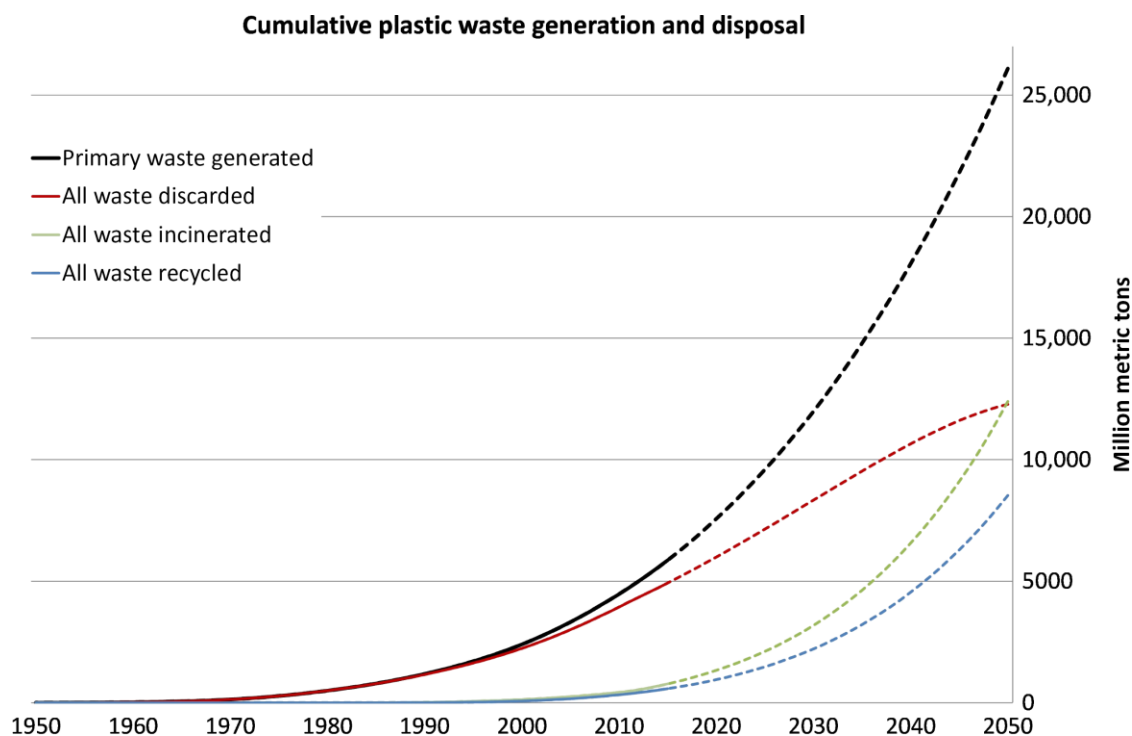


Figure 4: Cumulative plastic waste generation and disposal (in million metric tons). Solid lines show historical data from 1950 to 2015; dashed lines show projections of historical trends to 2050. (Geyer et al., 2017)

1.5.5 Sampling and extraction

1.5.5.1 Sampling

Soil sampling for microplastics (MPs) requires specialized techniques to prevent contamination, using stainless steel tools to collect topsoil samples (0-10 cm) from designated hotspots, such as agricultural fields, and storing them in glass, aluminum foil or metal containers.

To date, mainly the soil surface within the upper 10 cm has been analyzed as this is the range where the bulk of microplastic particles is most probable to be. However, the downward transportation mechanisms of microplastic particles of various sizes in undisturbed soils have not yet been analyzed. This should be done before defining a standard depth for soil surface analysis.

Arguably, representative sampling is one of the most important steps during environmental analysis. Nonrepresentative sampling will lead to unreliable data.(Möller et al., 2020)

Before actual laboratory analysis, how you collect soil samples greatly affects representativeness;

Systematic sampling; samples taken at regular intervals across a study area e.g., grid pattern, it is useful for spatial distribution studies.

Composite sampling; multiple subsamples from a site are mixed and analyzed together to represent that location.

Consider the number of samples, soil depth, and size to capture variability in microplastic distribution.

Sampling tools; clean non plastic tools such as shovels, spades, trowels, augers, are common instruments for collecting soil at specific depths. Use clean stainless steel or metal tools to avoid plastic contamination. One should put on cotton lab coat and gloves.

1.5.5.2 Extraction

Effective extraction involves density separation using solutions like Zinc Chloride sodium chloride or sodium iodide to float plastic particles; microplastics usually float on top because they are less dense than the solution. The floating fraction is then collected for further analysis. The separated fraction is then filtered and particles suspected to be microplastics are retained.

1.5.6 Identification and quantifications

FTIR and Raman spectroscopy identify polymer types in microplastics, while quantification counts particles per soil unit and categorizes them by size, shape, color, and polymer type.

Table 1: Microplastic types, shapes, size range, colors, and mean abundance in agricultural soils near industrial areas

Sample	City	MP Types (Polymer)	MP Shapes	MP Size Range	MP Colors	Mean Abundance (g)
1	Kapurthala	PP, PET	Fibers, Fragments, Film		Blue, White	0.267
2	Kapurthala	PP, PE	Fragments		Dark blue, Light green, White	0.452
3	Kapurthala	PBT, PP	Fibers, Misc., Fragments		Orange, Blue	0.309
4	Kapurthala	PS, PP	Fragments, Fibers	100–200 μm	White, Blue	0.209
5	Amritsar	PS, PP	Fragments		White, Light brown	0.117
6	Amritsar	PP, PE, PET	Fibers, Fragments, Film		Blue, White	0.215

Sample	City	MP Types (Polymer)	MP Shapes	MP Size Range	MP Colors	Mean Abundance (g)
7	Amritsar	PP, PBT	Fragments		White	0.009
8	Amritsar	PP	Fibers		Blue	0.007
9	Jalandhar	PP, PET	Miscellaneous, Film	100–5 mm	Light sky blue, Transparent	0.234
10	Jalandhar	PP, PE	Fragments, Fibers		Blue, Light pink	0.017
11	Jalandhar	PP, PE	Fragments	2–5 mm	Blue, Transparent	0.023
12	Jalandhar	PP, PET, PE	Fibers, Fragments		White, Dark blue, Green	0.113

(Thakur et al., 2023)

1.5 7 Phytoremediation

Phytoremediation is an eco-friendly technique that uses plants and their associated microorganisms to absorb, stabilize, or break down pollutants in soil, water, and air. It is cost effective, ecofriendly and versatile.

Studies have been conducted to track the transport of MPs in plants. For example, the use of fluorescent microbeads and a confocal laser scanning microscope to examine how PS beads were translocated in *Triticum aestivum* (wheat). They observed that the beads moved from roots to the aerial parts of the plant through the apoplastic pathway and the leaf veins, which implies that it is possible for plant roots to absorb MPs, which are subsequently transported to other parts of the plant. This confirms phytoextraction (removal of contaminants by plants or roots from water bodies through root uptake or absorption) as a mechanism of MPs phytoremediation. The accumulation of MPs in the young roots was affected by the size of the MPs, where those smaller than 10 m were found to be more abundant. This study again points to MPs size as a factor affecting their uptake by plants, and MPs of smaller sizes are usually taken up more easily. The translocation of MPs to other parts of the plant was not reported.(Ho & Tang, 2023)

CHAPTER TWO

EXPERIMENTAL

2.1 Apparatus

Weighing of well dried soil samples was done on an AX523 OHAUS analytical balance (OHAUS Corporation USA), 30% H₂O₂ was used as an oxidizing agent. Conical flasks (250-500ML) were used for digestion reaction. A hot plate with a magnetic stirrer was used for controlled heating at 70°C and continuous mixing. Butyl alcohol acted as anti-foam and its dropper.

Zinc chloride solution (150ML) acted as the floatation medium, an orbital shaker agitated the mixture to ensure that microplastics trapped within sediment clumps were released into solution. Separating funnels or glass beakers served as mixing and settling vessels.

Filtration unit (vacuum pump, filter papers) was used in the recovery stage to capture the floated microplastics from the supernatant and a vacuum filtration setup (Whatman filter paper, 11µm pore size) which includes a flask and pump to quickly pull the liquid through the filter, leaving the microplastics on the surface for analysis.

Polymer identification will be done using a JASCO 6600 FTIR spectrometer equipped with liquid nitrogen cooled 64 × 64 detector elements focal array detector (FPA) with a 15 × 1R objective.

2.2 Materials

All materials were of analytical grade; they include hydrogen peroxide, butyl alcohol and zinc chloride.

2.2.1 Hydrogen peroxide

600ml of 30% hydrogen peroxide was prepared by measuring 360ml of 50% hydrogen peroxide and dissolving it in 240ml of water

2.2.2 Zinc chloride

Zinc chloride solution of density 1.8g/ml was prepared by weighing 84g of zinc chloride and dissolving it in 150ml of distilled water.

2.3. Procedure

2.3.1 Digestion

Soil samples (10g) were weighed using an analytical balance into clean conical flasks (3). 200ml of 30% H_2O_2 were added to the conical flasks gradually to avoid violent reaction. The flasks were placed in a cold-water bath to prevent over heating during oxidation. When the reaction stabilized, the conical flasks were transferred to a hot plate at 70°C , stirring continuously to avoid collision of soil and H_2O_2 . When excess froth formed, a few drops of butyl alcohol were added. Heating was maintained for 12 hours until sample turned greyish. The flasks were then allowed to cool before proceeding to the floatation process.

By the end of this process, organic matter would have been digested, leaving behind a cleaner soil matrix enriched with microplastics and soil minerals.

2.3.2 Density separation or floatation

30ml of zinc chloride solution was added to each digested soil in respective conical flasks and shaken for 1 hour at 200rpm in an orbital shaker. They were then left to stand for 48hours and then 20ml of the supernatant was decanted. 10ml of zinc chloride was added and shaken for 30 minutes, left to settle and supernatant was collected.

At the end of this process, MPs float due to lower density compared to soil particles.

2.3.3 Filtration

The supernatant was filtered using vacuum filtration. The floatation process was repeated until no MPs remain floating or adhered to flask.

The filter papers were placed in clean petri plates and dried in an oven at 60°C for 1hour.

At this point, the MPs collected on a filter paper are ready for spectroscopy characterization.

2.4 Treatment of results

The spectra which will be produced shall be analyzed using the data from the reference table below

Table 2: Reference wavenumbers for common polymer types (PE, PP, PS, and PET) for FT-IR identification.

Polymer name	Abbreviation	Typical wave numbers(cm^{-1})	Functional group / bond vibration
polyethylene	PE	2915 – 2845	C – H stretching
		1467 – 1462	CH ₂ bending
		730 – 717	CH ₂ rocking

polypropylene	PP	2950 – 2838 1458 997 – 972	C–H stretching /asymmetric vibrations CH ₃ asymmetry CH ₃ rocking
Polystyrene	PS	3025 2925 – 2850 1601, 1493, 1452 755, 696	=C-H stretching C-H stretching C=C aromatic ring stretching C-H out-of-plane bending
Polyethylene Terephthalate	PET	1715 – 1740 1245 722	C=O carbonyl stretching C-O ester stretching Aromatic C-H out-of-plane bending

CHAPTER THREE

RESULTS AND DISCUSSION

3.1 Results obtained from FTIR spectrum.

3.1.1 Sample 1(dump site)

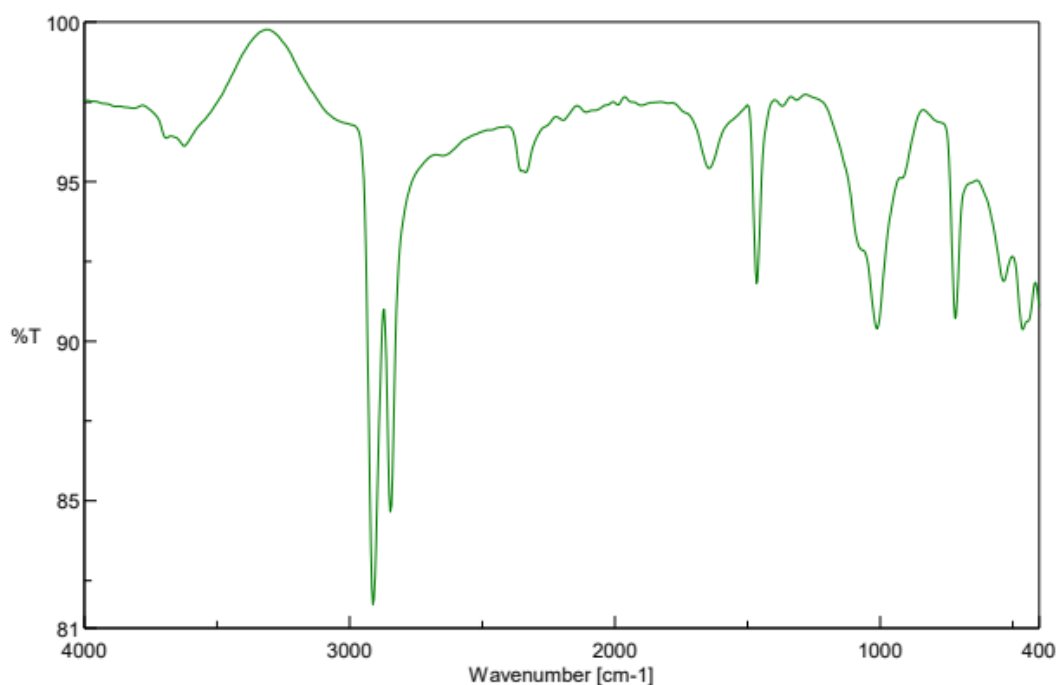


Figure 5: FTIR spectra of sample from dump site.

Interpretation;

The spectrum exhibits the characteristic doublet at 730-717 cm⁻¹ (CH₂ rocking) and a strong CH₂ bending peak near 1465 cm⁻¹, along aliphatic C-H stretches near 2920-2850 cm⁻¹. According to my reference table, this is clear evidence for polyethylene (PE). The sharp dip at 717 cm⁻¹ is particularly diagnostic.

3.1.2 Sample 2 (fertilizer site)

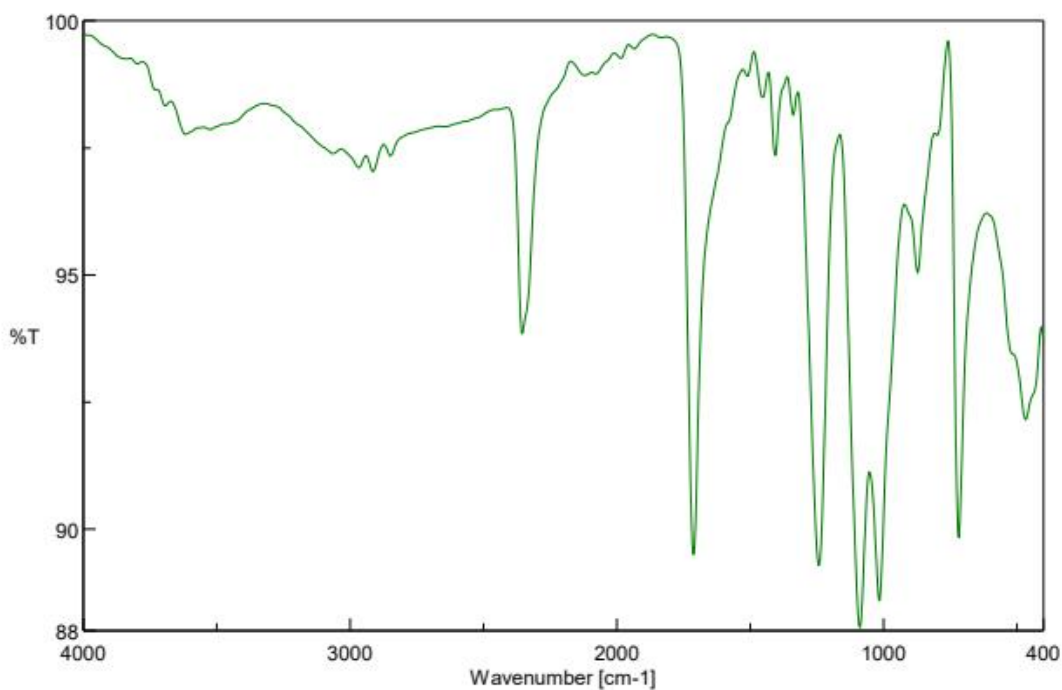


Figure 6: FTIR spectra of sample from fertilizer site

Interpretation:

The spectrum has characteristic pair of peaks near 997 cm^{-1} and 972 cm^{-1} (CH_3 rocking) and a clear dip at 1458 cm^{-1} , all of which match polypropylene.

3.1.3 Sample 3 (irrigation site)

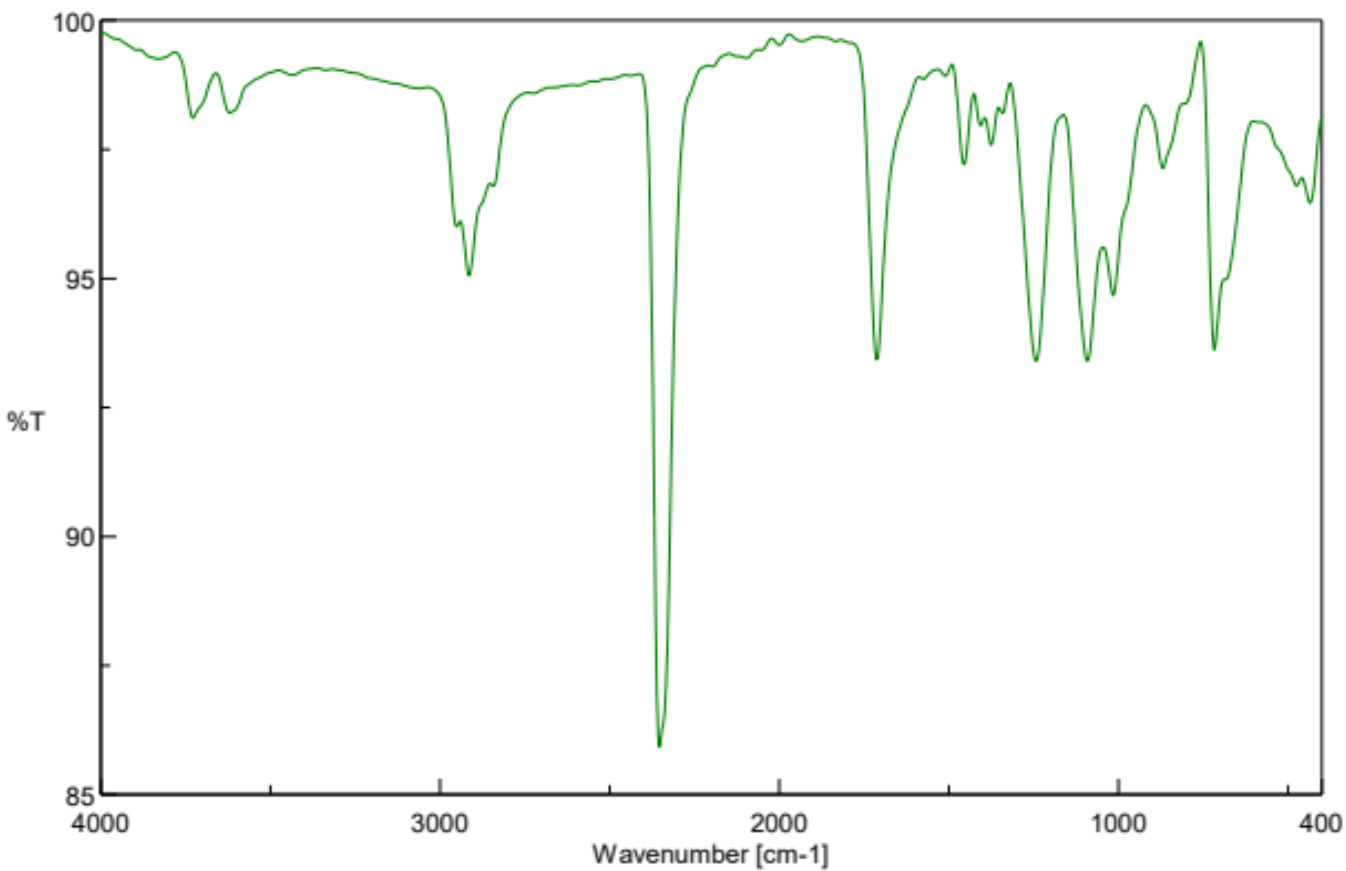


Figure 7: FTIR spectra of sample from irrigation site

Interpretation:

The spectrum shows a clear carbonyl (C=O) peak near 1716 cm⁻¹ and an ester peak near 1716 cm⁻¹, which are diagnostic of Polyethylene Terephthalate (PET).

Table 3: Summary of identified micro plastics based on spectral data.

Sample	Identified polymer	Key matching peaks
1	PE	2919,2850 cm^{-1} (C-H), 1465 cm^{-1} (CH_2 bend), 730-717 cm^{-1} (CH_2) rock doublet
2	PP	2954 cm^{-1} (C-H), 1458 cm^{-1} (CH_3), 997 & 972 cm^{-1} (CH_3 rock)
3	PET	1716 cm^{-1} (C=O), 1245 cm^{-1} (C-O ester)

3.2 Discussion of results

3.2.1 Irrigation site soil sample

The FT-IR spectrum of the soil collected from the irrigation channel showed a clear absorption band at 1716 cm^{-1} and another at 1245 cm^{-1} . According to the reference table in section 2.4, these correspond to the C=O carbonyl stretching and C–O ester stretching vibrations of Polyethylene Terephthalate (PET). The absence of the 722 cm^{-1} aromatic C–H bending peak may be due to the small particle size or the fibrous morphology of the PET particles, which can reduce the intensity of the out-of-plane bending mode. Nevertheless, the combination of the carbonyl and ester peaks is diagnostic for PET. This finding indicates that irrigation water is a

vector for introducing PET microplastics into agricultural soils. Potential sources include fragmentation of discarded plastic

water bottles or, more likely, synthetic textile microfibers (polyester is a PET polymer) shed during laundry and transported via wastewater used for irrigation(Prata et al., 2019)(Roy et al., 2022b)

3.2.2 Dump site soil sample

The waste dump soil produced a spectrum with strong absorption bands at 2919 cm^{-1} , 2850 cm^{-1} , 1465 cm^{-1} , and a characteristic doublet at 730 cm^{-1} and 717 cm^{-1} . The doublet is the classic “fingerprint” of Polyethylene (PE), assigned to the CH_2 rocking vibration. The bands at 2919 and 2850 cm^{-1} arise from C–H stretching, and the 1465 cm^{-1} band from CH_2 bending. These match exactly the reference table entries for PE ($2915\text{--}2845$, $1467\text{--}1462$, $730\text{--}717$). PE is the most widely used plastic in agriculture, particularly as mulch films, silage wrap, and irrigation pipes (Geyer et al., 2017). The dump site, being an uncontrolled disposal area for mixed solid waste, is a primary source of secondary microplastics formed by the environmental fragmentation of larger PE items. Wind and water runoff from such dumps can spread these PE particles into adjacent potato fields.

3.2.3 Fertilizer site soil sample

The soil from the fertilizer storage/handling area exhibited absorption bands at 2954 cm^{-1} , 1458 cm^{-1} , and a pair of peaks at 997 cm^{-1} and 972 cm^{-1} . The $997\text{--}972\text{ cm}^{-1}$ doublet is assigned to the CH_3 rocking vibration, and the 1458 cm^{-1} band to CH_3 asymmetry – both are characteristic of Polypropylene (PP) as listed in the reference table ($2950\text{--}2838$, 1458 , $997\text{--}972$). PP is commonly used for fertilizer bags, plastic twine, and slow-release fertilizer coatings (Guo et al., 2020). The

presence of PP in this specific location strongly suggests contamination from agricultural inputs: either the physical breakdown of woven PP fertilizer bags, or the direct application of polymer-coated fertilizers that release PP particles into the soil over time(He et al., 2018b).

3.2.4 Implications for soil health and food safety

The detection of these three common polymer types in agricultural soils is concerning. As discussed in the justification (section 1.4), PE and PP particles can alter soil bulk density, impede root growth, and be ingested by soil macro- and micro-biota (Roy et al., 2022b). PET microfibers can adsorb pesticides and heavy metals, acting as vectors for toxic co-pollutants. Furthermore, if particles are smaller than 10 μm (nano-plastics), they may be taken up by potato roots and translocated to tubers, posing a direct risk to the food chain (Ho & Tang, 2023)

3.2.5 Limitations

The FT-IR analysis identified polymer types but did not quantify particle abundance. Also, particle size and shape were not determined; smaller particles ($<20\ \mu\text{m}$) are more difficult to detect by transmission FT-IR without a microscope. Nonetheless, this study successfully provides the first spectroscopic evidence of microplastic contamination in Irish potato soils from Kween District.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATION

4.1 Conclusions

This study successfully identified and characterized microplastic contamination in soils from Irish potato farming area in Kween District, Uganda, using FT-IR spectroscopy. Three distinct soil samples – from a recently applied fertilizer soil, an irrigation channel, and a waste dump – each contained a different polymer type: Polypropylene (PP), Polyethylene Terephthalate (PET), and Polyethylene (PE), respectively.

The presence of PP in the fertilizer-associated soil points to the degradation of plastic fertilizer bags or polymer-coated controlled-release fertilizers. The PET identified in the irrigation channel soil strongly indicates contamination via water-borne synthetic textile microfibers or fragmented plastic bottles. The PE found in the dump site soil is consistent with the breakdown of agricultural mulch films, silage wrap, and general plastic waste disposed of openly.

These findings confirm that agricultural soils in Kween District are contaminated with microplastics, and that the type of contamination reflects local land use practices. The results also validate the hypothesis that terrestrial ecosystems, particularly agricultural lands, act as significant long-term sinks for microplastics. Given the potential risks to soil health, crop productivity, and food safety – including possible uptake of nano-plastics into potato tubers – this study provides essential baseline data for future research and policy interventions.

4.2 Recommendations

Based on the findings of this study, I strongly recommend that farmers take immediate action to mitigate microplastic pollution by first replacing conventional plastic mulch with biodegradable alternatives, such as PLA or PHA films to reduce the accumulation of PE microplastics in their soil. Furthermore, farmers should collect and properly dispose off plastic fertilizer bags, twine, and irrigation tape instead of leaving them in the field or burning them as these practices release harmful particles. Farmers should also avoid using untreated wastewater for irrigation where possible but if unavoidable, they should implement simple filtration, like sand or fabric filters to remove larger microplastic fibers before application. Finally, farmers should choose non-coated fertilizers or those with biodegradable polymer coatings to prevent the direct addition of PP microplastics to soil, thereby safeguarding long-term soil health and crop productivity.

To effectively tackle the growing threat of agricultural microplastics, local government bodies must first establish community-based plastic waste collection points specifically targeting agricultural plastics including mulch, bags, pipes, and twine while simultaneously launching awareness campaigns to educate farmers about the hidden risks of microplastics in soil, their effects on crop growth and food safety, and simple mitigation practices that can be adopted on-farm. Concurrently, authorities need to enforce stringent regulations against open dumping and burning of plastic waste near agricultural lands and water sources, as these practices release additional contaminants into the environment, and they should also prioritize the regular monitoring of irrigation water quality for microplastic contamination, especially if wastewater or surface water is used and invest in low-cost treatment options such as sedimentation basins or filtration units to reduce the influx of fibers and fragments before they reach croplands thereby protecting both soil health and downstream ecosystems.

Future investigations should first use Py-GC/MS analysis to quantify microplastic concentrations in mg/kg soil, providing a mass-based risk assessment that complements existing particle count data and should then conduct a systematic spatial survey across multiple Irish potato farms in Kween District to map the distribution and variability of microplastic contamination across different field zones and elevation gradients. Researchers must also investigate particle size distribution (e.g., using sieving and microscopy) to determine the fraction of nano-plastics ($<1\ \mu\text{m}$) that could be taken up by crop roots and translocated to tubers which is critical for food safety and they should also perform controlled pot experiments with Irish potatoes to directly assess the uptake, translocation and accumulation of PET, PE, and PP particles in edible plant parts under realistic soil conditions. Finally, studies should evaluate low-cost remediation methods such as biochar amendment, phytoremediation with these approaches hold promise for immobilizing or removing microplastics but their efficacy and side effects on tuber quality and soil biota remain to be tested through long-term field trials.

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