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Identifying the Source and Scale of Plastic in Compost Derived from Household and Commercial Food Waste

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Rialtas na hÉireann
Government of Ireland

Environmental Protection Agency

The EPA is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: Implementing regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.

Knowledge: Providing high quality, targeted and timely environmental data, information and assessment to inform decision making.

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The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

1. Office of Environmental Sustainability
2. Office of Environmental Enforcement
3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

Identifying the Source and Scale of Plastic in Compost Derived from Household and Commercial Food Waste

Authors: Percy Foster, Tony Breton and Eoin Bird

Lead organisation: Foster Environmental and Tony Breton Consulting

Identifying pressures

The presence of contaminants in food waste bins is undesirable because it necessitates further processing of the material, incurs higher costs (associated with removing the contaminants) and results in lower value compost and digestate. The main objective of stakeholders is to significantly reduce the input of contaminants, particularly plastics, into the soil from the application of compost and digestate derived from food waste.

As part of this project, 50 biowaste characterisation studies were undertaken to identify contamination trends, with a specific focus on plastics.

The characterisation studies found that the contamination rate in all household biowaste collections was 8.9%, with the rate in co-mingled collections of food and garden waste being 9.8% and in collections of food waste being only 5.8%.

The proportion of plastics found in household biowaste collections was 7%. This is nearly double the 4% found in the Environmental Protection Agency (EPA) 2018 waste characterisation study. In commercial food waste collections, the level was 7% compared with 1% in the EPA 2018 study.

This research project indicates that the amount of plastic contamination in biowaste collections is increasing and needs to be controlled.

Informing policy

Ireland's waste policy – A Waste Action Plan for a Circular Economy – aims to promote the segregation of food waste to help meet EU recycling targets, and to support bioeconomy policies and the new European Green Deal, which promote the recycling of nutrients from organic wastes into products that can be used as soil improvers and fertilisers, thereby reducing the use of mineral fertilisers.

Developing solutions

After a review of policies, legislation and alternatives, a suite of solutions was developed to address the increased contamination of collected food waste, which includes:

- a bin inspection programme;
- a contamination limit of 3%, with a maximum of 1% plastics, in waste collection permits and processing facilities licences, similar to the German Biowaste Ordinance conditions;
- establishment of a regulated feedstock quality control programme along the lines of the German Biowaste Ordinance conditions;
- continuation of the mywaste.ie national food waste recycling awareness campaign;
- a uniform contamination policy adopted by all waste collectors;
- enforcement of the Single Use Plastic Regulation on the ban of oxo-degradable plastics and conditions on plastic bottle rings/seals.

A proposed biowaste forum could coordinate the implementation of recommendations from this report.

EPA RESEARCH PROGRAMME 2021–2030

Identifying the Source and Scale of Plastic in Compost Derived from Household and Commercial Food Waste

(2021-GCE-1035)

EPA Research Report

Prepared for the Environmental Protection Agency

by

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DISCLAIMER

This report is based on research carried out/data from January 2022 to March 2023. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

The presence of contaminants in food waste bins is undesirable because it necessitates further processing of the material, incurs higher costs (associated with removing the contaminants) and results in lower value compost and digestate. The main objective of all stakeholders is to significantly reduce the input of contaminants, particularly plastics, into the soil from the application of compost and digestate derived from food waste.

Following extensive engagement to collate relevant information and insights, 50 food waste characterisation studies were undertaken to identify trends in types of contamination specifically related to plastics.

The characterisation studies found that the contamination rate in all household biowaste collections was 8.9%, with the rate in co-mingled collections of food and garden waste being 9.8% and in collections of food waste being only 5.8%. The proportion of plastics found in household food waste collections was 7%, which is nearly double the 4% observed in the 2018 EPA waste characterisation study. The overall contamination rate in commercial food waste collections was 7.8%, almost eight times that of the 1% level recorded in the 2018 EPA study.

A laboratory conducted forensic analyses on a range of household products commonly observed during the waste characterisation studies, to identify the presence and types of plastics they contained. The analysis showed that there was plastic in tea bags, fruit stickers, food condiment sachets (sugar, salt and sauces), ketchup seals, nappies, coffee cups, wet wipes, coffee capsules and vegetable nets.

Such an analysis has not been done before now and provides proof of the presence of plastics, which may act as a hidden source of microplastics, in materials.

After reviewing policies, legislation and alternatives, a suite of solutions was developed. These potential solutions were then presented to and voted on by all stakeholders at a webinar, to assess which solutions were considered most appropriate.

A proposal for a new EU Packaging and Packaging Waste Regulation and a draft Green Claims Directive have been published by the European Commission and are progressing through the co-decision process. Depending on the final version and time frame for implementation, this EU legislation may supersede Irish regulatory options for the solutions proposed by this study.

All solutions recommended are part of an integrated package aimed at solving the issue of plastics in food waste. The main solutions are ranked in order of ability of the market to deliver, quickness, cost, enforceability and benefits to the system, as follows:

1. continue running the mywaste.ie national food waste recycling awareness campaign;
2. require that all waste collectors adopt uniform contamination policies (e.g. National Standards Authority of Ireland standard/industry best practice);
3. enforce the Irish Single Use Plastic (SUP) Regulation on the ban of oxo-degradable plastics;
4. enforce SUP Regulation conditions on plastic bottle rings/seals (coming into force in July 2024);
5. legally require shops to use signs at point of sale instead of fruit stickers and legally, where it is impossible to remove them from the supply chain, any stickers and adhesives should be certified compostable and meet new Irish labelling requirements;
6. develop specific Irish legislation on labelling for tea bags, fruit stickers, lightweight bags and similar packaging to prohibit the word biodegradable (to prevent greenwashing) and to create a scheme to validate compostable products via local field testing, to ensure compatibility with Irish processing plants);
7. ensure that compostable products have a specific colour/specific labelling and that products are tested via local field testing, to ensure compatibility with Irish processing plants;

8. develop an Irish labelling regulation that is similar to the EU SUP Directive, and requires that labelling be affixed to nappies and pet faeces bags, stating “This product contains plastic – do not place in the food waste bin; place it in the residual waste bin”;
9. update the compost standard and develop a standard for digestate, after which a national end-of-waste criterion should be developed and linked to the standards; to contribute towards achieving EU recycling targets, only compost/digestate that meets end-of-waste criteria should be counted;
10. establish a contamination monitoring programme for processing plants;
11. stipulate that food-related coated board and fibre be both compostable and mechanically recyclable;
12. from a contamination perspective, encourage future collection services (e.g. for apartments) to consider providing a food waste-only collection service, as household food waste-only collections have less plastic contamination than co-mingled food and garden waste collections;
13. impose, through waste collection permits and processing facility licences, a contamination limit of 3%, with a maximum of 1% plastics, similar to the limits set by the German Biowaste Ordinance;
14. ban food condiment sachets;
15. establish a regulated feedstock quality control programme similar to that set out by the German Biowaste Ordinance; there could be scope for the local government sector through the Waste Enforcement Regional Lead Authorities to manage this.

The proposed Biowaste Forum could coordinate the implementation of the recommendations given in this report.

1 Introduction

This project was carried out as part of the EPA Research Programme 2021–2030. The project, entitled "Identifying the Source and Scale of Plastic in Compost Derived from Household and Commercial Food Waste" (2021-GCE-1035), involved a desktop study, 50 waste characterisation studies and laboratory analyses.

1.1 Background

Ireland's waste policy – *A* Waste *Action Plan for a Circular Economy* – aims to promote the separate collection of food waste (DECC, 2020), as outlined in the Household Food Waste Regulations[1] and Commercial Food Waste Regulations,[2] which were designed to promote the segregation and recovery of household and commercial food waste. The successful implementation of these regulations depends on end-of-waste criteria being developed for compost and digestate (Foster and Prasad, 2021). At the EU level, the separate collection of biowaste became mandatory in December 2023.[3] Making sure that there is no plastic contamination of food waste is vital for the organic recycling market and its development and long-term sustainability – particularly when it comes to realising the value of high-quality composts and digestates.

A recent study for the EPA, to update the compost quality standard and develop a new digestate quality standard, determined that the greatest risk to achieving such standards is the contamination of input feedstock (Foster and Prasad, 2021). The study's findings could provide the basis for reference standards to be developed, thereby enabling the development of a national end-of-waste standard for compost and digestate.

A European Environment Agency report by van der Linden and Reichel (2020) on the potential opportunities for biowaste across different countries in Europe warned that one of the barriers to exploiting the benefits of a more circular economy and delivering valuable soil-improving material and fertiliser, as well as biogas, a source of renewable energy, is the contamination of biowaste. Several countries highlighted that plastic is a key contaminant of compost and digestate products placed on the market that needs to be addressed. The presence of non-compatible packaging and other plastics in household and commercial biowaste is also an ongoing concern for the Irish organic recycling industry. In fact, the quality of feedstocks at a macro level is increasingly becoming a threat to the ability of the organic sector to sustainably contribute to the nation's circular economy and plastic waste aspirations as well as to the recycling targets set out in EU legislation (Martin Eves, Cré, 2023, personal communication).

To best develop strategies to reduce contamination before it reaches the organic recycling system, it is essential to know exactly what the sources of contamination are, e.g. the specific packaging types and their quantities. Furthermore, comparatively little is known about the plastics found in traditionally targeted waste. The best known of these specific waste types are tea bags and coffee pods and the labels stuck onto fruit and vegetables. Current separation and processing technologies are unable to remove such small particles and fibres; therefore, once they enter the system, the plastics they contain enter the environment "hidden" in otherwise high-quality composts/digestates. The majority of separately collected household food waste is processed by industrial composting plants in Ireland. In industrial composting, the harsh environment, pressures and shearing processes break down plastics into smaller and smaller fragments. Instead of focusing on identifying plastics at the end stage of this process, this project sought to comprehensively assess the amounts of plastics in the incoming food waste feedstocks, to identify and quantify the levels of both visible and "invisible" plastics.

1 European Union (Household Food Waste and Bio-Waste) Regulations 2013, Statutory Instrument (S.I.) 71 of 2013 and Amendment Regulations S.I. 251 of 2013.

2 Waste Management (Food Waste) Regulations 2009, S.I. 508 of 2009.

3 Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.

2 Literature Review and Stakeholders

2.1 Contamination

Even at low contamination rates of 2%, the amounts of plastics entering biowaste collections are estimated to reach almost 2 million tonnes annually across the 27 EU Member States (Favoino and Giavini, 2022). Moreover, in the worst-case scenario, the percentage of plastics in food waste could reach 15% (13 million tonnes). By 2030, extracting plastics from food waste across the EU could lead to additional costs of up to €2 billion per year. Italy alone estimates that at least €52 million is spent annually on the extraction of contaminating plastics by its biowaste system (CIC *et al*., 2017). This plastic contamination leads to the rejection of biowaste at compost and biogas sites and also drags a corresponding volume of biowaste attached to the plastic for disposal (Favoino and Giavini, 2022).

Research also indicates that, depending on their types and characteristics, plastics, including microplastics, may affect the biodegradation of biowaste during composting (Sun *et al.*, 2020). Plastic contamination may also impede the production of methane during anaerobic digestion. An experimental study found that methane production from food waste was inhibited in the presence of plastic materials, including polystyrene, polypropylene and high-density polyethylene (HDPE) (Lim *et al.*, 2018). Plastic materials, including hard and soft plastic containers, bags and plastic-coated paper products, can break down into smaller pieces but are never completely decomposed in finished material (Harrington, 2015). This breakdown into microplastics can occur as a result of the mechanical treatments performed on biowaste at industrial biological waste treatment plants (composting and anaerobic digestion) (ECN, 2021) and environmental factors such as UV radiation, light, heat and microbial activity (O'Connor *et al.*, 2022).

While it is widely accepted that eliminating physical contaminants (including plastics) completely from composts and digestates is not possible, there is increasing concern over the quantities of plastics currently present in these final products and being applied to land. Two food waste-derived compost samples in Ireland were tested. Based on a visual assessment, the samples contained hard plastics, glass, plastic bottle rings, soft plastics, plastic fibres, fruit stickers and soft plastic film. Soil samples were available from a farm that had two adjacent fields: one had a long history of compost (derived from food waste) application (10 t/ha every 5 years) and the other had no history of compost application. No plastic was detected in the samples taken from the soil with no history of compost application, whereas the plastic content of the samples from the field that received compost ranged from 0.018% to 0.236% w/w dry matter. These results demonstrate that food compost is a source of plastics in agricultural soil (Graça, et al., 2023). While it is unknown if these concentrations are high enough to generate observable effects on yields, it is known that microplastics tend to accumulate in soils. The accumulation of plastics from compost may thus, in the long term, become unsustainable (Cornelis *et al.*, 2021). Research on the occurrence of microplastics in food waste-derived soil amendments is in the early phase, and the relative importance of this potential pathway of microplastics to agricultural soils needs further clarification (Porterfield *et al.*, 2023). The German Environmental Agency is funding the development of a method for measuring microplastics in compost. This method should be examined to determine if it is suitable for use in Ireland as a method for testing compost and digestate.

To better understand the global variation in plastic contamination in biowaste and organic recycling, a desktop study and a survey of international composting associations were undertaken. The key results are shown in Table 2.1. Please note that there is likely to be some variation in the methodologies used in each of the studies cited; Chapter 3 contains further information on the methodologies used. Table 2.1 shows that there is wide variation in the level of contamination in biowaste feedstocks around the world, and that Ireland is unfortunate in that it has some of the most contaminated domestic feedstocks, at 14% (EPA, 2018a) and 18% (Gillen *et al.*, 2019). Despite the global concerns of the organic recycling sector, this work identified just two territories – Italy and Catalonia – that have established ongoing monitoring campaigns.

Table 2.1. Contamination rates in household and commercial collections from around the world

Location	Contamination (%)	Year	Reference
Italy – kerbside	4.5%	2017	Centemero (2017)
Catalonia, Spain – kerbside	4.7%	2020	Giró i Fontanals (2022)
New York, NY	7.1% (including 0.8% from clear plastic bags, 1.4% from other plastic bags and wraps and 1.1% from metal, glass and plastic)	2017	DSNY (2017)
South Korea	3.24%	2017	Ministry of Environment (2017)
Slovakia – three cities	0.5%, <1%, 2.9%		Martina Gaislová, JRK, personal communication
Seattle, WA – average	2.6%		City of Seattle (2022)
Seattle, WA – single-family household	0.9%	2016	Cascadia Consulting Group (2018)
Seattle, WA – multi-family household	5.7%	2016	
Seattle, WA – commercial	4.5%	2016	
New South Wales, Australia	2.2% (range 0.04–17.83%)	2020	Rawtec (2020)
	2.6%	2018	
Region of Peel located in the province of Ontario, Canada	5%		Susan Antler, Compost Council of Canada, personal communication
Ireland – household	14%	2018	EPA (2018a)
Ireland – commercial	6%	2018	EPA (2018b)
Sligo, Ireland	18%	2015	Gillen *et al*. (2019)
Scotland, UK – household	<0.1–1.3%	2019	Aspray and Tompkins (2019)
Scotland, UK – commercial	0–2.8%	2019	
Vancouver, Canada – multi-family household (MF), single-family household (SF), industrial, commercial and institutional (ICI)	Rubbish in bags: 0.4% (ICI) to 4.4% (SF); plastic film: 0.2% (ICI) to 0.6% (MF); rigid plastic: 0% (ICI) to 0.3% (SF)	2017	Tetra Tech (2017)

2.2 Case Studies of Good Practices to Prevent Contamination

There are different approaches to managing contamination, as outlined in the following case studies.

2.3 Irish Context

Prior to this study, the only extensive waste characterisation studies on food waste collections from households and commercial premises were the EPA waste characterisation studies (2018a,b) and the

Case study: Italy

As early as 2006, the Italian Composting Association (Consorzio Italiano Compostatori; CIC) developed an officially recognised methodology to analyse the quality of feedstocks being delivered to a composting facility in Italy. Today, the CIC annually undertakes ~1000 biowaste analyses per year on behalf of its members. These analyses enable operators to provide time-relevant feedback to the municipalities delivering biowaste, to help with communication campaigns. In some instances, there are contractual clauses in which the level of contamination dictates the gate fee. In 2018, Italy launched the world's first extended producer responsibility scheme for compostable plastic packaging – Biorepack. The scheme requires compostables producers to pay into the organic recycling system (€190/t); for the system to reclaim these monies, regular auditing of composting and anaerobic digestion plants is required. These audits consider the flow of the compostable plastic packaging throughout the plants and not just the feedstock. The audits showed that in 2021 51.9% of the 74 kt of compostable plastic packaging placed on the market in Italy was organically recycled. For further information, see the Biorepak website (https://biorepack.org/comunicazione/comunicati-stampa/bioplastiche-compostabili-il-riciclo-raggiunge-il-61.kl; accessed 10 April 2024).

Case study: New South Wales, Australia

In New South Wales, Australia, the average contamination rate of household biowaste bins in 2020 was 2.2% by weight across 26 areas/councils (in 2018, the rate was 2.6%). However, this varied significantly across areas/councils, ranging from 0.04% to 17.83%. The most common contaminants present (based on the number of times that each contaminant appeared in the list of the top five heaviest contaminants) across the areas/councils audited were plastics, all other organics (leather, rubber and oils), containerised food, metals and other miscellaneous materials. Five areas/councils found that a large proportion of bins (from 68% to 92%) contained no contamination. These areas/councils reduced contamination before the 2020 audits by targeting the households that were contaminating their biowaste bins (such as through bin-tagging programmes).

National Brown Bin Awareness Pilot Scheme in Sligo, Ireland, undertaken in 2014–2015. These studies found that 14% and 18%, respectively, of the weight of the material in household brown bin collections was non-target material, i.e. had been placed in the wrong bin (EPA, 2018a). Contaminants were primarily plastics and textiles. Another study by the EPA on commercial waste found a 6% contamination rate (EPA, 2018b). The surveys covered only 14 businesses for food waste-only collection, five household food and garden waste collection routes and one household food waste-only route.

2.4 Stakeholders' Views on the Scale of the Problem of Plastic in Food Waste

2.4.1 Compost and biogas plant managers

The managers from the six main compost and biogas plants in Ireland (representing 90% of national brown bin recycling) were interviewed about their experiences of contamination in food waste feedstocks. They were asked to list items that they had experienced operational and/or finished product problems with. In no specific order, those listed were stickers present on fruit and/or vegetables, rubber bands, vegetable nets,

Case study: Seattle, WA, USA

Seattle has a population of 734,000 and recycles almost 60% of its organic waste. The low contamination rate, of 2.6%, has been achieved through a combination of clear policies on labelling and outreach/education. Outreach and education in Seattle involves:

- distributing printed material that simplifies the message, includes dos and don'ts and mainly consists of graphics;
- focusing on the top five items wanted in the organic waste bin, with a clear message that there should be "no plastic bags";
- meeting people in person, for example in supermarkets.

Labelling policies to reduce contamination

Colour. Compostable products must feature labelling that uses green, beige or brown, or colour stripping or tints that help to differentiate compostable items from non-compostable items.

Claims. Compostability claims must be certified.

Lookalikes. Labelling non-compostable items with green, beige or brown colouring is discouraged.

Terms. The use of the term "biodegradable" is prohibited.

certain compostable products, food trays, carrier bags, oxo-degradable/"biodegradable" bags, yoghurt pots/pot lids, coffee pods, food condiment sachets, glass, metals, tinfoil, non-compostable plastic cutlery, lollipop sticks, plastic straws, ink straws from pens, concrete, metal cutlery, metal cut-offs, car parts, mattresses, bed clothes, furniture, wires, cables, rope and light plastic film that had broken down to less than 10 mm in size. Plant managers also stated anecdotally that contamination levels in biowaste coming from transfer stations can be higher than that coming directly from a waste collector/generator.

The main items identified by the plant managers as causing an issue in terms of process management were plastic films, such as lightweight shopping bags, and hard plastics, such as those in bottles, food

Case study: Catalonia, Spain

Since 2004, Catalonia has operated a system for the intensive monitoring of biowaste (Figure 2.1). The system is funded through environmental taxes placed on waste, landfill and incineration, which are refunded to municipalities based on various criteria including the quality and quantity of separately collected biowaste. Quality control is carried out at the municipal level, irrespective of whether municipalities collect biowaste individually or jointly with other municipalities. To carry out this characterisation service, the Catalan Waste Agency has contracted six characterisation companies. They work across Catalonia and are each assigned different biological treatment plants (composting/anaerobic digestion) and an equivalent number of samples to characterise. Sampling is carried out in successive quarters, until around 250 kg of biowaste has been sampled. A minimum of four characterisations are carried out per year per collection circuit. Currently, there are a total of 600 biowaste collection circuits. A total of 2000 characterisations are being carried out per year, and since 2005 nearly 23,000 biowaste characterisations have been carried out. All the collected data are publicly available online: https://sdr.arc.cat/cform/ListCaracteritzacions.do (accessed 10 April 2024).

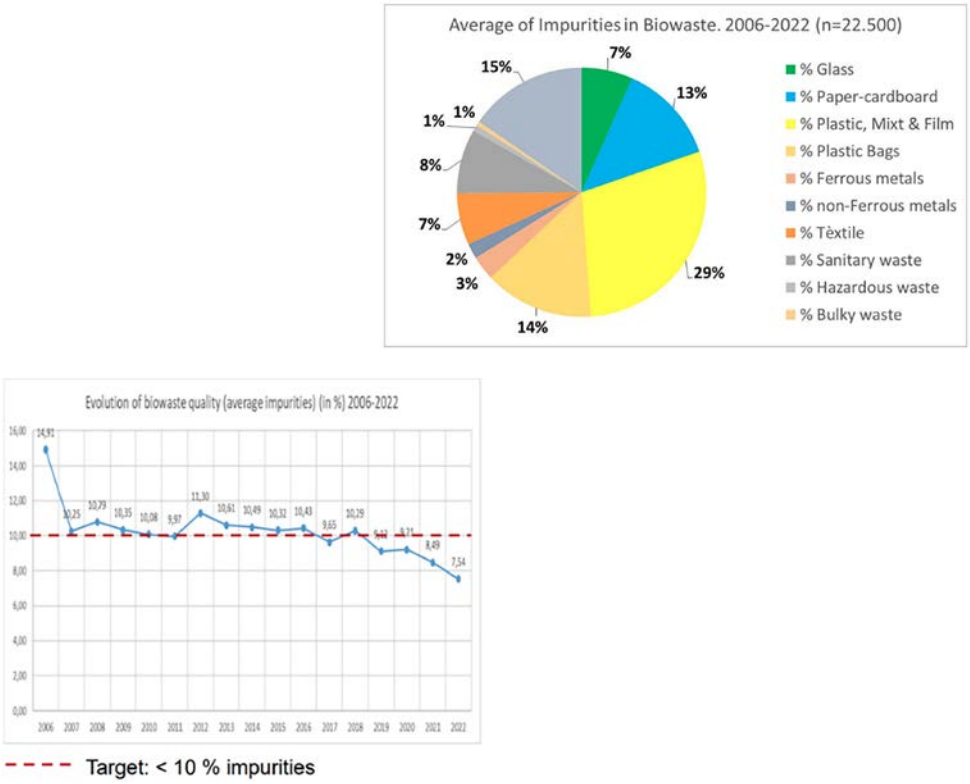


Figure 2.1. Average level of impurities in biowaste (top panel) and evolution of biowaste quality (based on average level of impurities; bottom panel) from 2006 to 2022 in all collection systems. For bring system collections the average was 13.9%, and for door-to-door system collections the average was 4.7%. Reproduced from Giró i Fontanals, 2022; licensed under CC0 1.0 (https://creativecommons.org/publicdomain/zero/1.0/).

trays, metals and glass. In terms of materials being present in final compost/digestate, their main concerns related to plastic film; plastic bottle rings; small, fractured plastics that make their way through the screening process because of their small physical size (e.g. lollipop sticks, plastic straws and ink straws from pens); glass; fruit/vegetable stickers; rubber bands; bottle seals; and plastic knives, forks and spoons. One plant manually removes rubber bands and vegetables nets from food waste and also uses a bespoke technology that helps to remove plastic bottle rings, bottle seals and yoghurt pots.

Plants do not seem to have an accurate estimate of how much contamination costs them in additional processing effort. Individual plants gave the cost to them of disposing of contamination as €60,000, €100,000 and €180,000. However, one plant manager pointed to the difficulty of providing a definitive figure, as the cost continuously accrues as a result of contamination increasing the wear on equipment, breakages, frequency of machine maintenance, downtime in processing, number of personnel needed to operate machines, diesel use, haulage and disposal costs related to contamination, and lost sales of compost/digestate. When asked their view on what technologies could be used in Ireland to remove contamination, the general feedback was that there is no technology that can remove 100% of contamination.

The authors did a survey of some annual environmental reports from eight composting plants. In 2018, the eight plants disposed of a combined total of 9650 tonnes of contamination from biowaste material that they had accepted for processing. In 2021, two plants stated that their contamination rates for the year were 8.6% and 8.65%, respectively.

Interestingly, despite contamination being given as a major issue for plant operators, only one stated that the plant had acceptance criteria in place for contamination levels in biowaste feedstocks arriving at the plant. Facilities that do not have such criteria never reject any loads. The one plant that has criteria in place stated that its rejection rate was low. The reluctance to reject loads can be attributed to the fear of losing feedstock in a highly competitive market, and any action would need to be universal, e.g. driven by policy. It is worth noting that a 2017 survey of Scottish composters reported that 5 of the 15 surveyed site operators rejected between one and three loads because of contamination, and one site operator rejected eight loads because of contamination (US EPA, 2021).

When the plant managers were asked about their views on strategies that could be adopted to reduce contamination, it was quite clear that the key focus should be on the education of waste generators, to prevent contamination from entering the food waste bin in the first place. Some also held the view that policymakers should play a role in reducing contamination by reducing the amounts of non-compostable products used to package and protect food in the marketplace.

2.4.2 International trade bodies

In addition to the views of the compost and biogas plant managers in Ireland, we sought views from trade bodies in Canada, the USA, Portugal, the Netherlands, Estonia, Germany, Italy and New Zealand. From these discussions, and regardless of the country, the same issues were identified. The problematic items listed were fruit stickers, plastic film, tea bags, fruit nets, fruit ties, rubber bands, bread tags and oxo-degradable/“biodegradable” bags. Strong concerns were also raised regarding the greenwashing of products with non-compostable items that are supposedly alternative products to conventional plastic products but do not live up to these claims in reality.

2.4.3 Other stakeholders in Ireland

We tried to also get views of other stakeholders in Ireland, such as supermarkets and food producers, via an online survey and interviews. Unfortunately, there was very limited engagement with this aspect of the project. One large food producer did acknowledge that the issue of fruit stickers is being discussed globally, and their view was that those in this sector would probably change to compostable stickers in the future.

2.4.4 Contamination in two compost samples

A 15 L compost sample was obtained from two different composting plants. The visible contamination found was manually sorted and is displayed in Figure 2.2. The contamination was visually categorised into glass, plastic bottle rings, hard plastics, soft plastics, plastic fibres, fruit stickers and soft plastic film.

2.5 Regulation and Policy to Reduce Contamination

In Ireland, there are no specific, sectoral regulations that place restrictions on the level of contamination permitted in the biowaste stream or can be accepted by organic waste recycling facilities. Similarly, there are no specific regulatory requirements for any particular packaging or product, e.g. a waste bag or fruit sticker, to be compostable. From a policy point of view, the only restrictions are those that are

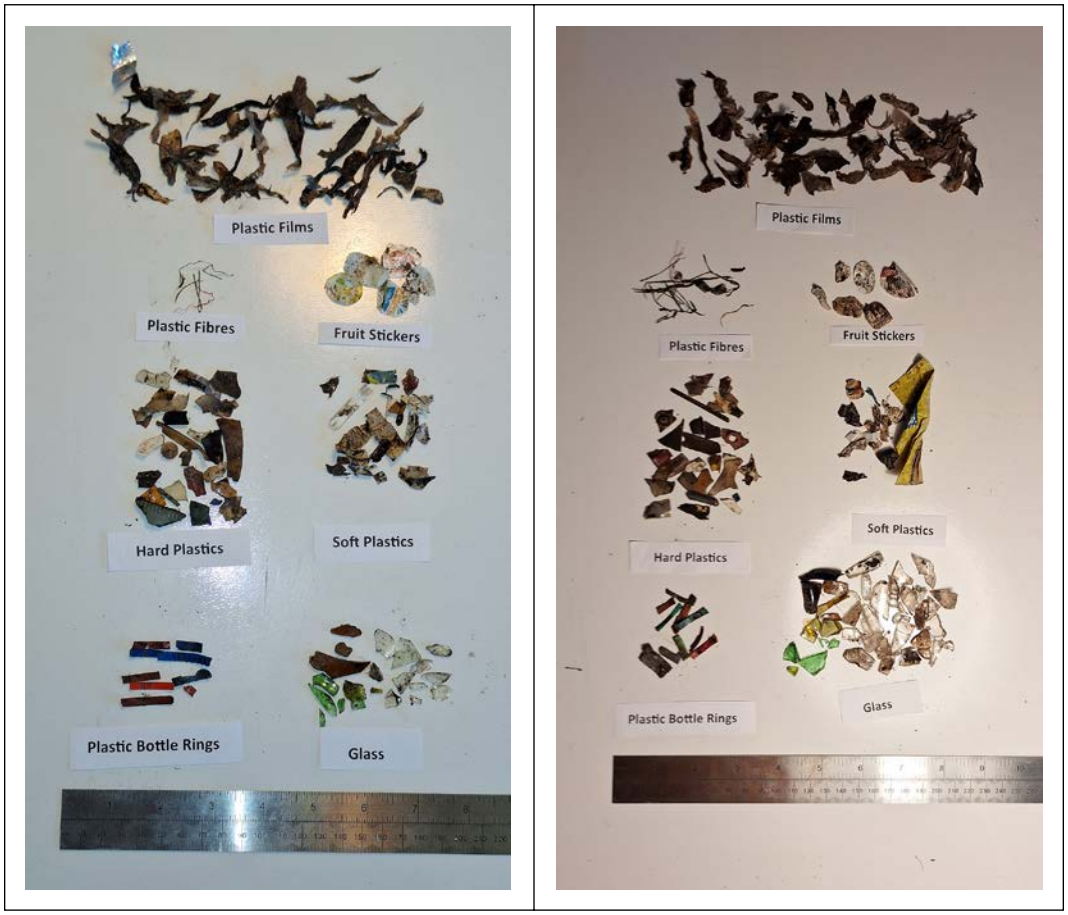


Figure 2.2. Photograph of the visible contamination found in two different 15 L compost samples.

individually set for outputs in a compost/biogas plant operator's waste licence/permit. Globally, however, there are some examples of policymakers showing leadership in this area.

In 2022, the revised German Biowaste Ordinance[4] introduced a new "control value" for contamination – especially plastic contamination. From May 2025 onwards, the following restrictions will come into force:

- a maximum content of 1% plastics for solid biowaste from separate household collection, before entering the first biological treatment step;
- a maximum content of 0.5% plastics of > 2 mm in dry matter for liquid and sludge forms of biowaste materials, especially packaged food waste, before entering the first biological treatment process;
- a maximum content of 0.5% plastics of > 20 mm in fresh mass for solid biowaste materials, especially packaged solid food waste, before entering the first biological treatment process.

Every load of delivered biowaste should be visually inspected. Based on the visual inspection, if the total contamination exceeds 3%, the options are as follows:

- The biowaste is rejected by the plant operator and the feedstock supplier must take back the material.
- The plant operator accepts the biowaste and must remove the macro-contamination. Following a visual inspection, if the level of plastics is greater than 1%, the plant operator must undertake a full waste analysis. It must inform the competent authority of the result, and the competent authority must order measures to be implemented to remedy the situation and may ban acceptance of this biowaste at the plant.

4 https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/bioabfaelle#bioabfalle-gute-qualitat-ist-voraussetzung-fur-eine-hochwertige-verwertung (accessed 10 April 2024).

In 2021, the Environment Agency in the UK published its response[5] to Standard Rules Consultation No. 20: Revision of Standard Rules Permits for Biowaste Treatment. The agency was concerned about the environmental and market harms being caused by plastics, stating that it had calculated that, through the application of food waste digestate alone, over 600 tonnes of plastics enter soil through contaminated compost/digestate each year. To counter this, it announced that over the next 5 years:

- All biowaste facilities will have to implement pre-acceptance and acceptance procedures that demonstrate that waste contamination levels are minimised.
- All biowaste facilities should aim for a year-on-year reduction in incidental plastic contamination in waste received from kerbside collections, starting with non-compostable plastic at 5% w/w input for standard rules permits – but operators will be required to remove all non-compostable and digestate plastic contamination as much as is reasonably practicable prior to treatment.
- All farm operations and green waste-only sites should be able to control incidental plastics to ensure that contamination rates do not exceed a 0.5% w/w limit with immediate effect. They should work with local authorities and reject any contaminated loads as appropriate.

To the best of our knowledge, England and Wales are the only two territories where limits on inputs are legally in place, although it is worth noting that, on a site-by-site basis, it is common outside Ireland to have contractual limits stipulating that plastic contamination in feedstocks should not exceed 5%.

The Italian Government has published new obligatory targets for recycling and established quality parameters, something badly needed in most nations.[6] To be classified as recyclable, organics will have to achieve a minimum 95% purity level of inputs to composting and biogas. The targets must now be included in all tenders for waste collection across Italy.

Interestingly, despite not having specific limits on total contamination, some countries (e.g. Belgium (specifically Flanders), the Netherlands and New Zealand) have introduced specific measures for some plastic items/ packaging materials often found in biowaste collections. It is worth noting that, in November 2022, the European Commission published its proposal for a Packaging and Packaging Waste Regulation (PPWR). The draft regulation contains measures relating to a number of the contaminants regularly flagged as problematic by site operators and identified in this study. It is very likely that the text of the regulation will be amended somewhat prior to adoption, but inspiration from the draft regulation is used in this report when making recommendations on solutions. One of the key relevant items in the draft regulation is the proposal that tea bags, coffee bags, coffee pods, fruit and vegetable stickers, and fruit and vegetable bags should have to be compostable.

Plastic fruit and vegetable stickers. These are typically removed before fruits and vegetables that have an edible skin or outer layer are eaten. However, for fruits and vegetables with skin or an outer layer that is not consumed (e.g. avocado, orange), or fruits and vegetables that are not consumed at all (i.e. wasted), the plastic sticker sometimes remains attached to the food material prior to going into the food waste bin. Fruit stickers, which are small, thin, sturdy and water resistant, often pass through the trommel screens and do not break down in the composting process.

Different approaches are being taken to solve the issue of fruit and vegetable stickers ending up in final compost, such as those outlined below:

- Colombian law prohibits the introduction, commercialisation and distribution of adhesives, labels or any marking affixed to vegetables.[7]

5 https://www.gov.uk/government/consultations/environmental-permitting-standard-rules-consultation-no-20/outcome/standard-rules-consultation-no-20-revision-of-standard-rules-permits-for-biowaste-treatment-summary-of-responses#plastic-limits (accessed 10 April 2024).

6 https://www.riciclanews.it/rifiuti/rifiuti-urbani-pubblicati-i-cam-nuovi-obiettivi-di-qualita-per-la-differenziata_20473.html (accessed 10 April 2024).

7 Those who introduce, market or distribute single use plastics included in the list of Article 5 (e.g. stickers on vegetables) on the market will have until the ban comes into force to carry out the gradual and progressive replacement of these products with any of the sustainable alternatives indicated. In paragraph 2 of Article 2 of this law, the sustainable alternatives are defined as reusable or biodegradable non-plastic materials or biodegradable plastics under natural environmental conditions, regulated for the progressive replacement of single use plastics. https://www.alcaldiabogota.gov.co/sisjur/normas/Norma1.jsp?i=125439 (accessed 10 April 2024).

- In Flanders, Belgium, the use of stickers that are applied directly to fruit and vegetables is prohibited, unless the information on the sticker is functionally or legally required, or unless the stickers are certified as home compostable.[8]
- Belgium has submitted a notification[9] to the European Commission for more restrictions on single use plastics in Belgium, including, for the first time, a prohibition from 1 January 2025 on placing labels that are not compostable at home, intended to be glued onto fruit and vegetables, on the market.
- In France,[10] as of 1 January 2022, the affixing of labels directly onto fruit or vegetables has been discontinued, with the exception of labels that can be composted at home.
- In New Zealand,[11] as of July 2023, fruit and vegetable labels must be home compostable.
- In March 2023, the Canadian Product Marketing Association released[12] guidance to Canada's fresh produce industry on a change to certified industrially compostable stickers. In April 2023, the Canadian Government held a consultation to consider a proposal for fruit stickers and other forms of labelling to be made compostable.
- In Italy, a compostable fruit sticker has been introduced on some Italian apple brands.
- Natural Branding[13] is a laser technology that allows labelling to be etched directly onto the skin of a food. Since 2011, the US authorities have restricted its use to citrus fruit. Australia and New Zealand have used this type of labelling since 2009, and the EU approved it for use in 2013.

Teabags. 8088 tonnes of black tea (in tea bags) was consumed in Ireland in 2021 (Euromonitor International, 2022). Tea bags may appear to be made from paper, but on further investigation usually contain plastics. Standard tea bags contain about 20–30% polypropylene fibre to allow the heat sealing (van den Oever, 2017) of the paper layers, which otherwise would separate. In Ireland, no tea bag is certified as being compostable, and instead tea bag suppliers are using the term "biodegradable" on their packaging. There is one brand on the Irish market whose tea bags are made of paper and do not require polymers to be sealed, as they are folded using a string/label attached to a knot. In the Netherlands, a large proportion of tea bags are made this way. In 2020, there was a motion in the European Parliament to ban tea bags containing plastics.[14]

Different approaches are being taken globally to remove plastics from tea bags:

- The voluntary UK Plastics Pact mandated that all tea bags should be compostable by the end of 2022.
- The UK Environment Agency published guidance[15] on appropriate measures for biological waste treatment and this states that plants should not accept non-compostable tea bags.
- In January 2019, in Flanders, Belgium, coffee and tea bags were removed from the list of acceptable feedstocks in food waste collections because they can contain plastics.
- In the Netherlands in January 2019, it was decided to remove coffee and tea bags from the list of acceptable feedstocks in food waste collections, because they can contain plastics (Waegemaekers, 2020). In 2021, the Netherlands Government created a Green Deal[16] with the aim of reducing the (non-compostable) plastics in coffee pods and tea bags so that they can be discarded in the food waste stream. That Green Deal meant that many suppliers either switched

8 Article 5.3.14.1 of the Order of the Government of Flanders adopting the Flemish regulation on the sustainable management of material cycles and waste.

9 https://technical-regulation-information-system.ec.europa.eu/en/notification/23466 (accessed 10 April 2024).

10 https://www.legifrance.gouv.fr/loda/id/JORFTEXT000041553759/ (accessed 10 April 2024).

11 https://environment.govt.nz/publications/plastic-products-banned-from-july-2023/#non-home-compostable-plastic-produce-labels (accessed 10 April 2024).

12 https://www.biocycle.net/compostable-plu-stickers/ (accessed 10 April 2024).

13 https://gardenculturemagazine.com/produce-stickers-and-tattoos/gui (accessed 10 April 2024).

14 https://www.europarl.europa.eu/doceo/document/B-9-2020-0447_EN.html (accessed 10 April 2024).

15 https://www.gov.uk/guidance/biological-waste-treatment-appropriate-measures-for-permitted-facilities/6-waste-pre-acceptance-acceptance-and-tracking (accessed 10 April 2024).

16 https://www.greendeals.nl/green-deals/green-deal-koffiepads-en-theezakjes-bij-het-gft (accessed 10 April 2024).

to polylactic acid (PLA) or removed plastics completely from their bags.
- In France, non-compostable tea bags have also been banned (Copello *et al*., 2022).
- The New South Wales Environment Protection Authority regulations state that tea bags are not permitted in biowaste bins.
- The New Zealand Ministry for Environment held a public consultation in 2022 on banning tea bags from kerbside organic collections, given that so many manufacturers were still using non-compostable tea bags.
- In 2020 Portugal[17] signed the New Plastics Economy Global Commitment and several proposals are under discussion; avoiding or replacing fruit stickers is one of the topics that will be addressed.

Coffee pods. Plastic, metal and compostable versions of these pods are currently available, and it is a growing market. The first draft of the proposal for an EU PPWR contains a requirement for these items to be compostable. In Belgium, the government is seeking to ban single use coffee capsules containing plastics or aluminium.

Fruit and vegetable nets. There are cotton nets on the market, but they have a metal ring and a plastic tab. The first draft of the proposed EU PPWR proposes banning the use of these nets for fresh fruit and vegetables sold in quantities of less than 1.5 kg.

Food condiment sachets (sugar, butter and sauces). Food condiment sachets were a common contaminant found in food waste collections from the commercial sector in Ireland (see Chapter 4). Globally, there are some initiatives to reduce their usage, including the following:

- In the USA, California law (AB 1276) and Washington State law,[18] in place since 2022, mandate that restaurants must no longer automatically include food condiment sachets with food orders, although customers can still request individual items if needed.
- While EU Member States are prohibited from banning packaging from being placed on the market, the Single Use Plastic (SUP) Directive does give discretion to ban packaging items under a notifiable procedure in accordance with Directive (EU) 2015/1535. Using this mechanism, under Ireland's Waste Action Plan for a Circular Economy, the Department of the Environment, Climate and Communications is committed to banning condiment sachets.
- The first draft of the proposed EU PPWR proposes banning the use of food condiment sachets for food to be consumed in restaurants but permitting their use for takeaway meals.

Plastic packaging for fruits and vegetables. There are different policy approaches being taken around the world to address the issue of plastic packaging, including the following:

- Countries such as France, Portugal, Luxembourg and Spain have banned single use plastic packaging for many fresh fruits and vegetables (Copello *et al*., 2022). There are exceptions to this ban; for example, it applies only to those fruit and vegetable packages weighing under 1.5 kg (in Luxembourg and Spain) and does not apply until 2026 for certain fruits and vegetables.
- In Austria,[19] since 2020, the use of all plastic carrier bags, **except** compostable bags for fruit and vegetables, is prohibited.
- The EU Organic Regulation (Regulation (EU) 2018/848)[20] requires organic produce in supermarkets to be kept separate from non-organic produce in food displays, but that does not mean that it has to be packaged with plastic. Whether organic food must be packaged in plastic depends on if the retailer has an organic licence. If they have an organic licence, they can sell loose organic produce, as long as it is kept

17 https://www.pactoplasticos.pt/ (accessed 10 April 2024).

18 https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Waste-reduction-programs/Plastics/2021-plastic-pollution-laws/Food-serviceware (accessed 10 April 2024).

19 https://www.bmk.gv.at/en/topics/climate-environment/plastics/bags_single-use/plastic-bag-end2020.html (accessed 10 April 2024).

20 Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007.

separate from non-organic produce, whether by means of a physical barrier, by placement at the opposite end of the display, or by being kept in colour-coded containers and identified with clear labelling and/or signage.[21] If the retailer does not have an organic licence, they must sell the organic produce packaged. It is the authors' understanding that, in Ireland, authorities have not approved this exemption.

Plastic bags. Single use carrier bags, fruit and vegetable bags and waste bags have long been identified as problematic contaminants for organic recyclers. They have been the flagship target for policymakers seeking to reduce plastic litter. In 2002, Ireland[22] was the first country in the world to introduce a levy on single use plastic bags, and since then a range of levies,[23] charges,[24] taxes[25] and bans[26,27] have been introduced around the world, including an EU directive[28] requiring all Member States to introduce measures to reduce their consumption of single use plastic bags. In 2006, to support its world-leading organic recycling industry, Italy (which recycles more food waste than the rest of Europe combined) introduced legislation requiring wet (food) waste to be collected in reusable containers or in bags certified to EU standard EN 13432.[29] In 2011/2012, Italy was also the first EU country to ban non-compostable single use plastic bags, permitting the use of only bags that meet EU standard EN 13432, that is, those that can be repurposed into waste bags (Law 28/2012). In 2015, Italy banned non-compostable fruit and vegetable (very lightweight) bags, while specifying that compostable bags should have an increased bio-based content over time. Since 2020, Spain[30] has instated similar laws for carrier bags and very lightweight bags, with organic waste bags being included since 2022. France[31] (2017), Austria[32] (2020) and most recently California,[33] USA (from 2025), require very lightweight bags to be compostable (home compostable in France), and, in California, USA, they must also be suitable for use in kitchen caddies. In 2020, Washington State, USA, passed a state-wide ban on single use plastic bags. It now allows the use of only bags made from paper with a high recycled material content, reusable bags and green or brown compostable shopping bags.

2.6 Set Markings/Colours on Compostable Products

Compostable products can look almost identical to non-compostable packaging, leading to confusion. This confusion makes it difficult for the public to easily identify compostable products.

In 2022, Washington State introduced a new law, E2SHB 1799,[34] amending the existing Product Degradability Labeling Requirements standards, which stipulates that, to meet the American Society for Testing and Materials standards, compostable products must use green, brown or beige labelling, colour striping or other markings that help to

21 In Edition 2 of the Irish Organic Association's Organic Food and Farming Standards, this has been detailed as the approach that is being taken throughout Ireland.

22 https://www.irishstatutebook.ie/eli/2001/si/605/made/en/print (accessed 10 April 2024).

23 https://www.frcs.org.fj/wp-content/uploads/2017/01/PS58-ECAL-on-Plastic-Bags.pdf (accessed 10 April 2024).

24 https://www.gov.uk/guidance/carrier-bag-charges-retailers-responsibilities (accessed 10 April 2024).

25 https://cijuf.org.co/node/13323 (accessed 10 April 2024).

26 https://leap.unep.org/countries/rw/national-legislation/law-no-572008-10092008-relating-prohibition-manufacturing (accessed 10 April 2024).

27 https://legalaffairs.gov.ag/pdf/bills/External_Trade_Prohibition_of_Plastic_Bags_Order_2017.pdf (accessed 10 April 2024).

28 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32015L0720 (accessed 10 April 2024).

29 An EU standard detailing the requirements that must be met by packaging if it is to be subjected to industrial composting processes.

30 https://technical-regulation-information-system.ec.europa.eu/en/notification/15985 (accessed 10 April 2024).

31 https://www.ecologie.gouv.fr/fin-des-sacs-plastique (accessed 10 April 2024).

32 https://www.bmk.gv.at/en/topics/climate-environment/plastics/bags_single-use/plastic-bag-end2020.html (accessed 10 April 2024).

33 https://legiscan.com/CA/text/SB1046/2021 (accessed 10 April 2024).

34 https://app.leg.wa.gov/billsummary?BillNumber=1799&Initiative=false&Year=2021 (accessed 10 April 2024).

differentiate compostable items from non-compostable ones. Compostable food service products must be fully or partially tinted, coloured green, brown or beige, or have a green, brown or beige stripe or band of a specified minimum width (approximately 6 mm). This is the first requirement of its kind in the USA.

In the revised German Biowaste Ordinance, compostable bags used for collecting biowaste must be white or green. In addition, a specified marking must be present on the bags of the seedling logo in a specific format, as well as mandatory text explaining what the bag is to be used for. According to the Amendment to Ordinance on Biowastes (BioAbfV) 2012,[35] the text displayed on the bags should say: "Biologically degradable plastic bag for the separate collection of biowaste certified as industrially compostable according to the specifications of the German Biowaste Ordinance. The collection bag may be used for the separate collection of organic waste (e.g. organic waste bin) if this is permitted in your municipality, your special–purpose association, etc. (public waste management authority)."

In April 2023, the Government of Canada issued a draft framework document on labelling rules for plastics.[36] It includes a proposal that would prohibit the labelling of products as biodegradable/degradable. Items labelled "compostable" will be required to be certified by an accredited third party to show that they meet an acceptable standard specification for compostable plastics, have undergone an in-field test at a composting facility in Canada, display the word "compostable", and feature labels stating that their use is specific to industrial composting facilities and that they are "non-recyclable", to prevent people from putting them into dry recycling bins.

The US Composting Council and Biodegradable Products Institute has recently released[37] a set of guiding principles to inform the development of model legislation for labelling compostable products.

2.7 Preventing Greenwashing Terminology on the Labelling of Products

In March 2023, the European Commission published the draft Green Claims Directive,[38] which complements the proposed changes to the Unfair Commercial Practices Directive. The purpose of the Green Claims Directive is to ensure that consumers are empowered to make better informed choices. Under this directive, making generic environmental claims on products, such as "biodegradable", "biobased" or similar, is prohibited unless they are verified by an independent certification scheme.

In Belgium in 2008, a royal decree was issued that prohibited the use of the word "biodegradable" in association with packaging unless the packaging is certified to EU standard EN 13432. The word "compostable" can be used only on products that are certified to a recognised standard, and this is the case in many jurisdictions such as Washington State,[39] California,[40,41] Minnesota,[42] Maryland (USA),[43] Belgium, Spain and France.[44] Other words, such as "biodegradable" and "degradable" are banned. It is likely that Canada has similar legislation in place.[45]

35 https://www.bmuv.de/en/law/amendment-to-ordinance-on-biowastes-bioabfv-2012 (accessed 10 April 2024).

36 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/recycled-content-labelling-rules-plastics.html (accessed 10 April 2024).

37 https://www.biocycle.net/compostable-product-labeling-legislative-guidelines/?utm_source=rss&utm_medium=rss&utm_campaign=compostable-product-labeling-legislative-guidelines (accessed 10 April 2024).

38 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023PC0166 (accessed 10 April 2024).

39 https://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bills/Session%20Laws/House/1569-S.SL.pdf (accessed 10 April 2024).

40 https://leginfo.legislature.ca.gov/faces/billVersionsCompareClient.xhtml?bill_id=202120220SB1046 (accessed 10 April 2024).

41 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1201 (accessed 10 April 2024).

42 https://www.revisor.mn.gov/laws/2009/0/37/ (accessed 10 April 2024).

43 https://mgaleg.maryland.gov/mgawebsite/legislation/details/hb1349?ys=2017rs (accessed 10 April 2024).

44 This legislation states that is prohibited to include, on a product or packaging that is new to the consumer, the words "biodegradable", "environmentally friendly" or any other equivalent environmental claim (https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000045726094?mc_cid=4c84f468c1&mc_eid=8ff73b6e17-; accessed 10 April 2024)

45 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/recycled-content-labelling-rules-plastics.html (accessed 10 April 2024).

2.8 Best Practice Contamination Policy for Waste Collectors

The Irish waste collection industry does not currently have an agreed contamination policy for biowaste collected from households. Current practices vary from not addressing this at all to not collecting contaminated bins. Some practices involve the collection crew using a phone app to take photos of contaminated bins, then a customer care team following up with the account holders to explain why their bins had not been collected. Globally, there are some interesting examples of programmes aimed at improving biowaste quality, as detailed below.

2.8.1 Calgary, Canada

The city of Calgary has one of the lowest contamination rates for biowaste in the world, at 1.24%. This is achieved through:

- ongoing public education and communication campaigns;
- a bin-tagging programme that involves the identification of contaminated bins and tagging of the bin to inform the resident of a specific issue; repeating the bin checking and tagging for up to 3 consecutive weeks results in a high rate of resolution;
- the suspension of collection services when bins are found to contain a significant amount of contamination; in these cases, the bin is tagged and the resident informed that their bin will not be collected until the contamination issue is resolved;
- following up on repeat tagging with non-compliance letters in the post that explain the non-compliance issue and describe the consequences of continued non-compliance, i.e. fines, and include a booklet explaining how to resolve the issue;
- onsite visits from a bylaw officer for those residents who choose to disregard bin tagging and collection suspension; visits could be for educational purposes or to issue formal warnings or penalties.

2.8.2 Seattle, Washington

As mentioned in section 2.2, the contamination rate in Seattle – the largest city in Washington State – is 2.6%. This is achieved by using a combination of clear policies on labelling and outreach/education.

2.8.3 Italy

In Italy, the most common techniques used to foster behaviour change are as follows:

- Using a sticker stating that the bin was not collected because it was contaminated. The message on the sticker can vary depending on the degree of enforcement that the municipality wants to apply. For instance, it can be “your bin had some impurities, but it was collected anyway – next time be careful” (nudging approach) or “you bin was not collected – please remove contamination” or “you will get a fine if your bin is found to have impurities again”.
- Good communication campaigns, specifically addressing the issue. The results were impressive from campaigns such as the “clean and wet” campaign run by Etra the main message of which was that food waste (wet) has to be clean. The cost of the campaign was completely covered by the additional savings made by the composting plant as a result of fewer impurities[46] being present in the feedstock.

2.8.4 Catalonia, Spain

Generally, in the Catalan model, the following measures are taken:

- A refund of landfill/incineration taxes is given to local authorities based on the quantity and quality of food waste collected.
- Free compostable bags and a vented kitchen caddy are given to households when a collection is started.
- Awareness campaigns focus on high-quality recycling and encourage no contamination.
- The level of contamination on collection routes is measured.

46 https://www.biocycle.net/images/art/1009/bc100946.pdf (accessed 10 April 2024).

- If bags in the bins are found to not be compostable and if contamination is visible, the bin is not collected, and a sticker is left to explain why; then, when the household removes the contamination, the bin is collected.

2.8.5 London, UK

In the London borough of Greenwich,[47] a "bin-tagging" campaign was launched in November 2022. The contamination rate decreased from 14.5% in the month the campaign was launched to 3.8% in the first full month of collections. Contaminated bins are not collected; instead, warning stickers are placed on them. After three incidents, contaminated bins are removed permanently. The council's waste advisors also attend affected properties "to help residents identify the items they need to remove".

2.8.6 San Francisco, California

The San Francisco Refuse Separation Compliance Law[48] requires that the refuse (compostables, recyclables and residual waste) of large producers is audited to identify contamination and requires them to engage staff (a "Zero Waste Facilitator") to ensure that adequate material separation is carried out when necessary. A waste collector, Recology, has produced a video[49] that shows what an auditor is looking for when they audit the compost, as well as common contaminants found in compost, examples of passing and failing compost audits, and best practices for proper sorting.

2.8.7 Germany

In the municipality of Borken, Germany, increased public communication about biowaste recycling, having visual control measurements of biobins at the source and the rejection of bins led to a decrease in contamination from about 3.48% to 0.38% between August 2020 and August 2021 (Irmgard Leifert, RETERRA, personal communication).

In May 2023, a new German campaign was launched with the aim of raising awareness of the importance of pure biowaste for the production of compost and digestate. Citizens are requested to be conscious of the fact that impurities (plastics, glass and metals) do not belong in the biobin. See here for further information on the campaign: https://ab-kommunen.de/ (accessed 10 April 2024).

2.8.8 New Zealand

The New Zealand Ministry for the Environment has taken a different approach to compostables. It excludes[50] compostables (both plant- and fossil-based) from biowaste collections, reflecting the fact that they are not desirable inputs for many food waste-processing options because they do not contain nutrients and are a source of confusion[51] for members of the public.

2.8.9 Local testing of compostable products

Compostable products are tested in controlled laboratory conditions. There is now a trend emerging in which the local field testing of products is being requested by industry (e.g. in Italy, Ireland and the USA) or by national regulations (e.g. in Canada and Germany for food waste bags). In Ireland, the trade body for composting and biogas plants, Cré – the Composting and Anaerobic Digestion Association of Ireland – has established a scheme in which packaging/products certified to EU standards are tested in an Irish composting plant to ensure that they are compostable under Irish conditions. If the packaging/products pass, they are awarded certification from Cré confirming that they are compostable in Ireland.

47 https://www.letsrecycle.com/news/greenwich-cuts-contamination-by-10-7-after-bin-tagging/ (accessed 9 April 2023).

48 https://sfenvironment.org/largerefusegenerator (accessed 10 April 2024).

49 https://www.youtube.com/watch?v=-LCY9kH6AEs (accessed 9 April 2023).

50 https://www.pmcsa.ac.nz/topics/food-rescue-food-waste/what-can-i-do-with-my-food-waste/compostable-packaging/ (accessed 10 April 2024).

51 https://environment.govt.nz/assets/publications/General-public-attitudes-to-composting-and-home-compostable-packaging-Survey-report.pdf (accessed 10 April 2024).

2.8.10 Fiscal penalties

Fines on households do play a role in some jurisdictions, typically as a last resort, if households do not comply with instructions given by collectors or regulators, or do not act based on the education provided. The city council in Hayward, CA, has fitted collection trucks with monitoring cameras. Fines of $25 per bin are imposed ($75 for larger bins) for repeated instances of contamination following a 4-month community education campaign.[52] In California, as of the beginning of 2024, state law permits fines to be awarded against those who contaminate their organic waste collection. A first offence could cost between $50 and $100, with third and subsequent offences costing up to $500.

2.9 Survey of Compost and Biogas Plant Managers on Technologies to Remove Contamination

An online survey was completed by 21 plant managers from various countries[53] on their experience of the efficiency of technologies at removing contamination from unprocessed feedstocks and the final compost and digestate. The number of responses was relatively small; therefore, the trends should be interpreted with caution. For biowaste feedstocks, the most common tools and techniques used were hand picking, trommel screens and magnets. For packaged/unpacked food feedstocks, the most common tools and techniques were magnets and sedimentation tanks with air injection.

According to compost plant managers responses, the most common tools and technologies used to remove plastics from their feedstocks were hand picking, trommel screens and wind shifters. Regardless of the technology employed, a plastic removal rate of between 60% and 80% was achieved. It was noted by one manager that the efficiency depended on the level of impurities and the technology used. As noted above, magnets are one of the tools most commonly used to remove metallic contamination. Anaerobic digestion plant managers reported that the most common tools and techniques used to remove plastics from feedstock arriving at their facilities were hand picking, hammermills and sedimentation tanks with air injection. The efficiency rate of these tools and techniques for plastics removal is between 60% and 80%.

2.9.1 What techniques do you use to remove contamination from the final compost or digestate?

For compost, the tools and techniques most commonly reported as being used were trommel screens (14 plants); magnets (11 plants); air lift separators (six plants); conveyor separation with air (six plants); star screens (five plants); picking stations (four plants); vibrating screens with apertures (or holes) of less than 2 mm (four plants); hand sorting (four plants); gravity separation (four plants); optical sorting (one plant); and air classifiers (one plant). One plant mentioned that it uses a wind shifter, ballistic separator and cascade vibrating screen.

For digestate, only one respondent reported using vibrating screens with apertures (or holes) of less than 2 mm – for removing plastics. Another respondent reported using a screw press separator with a 2-mm final screen.

2.9.2 What particle size (mm) do you screen the final compost or digestate for?

Most commonly, compost or digestate is screened for particles of 10 mm or above (9 plants), followed by 12 mm or above (six plants). Some plants screen for particles as small as 2 mm (two plants) and 5 mm (two plants), and, at one plant, the screens used had apertures as large as 40 mm. From Table 2.2, it can be seen that trommel screens are most effective at removing plastic contamination (with most plants reporting a removal rate of ≥90%). Across all the technologies used, the rate of plastic removal from compost/digestate ranges from 60% to 90%.

52 https://wasteadvantagemag.com/hayward-ca-city-council-awards-new-garbage-collection-organics-recycling-contract/ (accessed 9 April 2023).

53 Australia, Catalonia (Spain), Croatia, England (UK), Finland, Germany, Italy, Ireland, the Netherlands, Portugal, Scotland (UK) and the USA.

Table 2.2. Respondents' experiences of the efficiency of various technologies at removing plastic contamination from compost or digestate

Technology	Number of respondents reporting plastic removal, by rate of removal						
	60%	70%	<80%	<90%	<95%	<97.5%	<99%
Compost							
Trommel screens	1	1	1	2	3	2	1
Conveyor separation with air	1	2	3	1			
Air lift separators		1	3	1			
Picking stations	2		1	1			
Star screens	1	1	2			1	
Hand sorting	3	1		1	1		
Flotation separation	1	1					
Air classifiers	1		1	1			
Gravity separation	1	1	1	2			
Optical sorting/near infrared				1[a]			
Digestate							
Vibrating screens – screened at less than 2 mm – plastics	1		1	1	1		
Screw press							1

[a]**This depends on the dimensions and load.**

3 Waste Characterisation

3.1 Review of Existing Biowaste Composition Analysis Systems

3.1.1 Outputs of initial screening

To undertake this review, all of the leading bodies in organic waste recycling in Europe, the USA, Canada and Australia were contacted to see if they had a protocol for analysing incoming biowastes and, if possible, to obtain a copy of that protocol. In addition, extensive searches of Google and Google Scholar were undertaken.

The research identified that there are numerous methods applied and reported across the world to analyse the composition of general waste and dry recyclables (Dahlén and Lagerkvist, 2008; Edjabou, 2015; ASTM D5231-92(2016)[54]). Similarly, a number of papers have looked at food waste and biowaste composition. Malamis (2015), van der Werf *et al.* (2020a), Everitt (2021) and Gallardo *et al.* (2021) reported on the contamination present in organic waste street containers in Spain but did not provide details of the protocol they used to assess waste composition. For determining the composition of biowaste with a specific focus on contamination, relatively few methods (five) have been published.

The only formal national standard that we could identify was in Italy, namely UNI PdR/123:2021[55] "Metodo di prova per la determinazione della qualità del rifiuto organico da recuperare attraverso i processi di digestione anaerobica e compostaggio". This standard is based on a main approach whereby wastes are split into compatible (e.g. compostable products, paper, wood), neutral and non-compatible (plastic, metal and glass), and a more detailed approach whereby the bags in which food and other wastes are contained are separated into individual types. Italy has also recently introduced the world's first extended producer responsibility scheme for producer responsibility organisations for compostable plastic packaging, making accounting for this type of packaging as it flows into organic recycling facilities necessary. Annually, the Italian Composting Association (Consorzio Italiano Compostatori; CIC) also undertakes ~1200 waste analyses at organic recycling facilities in Italy.[56] Methods have been published for analysing contamination levels in biowaste in Germany, by the Federal Compost Quality Association (Bundesgütegemeinschaft Kompost (BGK)), and in the UK, by the Association for Organics Recycling, which is now part of the Renewable Energy Association (REA).

In Ireland, as part of the EPA national waste characterisation study, consultancy company RPS published a report in 2015 titled *Review of the Methodologies Used for the Characterisation of Household Municipal Waste*. According to the 2018 EPA waste characterisation report (EPA, 2018a), the protocol developed in 2015 was updated with new sampling plans in 2017. In addition, the Department of the Environment, Climate and Communications in Ireland supported the National Brown Bin Awareness Pilot Scheme in Sligo City (Gillen *et al.*, 2019), which undertook numerous waste analyses. Some details of the protocol developed during this Sligo pilot scheme are included in the study's final report (Gillen *et al.*, 2019). The RPS 2015 methodology is not publicly available in full, although the 2018 EPA report does contain a summary of the protocol used for biowaste (EPA, 2018a). Similarly, the Sligo protocol was not published, but has been made available for review purposes to the authors of this report.

Carrying out detailed analyses of biowaste is resource intensive and therefore is not commonly applied at organic waste facilities, other than in Italy. However, it would still be potentially helpful to facility operators and those delivering the biowaste for rapid quality

54 American Society for Testing and Materials D5231-92(2016): Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste.

55 http://store.uni.com/catalogo/uni-pdr-123-2021 (accessed 10 April 2024).

56 *L'Italia del Riciclo 2021*, p. 163 (https://www.fondazionesvilupposostenibile.org/wp-content/uploads/ITALIA_DEL_RICICLO_2021_web.pdf; accessed 10 April 2024).

assessments to be undertaken on delivery of a load. To this end, both the BGK[57] and the REA[58] have developed visual assessment protocols. Both methods provide guidance on identifying contamination in cases of dispute, with the BGK visual assessment protocol being used as a precursor to its more formal method, and the REA protocol using a simple count of plastic bags as a precursor to accepting or rejecting a load.

Beyond the published methodologies, in Catalonia the waste handling chain has to undertake waste analyses and report the data, with pictures, to a freely available online database available in Catalan and Spanish.[59] Analyses must be undertaken on all waste streams, resulting in a highly transparent system, open to not only industry and regulators but citizens too.

The review of the five published methods identified three areas that can be considered most relevant to the technical design of the analysis. These are sample preparation, sample size for analysis and categories of waste. A summary of these main aspects can be found in Table 3.1. In addition, other aspects that are commonly considered in published methods are health and safety, record keeping and sampling frequency/ sampling plan.

3.1.2 Sample preparation

Unless characterisation is being performed on an entire load, it is necessary to homogenise the waste as much as is possible prior to sampling. Biowaste is often highly heterogeneous. This is because some waste producers are better at separating their waste than others, and it is not uncommon for the same collection vehicle to be used for different waste streams, meaning that it is possible for contamination to arise simply from collections being undertaken without the vehicle previously being emptied or cleaned.

The most common method identified for homogenising samples was mixing with a front-end loader followed by the "coning and quartering" method. The latter, which is taken from analytical chemistry, is defined as follows: "The reduction in size of a granular or powdered sample by forming a conical heap which is spread out into a circular, flat cake. The cake is divided radially into quarters and two opposite quarters are combined. The other two quarters are discarded. The process is repeated as many times as necessary to obtain the quantity desired for some final use (e.g. as the laboratory sample or as the test sample). If the process is performed only once, coning and quartering is no more efficient than taking alternate portions and discarding the others" (IUPAC, 2019).

Because samples are being taken from a load typically weighing many tonnes, often for biowaste sample preparation, coning and quartering of the whole load happens only once. Thereafter, smaller samples are taken, combined and reduced again until the desired sample size is achieved.

3.1.3 Sample size

For the five methods identified, the size of the sample that undergoes final analysis was found to vary significantly, ranging from 100 to 1000 kg. Both methods that use larger sample sizes, i.e. the REA and BGK methods, are intended to be used to analyse mainly separately collected garden waste or co-mingled food and garden waste in which garden waste is the dominant material. For those methods that use small sample sizes, e.g. the methods used in Italy, the biowaste targeted typically has a higher proportion of food waste (RPS Group, 2015). Consultations undertaken with the CIC clarified that over time the sample size in Italy has varied, but that long-term experience meant that the CIC could confirm statistically that 130 kg was the optimal sample size based on typical load weights (30 tonnes) and sample variation.

3.1.4 Waste categories

The types of waste that can be analysed using the different protocols vary significantly. The BGK method is the simplest and the REA method the

57 https://www.kompost.de/fileadmin/user_upload/Dateien/Themen/Methoden/Methodenpapier_-_Sichtkontrolle_fester_Bioabfaelle.pdf (accessed 10 April 2024).

58 http://www.organics-recycling.org.uk/uploads/article2903/Visual_assessment_guidance_light_plastics_V1R0.pdf (accessed 10 April 2024).

59 https://sdr.arc.cat/cform/ListCaracteritzacions.do (accessed 10 April 2024).

most detailed. The Irish sampling protocols appear to be based on taking a consistent approach to all waste streams, as required by the EPA, whereas the Italian standard allows both simple and detailed analyses. The Italian standard also provides for a high level of understanding of different compostable and non-compostable waste collection bags, articles and packaging.

3.1.5 Other aspects

In addition to the protocol used for the actual analysis, another factor that has a potentially significant impact on the validity of the results is the sample from which the waste to be analysed is taken. The review identified different approaches to sampling, which appear to have been chosen depending on the secondary use of the outcomes from the analysis. In some cases, researchers have taken a selection of bins from the kerbside as their source (e.g. van der Werf *et al.*, 2020b), and in this case the data on food waste were related back to the proximity to food outlets (e.g. supermarkets, takeaways). In other cases, e.g. a study in King County, WA (Cascadia Consulting Group, 2020), bins or loads were taken from known housing types, e.g. detached or multi-occupancy housing, to gain an overall view of the waste stream or a specific view according to housing type.

3.1.6 Conclusions of the review of the Irish context

In preparing the biowaste contamination characterisation protocol presented below, we considered a number of aspects relevant to both this project and the Irish biowaste collection and recycling market more generally. These were as follows:

- **Types of collection.** In Ireland, domestic biowaste is mainly collected in 240 L wheelie bins on a fortnightly cycle as standard, on a pay-per-lift charging system. The biowaste collected is a mix of food and garden material, but, because of the pay-per-lift system, it may not be collected for up to 4 or 6 weeks, by which point it will have started decaying in the bins. This results in wetter waste than is typically found in other similar collection systems, making it difficult for plants to handle. Commercial food waste tends to be collected separately (not with garden waste) and is typically collected more frequently, at least weekly, meaning that this waste, while wet in nature, tends to be fresher and thus easier to handle.
- **Aims of the project.** The overarching aim of the project was to assess the level of plastics in separately collected food waste. Plastics can be either hidden, e.g. in teabags or other small articles, or highly visible, e.g. in the form of bags. In addition, there are increasing amounts of compostable plastic packaging, e.g. waste bags, in the Irish market.
- **Resources for undertaking waste characterisation.** The project allocated two people per waste analysis, with 50 analyses requiring completion. Naturally, the more detailed the separation and the more difficult waste is to handle, the longer waste separation will take, while, in contrast, the simple separation of a simple waste stream will be relatively quick. Time and available resources meant that all weights were taken as fresh (wet) weight.

Combining these factors, for the protocol presented and utilised in this study, we adopted a system that sampled 130 kg of biowaste from each load and characterised each sample for more categories than suggested by established methodologies. For the purposes of developing a method that can be readily applied at facilities in the future, e.g. to assess contamination on a regular basis to provide customer feedback or to assess the biowaste for the presence of specific contaminating articles, we propose establishing a second system (see Appendix 2), identical to the first, differing in only the number of characterisation categories.

3.2 Household Collections

During this study, 36 waste characterisations were performed on household collections. There are two types of collection systems: co-mingled food and garden waste and food waste-only collections. The detailed results of the characterisations are provided in Appendix 2. The overall result for the percentage of contamination in all household collections (8.9%), together with the contamination level per collection type, i.e. food and garden waste (9.8%) and food waste-only (5.8%) collections are presented in Table 3.1. Waste characterisations were carried out on collections from Donegal, Leitrim, Sligo, Galway,

Table 3.1. Collection systems and contamination levels

Type of collection	Number of characterisations	Contamination (%)		
		Average	Median	Lower to upper limit
All household	36	8.9	8.1	3.4–21.7
Household food and garden	28	9.8	9	3.4–21.7
Household food waste only	8	5.8	5.7	3.4–7.9

Roscommon, Limerick, Cork, Meath and Dublin. Household food waste-only collections were observed to have less contamination than food and garden waste collections. Samples were taken from four collection routes (in Galway) in August, and these were resampled in January to see if there was a seasonal effect, i.e. an effect of there being less garden waste. The results show that the collections contained slightly more contamination in January, but this was not statistically significant.

Table 3.2 shows that compostable products made up 2–4% of collections in 2023.

Table 3.2 shows the contamination levels in household collections, revealing some similarities in data from the 2018 EPA waste characterisation study (EPA, 2018a). The notable differences are as follows:

- The level of plastics observed in samples taken during this study is nearly double than that reported in 2018.
- The samples in this study contain less textiles, metals, glass and wood than those taken in 2018.

In comparison with the 2022 EPA household waste study (EPA, 2023a), there are some differences; for example, less plastic contamination was found in the EPA study than in this study. It is worth noting that the number of samples analysed in the recent EPA study was only eight, whereas 36 samples were analysed in this study.

3.3 Commercial Collections

During this study, 14 waste characterisations were done on commercial food waste collections. The detailed results of the characterisations are provided in Appendix 2. The overall percentage of contamination in all commercial collections was 7.8% and the results are presented in Table 3.3. Waste characterisations were performed on samples taken from collections in Galway, Limerick, Cavan, Meath and Dublin.

Table 3.4 shows that this study found more plastic contamination than the EPA studies conducted in 2018 and 2022 (EPA, 2018b, 2023b).

Comparing the results from this study (Table 3.4) with those from the 2018 EPA characterisation study

Table 3.2. Household collection contamination levels identified in this study versus levels identified in EPA studies

Waste type	All household	Food and garden	Food waste only	EPA (2018a)	EPA (2023a)
Number of characterisations					
	36	28	8	6	8
Contamination (%)					
Organic waste	83	82	86	84	94
Paper, card and beverage containers[a]	5	5	4	4	1
Plastics	7	8	6[b]	4	4.2
Textiles, metals, glass, wood and others	3	2	0.2	9	1.2
Compostables[c]	3	2	4		

[a]Contain plastics; in this study, we categorised these items as plastics.

[b]If tea bags were compostable, this value would reduce to 1%.

[c]Added category – not in the 2018 EPA study (EPA, 2018a).

Table 3.3. Commercial food waste collection systems and contamination levels

		Contamination (%)		
Type of collection	Number of characterisations	Average	Median	Lower to upper limit
Commercial food waste	14	7.8	7.7	3.9–13.6

Table 3.4. Commercial food waste collection contamination levels identified in this study versus levels identified in EPA studies

	Contamination (%)		
Waste type	Food waste only	EPA (2018b)	EPA (2023b)
Organic waste	86	94	92
Paper, card and beverage containers[a]	5	3	3
Plastics	7	1	0.2
Textiles, metals, glass, wood and others	1		0
Compostables	1	1	2
Unclassified incombustibles, unclassified combustibles and composites			3

[a]**Contain plastics; in this study, we categorised these items as plastics.**

(EPA, 2018b) suggests that there has been an increase in the amounts of plastics in commercial food waste collections since 2018. Glass was mentioned by all plant managers as being a significant contaminant in feedstocks, and this study found that different-coloured glass was present in samples, indicating food containers and drink bottles as a potential source.

In comparison to the recent EPA study, there are some differences, one being that less plastic was found in the EPA samples than those taken for this study. It is also worth noting that the number of samples analysed in the recent EPA study was 8, compared to 36 samples in this study.

3.4 Types of Contaminants and Human Behaviour

Table 3.5 shows each category of contaminant expressed as an overall percentage of the total level of contaminants. The following trends can be seen:

- Household collections of food and garden waste contain a wide range of contaminants when compared with food waste-only collections from households.
- Household food waste collections, in general, contain fewer categories of contaminants. For example, the following categories were not found: glass, nappies, wet wipes, waste electrical and electronic equipment, batteries, hazardous materials, textiles, stones, pet faeces and plastic gloves.
- In commercial food waste collections, there is a lot of contamination in the form of glass and oxo-degradable bags.
- The presence of small, obviously plastic items in the kitchen caddy, for example plastic bottle rings, sauce/juice seals, rubber bands, coffee pods and nets from vegetables, may be due to them being inadvertently scraped in with chopping board scraps.

Table 3.6 gives the detailed breakdown of each type of plastic contamination identified in the study. It shows that there are differences according to the collection model and source of biowaste. For each type of collection system, the top five plastic contaminants are as follows:

- household food and garden – soft plastics, tea bags, coated papers, hard plastics and nappies;
- household food waste – tea bags, soft plastics, hard plastics, coated paper and nets from vegetables;
- commercial food waste – soft plastics, biodegradable bags, tea bags, coated paper and hard plastics.

Table 3.5. Percentage of contaminants in household and commercial collections

Type of contaminant	Contamination, as a percentage of total contamination (%)		
	Household food and garden[a]	Household food waste	Commercial food waste
Tea bags	4.99	78.28	6.75
Total glass before breaking into categories (18 samples)	2.07	0	15.97
Glass food jars	0.37	0	1.97
Glass drink bottles	0.60	0	1.73
Glass – other	0.10	0	0.00
Total metal before breaking into categories (18 samples)	2.77	0.21	2.43
Metal – aluminium can	0.66	0	0.34
Metal – tin can	1.23	0.35	0.75
Metal – aluminium tinfoil/tray	1.27	1.64	1.45
Metal cutlery	0.08	0.26	0.32
Metal – other	1.05	0.28	2.34
Soft plastics – bags/film	31.28	10.80	22.55
Biodegradable plastic bags	0.76	0.64	16.18
Plastic bottles	2.19	0.18	1.31
Rubber bands	0.02	0.04	0.02
Butter sachets	0.19	0.10	1.01
Fruit/vegetable stickers/labels	0.02	0.16	0.03
Plastic bottle rings	0.07	0.01	0.01
Vegetable nets	0.62	0.95	0.13
Coffee pods	0.26	0.32	0.52
Food condiment sachets	0.37	0.08	0.89
Bottle seals	0.01	0.01	0.01
Salt and sugar paper sachets	0	0.01	0.15
Hard plastics	12.36	3.02	4.60
Nappies – sanitary products	7.76	0	1.43
Wet wipes – hands	0	0	2.81
Plastic bread bands	0.02	0.01	0.00
Metal bread ring	0.02	0	0.01
Flower ribbons/bands	0.00	0	0.01
Waste from electrical and electronic equipment	0.11	0	0.00
Batteries	0.01	0	0.00
Hazardous – e.g. aerosol cans, medical related	0.35	0	0.12
Textiles	6.02	0	2.28
Coated paper/board/Tetra Pak/cartons	13.7	2.18	5.93
Treated wood	2.30	0	0.12
Stones greater than inch	2.03	0	0.47
Non-compostable coffee cups/lids	0.70	0.20	1.09
Pet faeces in compostable bags	0.00	0	0.00
Pet faeces in conventional plastic bag	0.96	0.12	2.13
Plastic gloves	0.18	0	0.89
Egg boxes	0.08	0.07	1.25
Roof tiles	0.06	0	0
Ceramics	1.37	0	0
Cigarette butts	0.01	0	0
Banana paper wrap	0.04	0	0

[a]A single concrete block was not included in the analysis because it would have skewed the data, as it constituted 45% of the total level of contamination.

Table 3.6. Percentage plastic contamination in all collection systems

Plastic contaminant	Contamination (%)			
	All household collections	Household food and garden only	Household food waste only	Commercial food waste only
Tea bags	19.30	6.53	80.60	11.13
Soft plastics – bags/film	35.79	40.94	11.12	40.04
Hard plastics	13.91	16.17	3.11	7.01
Nappies – sanitary	8.40	10.15	0.00	0.54
Oxo-degradable plastic bags	0.94	1.00	0.66	24.63
Plastic bottles	2.40	2.86	0.19	1.16
Rubber bands	0.03	0.03	0.04	0.03
Butter sachets	0.22	0.24	0.11	1.41
Fruit/vegetable stickers/labels	0.04	0.02	0.16	0.03
Plastic bottle rings	0.07	0.09	0.01	0.01
Vegetable nets	0.84	0.81	0.97	0.08
Coffee pods	0.34	0.34	0.33	0.07
Food condiment sachets	0.41	0.48	0.08	1.47
Bottle seals	0.01	0.01	0.01	0.01
Salt and sugar paper sachets	0.00	0.00	0.01	0.04
Plastic bread bands	0.02	0.02	0.01	0.00
Plastic gloves	0.20	0.24	0	0.56
Flower ribbons/bands	0.001	0.001	0	0.0008
Coated paper/board/Tetra Pak/cartons	15.22	17.92	2.25	9.03
Non-compostable coffee cups/lids	0.80	0.92	0.20	0.69
Pet faeces in conventional plastic bag	1.06	1.23	0.13	0.27
Wet wipes – hands	0	0	0	1.78

Soft plastics constitute a large percentage (36–40%) of the contamination observed in all collection systems, with the exception of household food waste (10%). This is similar to the situation in Italy, where plastic items constitute 42.2% of the overall contamination observed in biowaste (CIC, 2017).

4 Laboratory Testing of Samples

4.1 Research Methods

The LCA Centre in the Netherlands was provided with 45 samples of packaging waste commonly observed during the waste characterisation studies. Forensic laboratory research, using Fourier-transform infrared (FTIR) spectroscopy and Raman microscopy, identified the presence and types of plastics. However, this research did not give insight into the amounts of plastics present. For the purposes of this research, the definition of plastic is as follows: “plastic” refers to a synthetic polymer, i.e. a polymer not occurring in nature, to which additives or other substances may have been added. Natural polymers that have been chemically modified are also considered synthetic. This definition is based on the definition of plastic in the SUP Directive (Directive (EU) 2019/904). Contrary to the SUP Directive, however, this study does consider adhesives to be plastics, as they can contain synthetic polymers. The plastic components, whether present or not in the packaging samples, were studied using forensic laboratory instruments. Both FTIR spectroscopy and Raman microscopy were used to provide information on the presence and types of plastics in the packaging material itself.

4.2 Results

Table 4.1. Plastic identification results per sample

ID	Item		Plastic?	Component	Type
1	Fruit sticker – avocado		Yes	Adhesive Ink Main sticker component	Mixed polymers Polyester LDPE
2	Fruit sticker – Pink Lady apple		Yes	Adhesive Main sticker component	Mixed polymers LDPE
3	Fruit sticker – Fyffes		Yes	Adhesive	Mixed polymers
4	Milk bottle plastic ring		Yes	Main component	HDPE
5	Vegetable net – onion		Yes	Net Tab	LDPE PP
6	Ketchup seal		Yes	Outside Tab Foam Inside seal	PET PET PE LDPE

Table 4.1. Continued

ID	Item		Plastic?	Component	Type
7	Condiment ketchup – Heinz		Yes	Outside Inside	PET PE
8	Condiment ketchup – Blenders		Yes	Outside Inside	PET PE
9	Sugar sachet – Bewleys		Yes	Inside	LDPE
10	Paper wrap around a bunch of bananas – Aldi		Yes	Adhesive	Mixed polymers
11	Sugar sachet – Insomnia		Yes	Inside	LDPE
12	Salt sachet		Yes	Inside	LDPE
13	Pepper sachet		Yes	Inside	LDPE
14	Wet wipe for hands – from a restaurant		Yes	Fibres	PET PE
15	Paper napkin		No		
16	Kitchen roll – Plenty		No		
17	Blue tissue roll		No		
18	Rubber band		Yes	Main component	Ethylene propylene diene terpolymer (rubber)

Table 4.1. Continued

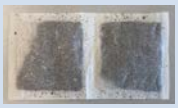
ID	Item		Plastic?	Component	Type
19	Coffee filter		No		
20	Paper wrap around a bunch of bananas		Yes	Adhesive	Mixed polymers
21	Tea bags on string – Lyons		Yes	Bag Seal label	PLA PE
22	Tea bags – Lyons		Yes	Bag	PLA
23	Tea bags – Barry Tea		Yes	Bag	PLA
24	Tea bags – Bewleys		Yes	Bag	PP
25	Tea bags – SHS and Twinings		Yes	Bag	PLA
26	Tea bags – Robert Roberts		Yes	Bag	PP
27	Tea bags – Stafford Lynch Ltd, Tetley		Yes	Bag	PP
28	Tea bags – Pukka		No		
29	Tea bags – Lidl, Fallons		Yes	Bag	PP

Table 4.1. Continued

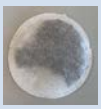
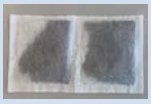
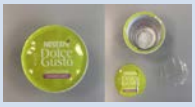
ID	Item		Plastic?	Component	Type
30	Tea bags – Aldi, McGrath		Yes	Bag	PLA
31	Tea bags – Dunnes Stores		Yes	Bag	PLA
32	Tea bags – Tesco		Yes	Bag	PP
33	Tea bag – Supervalue		Yes	Bag	PP
34	Unknown coffee bag		Yes	Bag	PE
35	Coffee bag – Marks & Spencer		Yes	Bag	PLA
36	Nappy		Yes	Overall fibres Tab Absorbent layer fibres	PP PP PET
37	Insomnia cup		Yes	Inside	LDPE
38	Paper straw		No	Adhesive	
39	Butter sachet		Yes	Inside	PE
40	Egg box		No	Adhesive	

Table 4.1. Continued

ID	Item		Plastic?	Component	Type
41	Coffee capsule – Nescafe Dolce Gusto		Yes	Top Film Cup	PET PP PP PP EVOH
42	Coffee capsule – Tassimo Kenco		Yes	Top Film Cup	Polyester PP PP
43	Wet wipe for hands – Defresh		Yes	Fibres	PET
44	Orange juice seal		Yes	Main component	LDPE
45	Bread pan plastic seal		Yes	Tab Adhesive	PP Mixed polymers

EVOH, ethylene vinyl alcohol; LDPE, low-density polyethylene; PE, polyethylene; PET, polyethylene terephthalate; PP, polypropylene.

4.3 Discussion of Results

In total, 38 of the 45 samples analysed contained plastics. Often these plastics were found in the main component of the samples and were mostly composed of polyolefins (polyethylene (PE) and polypropylene (PP), polyethylene terephthalate (PET) or PLA). As seen in Table 4.1, some samples contained more than one type of plastic. Often this was because of multiple layers of material being present in the parent sample acting as functional barriers, such as in the condiment sachets, the Heinz ketchup seal and the Nescafe Dolce Gusto coffee capsule. Sometimes a sample would contain other parts made out of different types of plastics, such as in the cases of the onion net and the nappy. Moreover, PLA, PP and PE were found in the tea and coffee bags, with these polymer fibres being used for their sealing functionality. However, of the polymers found in the tea and coffee bags, PLA is the only one that is compostable. The presence of any other polymers in the tea and coffee bags renders them not suitable for composting.

Some of the adhesives have been shown to consist of multiple polymers. Polymers often found in those mixes were styrene–butadiene, styrene–isoprene or styrene–acrylonitrile co-polymers. The adhesive found in sample 40, the egg box, was a starch-based adhesive and did not contain synthetic polymers. The only sample in which adhesives were undetectable was sample 38, the paper straw. However, it can be said with certainty that some type of adhesive was present, although in very small quantities – often about 1–2% adhesive is used in the manufacturing of paper straws (Waegemaekers and Hagen, 2022). These adhesives are primarily based on polymers; however, the presence of these adhesives could not be proven in this study for this specific item.

In 2021, 8088 tonnes of black tea bags were placed on the market in Ireland (Euromonitor International, 2022). In this study, we tested branded tea bags, which represented 90% of the market share. The leading brands in 2021 were Barry's Tea (25.9%), Lyons Tea (23.4%), Twinings (11.3%), Bewleys (9.9%), Robert Roberts (6.4%), Tetley (1.4%), Pukka (1.1%) and other private brands (7.6%).

5 Solutions

5.1 Webinar

At the end of the project, we hosted a webinar to allow stakeholders to vote on the proposed solutions. Of the 111 people who attended the webinar, 35% were from western Europe, 20% were from Ireland, 9% were from northern Europe, 6% were from the USA,19% were from southern Europe, 7% were from Canada, 3% were from Asia and 1% were from South America. Of the attendees, 14 represented the waste industry, 23 represented government agencies/governments, 10 represented compost plants, 4 represented biogas plants, 10 represented non-governmental organisations, 10 were in packaging-related roles and 38 were in other roles. Table 5.1 shows the results of the voting.

5.2 Solutions to Problematic Plastic Items

After considering the global and Irish industrial and regulatory contexts, as well as the data arising from the food waste (biowaste) characterisation analyses, solutions are provided below that the authors consider necessary to address the increasing problem of visible and invisible plastics present in food waste collections in Ireland. A number of different approaches are proposed, and, while on their own each will make an improvement, if the Irish organic recycling system is to reach the level necessary to meet all the current policy demands, e.g. in relation to EU recycling targets, peat replacement, soil health, organic fertilisers and soil improvers, and also advance the local bioeconomy, the recommended solutions in this section must be seen as a unit and not a set of individual possible actions.

5.2.1 Best practice contamination policy

Collections

From reviewing the information provided on policies in Italy, Seattle (WA), the UK, Canada, Ireland and Australia, a clear trend can be seen. Using the criterion of contamination levels in food waste, we have determined the best practice policy for kerbside collections of food waste (biowaste) from households and commercial premises to be as outlined below.

Bin inspection programme. Bins are inspected and a categorised according to a “traffic light warning system” (stickers are used). Heavily contaminated bins are not collected and the reason for this is explained to those in the household.

Set regulated maximum permissible contamination levels of 3% for food waste collections (as a standard condition in waste collection permits) and transfer stations. When contamination levels exceed 5%, it becomes almost impossible to create biowaste products of any value, costs increase enormously for processors and any ambitions for a circular bioeconomy driven by organic recycling are seriously jeopardised.

Run a targeted and ongoing public awareness campaign that focuses on high-quality food waste recycling, little to no contamination and the value of high-quality final products (compost and digestate). One region in Italy (Consiglio di Bacino Priula, within the province of Treviso) has contamination levels less than 1%, and this is attributed to a continuous 20-year campaign aimed at educating the public. All the evidence shows that there must be continuous communication with and education of the public on food waste recycling. Otherwise, contamination levels will increase. For example, authorities in Bavaria, Germany, stopped their education programme during the COVID-19 pandemic after 20 years. Within 1 year of this, the contamination level had increased significantly, from 3% to 9%, at which point a new education campaign had to be launched to address the increased contamination (Kevin Eves, Envirogrind, personal communication). The authors therefore recommend that the National Food Waste Recycling Programme be funded indefinitely.

Contaminated household bins should not be collected when non-compostable plastic bags or other contamination is visible. In such cases, a photo should be taken, and a sticker applied to the bin to explain why it was not collected and

Table 5.1. Votes of webinar attendees on proposed solutions, with green representing the most popular solutions and orange the least popular

Type of waste	Attendee votes as a proportion of the total number of votes by proposed solution				
Fruit stickers					
	Ban them	Make the stickers compostable	Use natural branding	Provide education	Wait for EU PPWR to enter into force (requiring stickers to be compostable)
	39%	39%	15%	1%	15%
Tea bags					
	Ensure all tea bags are EN 13432 certified (by Irish law as now)	Make all tea bags paper only	Ban tea bags in food waste bins until market adopts standard EN 13432 for compostability (e.g. as in the Netherlands)		Wait for EU PPWR to enter into force (requiring tea bags to be compostable)
	39%	38%	15%		7%
Coffee pods					
	Proposal in draft PPWR stipulating that coffee pods be compostable		Make them all aluminium or compostable	Ban single use coffee capsules containing plastic or aluminium (e.g. as Belgium is seeking to do)	
	41%		36%	23%	
Condiment sachets					
	Ban them in restaurants and instead use large bottles/ dispensers	Provide compostable option	Takeaways provide them only if asked for by customer	Takeaways put sauce in corner of box/bag of chips, for example	
	58%	31%	5%	5%	
Vegetable/fruit nets					
	In line with proposed EU PPWR, ban use of single use plastic packaging (nets, trays, bags and containers) for less than 1.5kg of fresh fruit and vegetables, unless there is a demonstrated need to avoid water or turgidity loss, microbiological hazards or physical shocks		Make them cotton and make the tab without metal or plastic	Educate the public about not placing these in the food waste bin	
	61%		25%	14%	
Glass					
	Offer deposit return scheme	Provide separate glass collection service for households	Encourage refilling/reuse, in line with draft PPWR	Increase the number of bring bank locations	Provide education
	45%	28%	11%	10%	7%

Table 5.1. Continued

Type of waste	Attendee votes as a proportion of the total number of votes by proposed solution				
Food waste collection bags					
	Stipulate that bags be compostable and appropriately marked in line with regulation	Enforce the EU Consumer Rights and Ban on greenwashing when it is made law		Industry agreement on acceptance via labelling/ marking system of compostable bags	Education
	51%	23%		19%	7%
What type of bag should any compostable system apply to?					
	All bags	Food waste collection bags	Very lightweight bags (e.g. fruit/vegetable bags)	Lightweight bags (e.g. shopping bags)	No bags
	51%	22%	11%	8%	8%
Should contamination limits be set on the following?					
	Waste producers	Waste processors (at the gate)		Waste collectors	None
	66%	17%		12%	5%
What is a practical and enforceable limit (for glass, metal and plastic) in feedstocks?					
	5%	1%	10%	0% in feedstock, with limits applying to only compost/ digestate	
	49%	32%	7%	12%	

provide information on what the issue/concern was with its contents. When the producer removes the contamination, the bin should be collected. Such a system may have an incremental approach, e.g. “your bin was contaminated with x, but we have collected it this time”, with a “two strikes to no collection” system implemented depending on the level of visible contamination. In the Irish market, it is important to have photographic evidence of the contamination inside the bin.

Businesses. “Food waste contamination policy is easier to enforce among businesses than among households” was a common remark made by various stakeholders. In Catalonia, businesses are inspected and receive a warning if the contamination level is high. In cases of recurrence, they can even be financially sanctioned. We have determined that the best practice policy for commercial food waste collections involves:

- Education: educate users on how to segregate waste and install proper signage at bins.
- Bin tagging: reject contaminated bins and explain why.

By December 2024, the Waste Enforcement Regional Lead Authorities, EPA and industry should create a common food waste collection policy to be applied by all collectors, which should be disseminated to all households and businesses prior to its implementation.

Treatment

There are also a number of measures that should be applied by processors, as outlined below.

Set (in permits/regulation) the maximum permissible contamination level in food waste received to 1–5% (the lower the better). All loads should be visually inspected, and any loads that are considered to have contamination levels in excess of the maximum should be subject to further analysis, which is paid for by the collector. The supplier would have the opportunity to recover the food waste and the regulator should be informed of each breach. The Waste Enforcement Regional Lead Authorities, EPA and industry should create a common waste acceptance policy to be applied by all facilities.

Provide a list of acceptable/unacceptable items in feedstocks. There needs to be a list of acceptable items in feedstocks that is enshrined in law. For example, the German Biowaste Ordinance includes lists of items that are acceptable and that are not acceptable (e.g. glossy paper because it contains plastics). In Ireland, the end-of-waste decision being drafted should also include lists of items that are acceptable and unacceptable in feedstock.

5.3 Recommended Solutions for Problematic Single Use Items Containing Plastic

The findings of the food waste characterisation analyses highlight the prevalence of a number of specific items that contain visible or invisible plastics. These are listed below, along with recommended measures to address the problems they pose for Irish organic recycling facilities. At the EU level, two draft legislative proposals are being negotiated for a new PPWR and for a Green Claims Directive. Depending on the final text, implementation time frame and requirements of the new legislation, it might supersede Irish regulatory options for the solutions proposed by this study.

5.3.1 Recommended measures for addressing problems caused by specific items containing plastic

Fruit stickers

By July 2024, shops should be legally required to use signs at the point of sale instead of stickers. In addition, where it is impossible to remove stickers from the supply chain, it should be a legal requirement that any stickers and adhesives are certified compostable and meet new Irish labelling requirements.

Tea bags

These are a flagship item in most food waste separation campaigns and contain organic matter that is important for the system, yet many still contain up to 20–30% non-compostable plastic. If all the tea bags in Ireland were compostable (e.g. paper only/be certified to EN 13432), the level of contamination in household food waste collections would be reduced from 5.7% to 1.3%. By July 2024, it should be a legal requirement that all tea bags are certified compostable and meet new Irish labelling requirements.

Plastic bottle rings and seals

The issue of plastic bottle rings and seals[60] should be solved by July 2024 when the SUP Directive condition (Article 6(1)) is implemented in Ireland under Statutory Instrument (S.I.) 516 of 2021.[61] From 3 July 2024, no producer in the EU shall place on the market beverage containers of up to 3 L in capacity that do not have tethered caps. In addition, the introduction of the Deposit Return Scheme in Ireland should reduce the frequency of drinks bottles entering the biowaste system.

Food condiment sachets (sugar, butter and sauces)

Food condiment sachets were a common contaminant found in food waste collected from the commercial sector.

By July 2024, these should be banned, as outlined in the Waste Action Plan. This will encourage the use of large bottles/dispensers. If exemptions are provided for, for instance in healthcare settings, any single use sachet or similar product should be certified compostable and meet the new Irish labelling requirements, and the number of sachets provided should be limited by making them available only to patients who request them.

Coffee pods

A number of aluminium and plastic coffee pods were found in the food waste. To the best of our knowledge there are no separate collection systems for coffee pods in Ireland. Therefore, given the organic content of the pods, it would appear sensible to consider policies that maximise the recycling of the organic content, for example mandatory separate collection of aluminium pods and/or requiring all non-aluminium pods to be compostable and meet new Irish labelling requirements.

Vegetable/fruit nets

The first draft of the EU PPWR proposal contains a provision that nets should be banned for fresh fruit and vegetables sold in amounts of less than 1.5 kg. There are cotton nets available on the market, but they have a metal ring and plastic tab as part of their structure. The authors recommend that cotton nets are used, but only those with no metal ring or plastic tab attached to them. Cotton will break down in the composting process.

Rubber bands on scallions/cut herbs, etc

The authors have not determined a technical solution for these products. Practical solutions would be to minimise their usage, e.g. to not use rubber bands on cut herbs unless necessary, and to specify that rubber bands should not be placed in a food waste kitchen caddy in communications campaigns.

Oxo-degradable/biodegradable "waste bags"

A significant number of oxo-degradable bags were found to have been used in commercial collections from nearly all collections (e.g. Dublin, Cork, Galway) that were characterised in this study. Enforcement of the SUP Directive is required under S.I. 516 of 2021, which, as of 3 July 2021, prohibits placing a product wholly or partially made of oxo-degradable plastic on the market in Ireland. If compostable bags certified to EU standard EN 13432 were to be used, it would reduce the average contamination rate from 7.8% to 6%.

Food waste bags

The Irish Food Waste Regulations should specify that only certified compostable paper or plastic bags meeting new Irish labelling requirements should be used in food waste collections.

60 Article 6(1) of the SUP Directive states that: "Member States shall ensure that single-use plastic products listed in Part C of the Annex that have caps and lids made of plastic may be placed on the market only if the caps and lids remain attached to the containers during the products' intended use stage". In addition, according to section 4.4.2 of the SUP guidelines, lids are "plastic or composite material that include plastic films sealed onto beverage containers, beverage bottles and cups for beverages. They can be peeled or torn-off. Once such a lid is removed on first opening by a consumer it cannot be placed back on the product. Lids can also refer to certain larger diameter or non-round caps".

61 European Union (Single Use Plastics) (No. 2) Regulations 2021, S.I. No. 516/2021.

Lightweight and very lightweight bags

In this study, soft plastics, predominantly plastic bags, were one of the more significant categories of visible plastic contaminants found. According to the latest data, over 15 million single use carrier bags were sold in Ireland in 2020–21. Given that the most effective way to separate food waste in a domestic kitchen is to use a caddy with a compostable bag or liner (such as paper), we recommend using the opportunities provided by the SUP Directive[62] and Carrier Bag Directive[63] and by July 2024 require that all lightweight and very lightweight bags are certified compostable and meet the new Irish labelling requirements.

Nappies

A new Irish labelling requirement should be developed that requires the following to be printed on all nappies and their packaging: "This product contains plastics – DO NOT PLACE IN FOOD WASTE BIN; PLACE IT IN THE RESIDUAL WASTE BIN".

Pet faeces

A large quantity of pet faeces was found during the characterisation of waste in compostable and non-compostable green/black bags. According to the New Zealand Government,[64] "studies show that pathogens, including viruses and intestinal worm eggs, are not always killed at composting facilities. To protect human health, potential pathogen sources such as pet faeces cannot be added to food waste bins. These should be placed in the residual waste bin." A new Irish labelling requirement should be developed, stipulating that pet waste bags are not green and display the text "DO NOT PLACE IN FOOD WASTE BIN".

5.3.2 Irish labelling/marking

At EU level, two draft legislative proposals are being negotiated, one for a new PPWR and the other for a Green Claims Directive. Depending on the final text and implementing time frame of any new legislation, the requirements it contains might supersede Irish regulatory options related to the solutions proposed in this study.

It is important that consumers are aware of which products are compostable. New Irish labelling regulations should be developed similar to those that exist in Washington State and Canada, for example:

- **Language.** Prohibit the use of the word "biodegradable" in association with packaging.
- **Colour.** Compostabe products must feature labelling that uses green or colour striping or tinting that helps to differentiate compostable items from non-compostable items.
- **Claims.** Claims that an item is compostable must be independently certified and verified in Irish facilities, and compostable items must display unique certification identification codes.
- **Lookalikes.** A list of products that are prohibited from being labelled in green should be developed.
- **Non-desirables.** A list of products, including nappies and dog waste bags, should be developed, and manufacturers should be required to print "contains plastics – do not place in food waste bin" on these products.

5.3.3 Perfluoroalkyl and polyfluoroalkyl substances

Food-related coated board and fibre materials, including baking paper and paper-based food containers, such as coffee cups, pizza boxes, plates and bowls, paper bags and cardboard packaging, often contain additives that make food packaging water and grease resistant, and these additives can include perfluoroalkyl and polyfluoroalkyl substances, which can cause harm to humans and the environment. It is worth noting that all certification schemes for compostables around the world have banned the use of perfluoroalkyl and polyfluoroalkyl substances in products. Ideally, if it meets the requirements of the paper recycling industry, all coated board should be put in the dry recycling bin.

62 Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.

63 Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags.

64 https://www.epa.nsw.gov.au/your-environment/recycling-and-reuse/household-recycling-overview/fogo-information-for-households (accessed 10 April 2024).

However, with the reduction in the use of plastics in food packaging, paper-based packaging is increasingly being used in this industry. We therefore recommend that food-related coated board is made both compostable and recyclable, as this will maximise opportunities for recycling.

5.3.4 Funding

In the region of 50% of all contamination identified in the study, by weight, was accounted for by packaging materials. Therefore, Repak, an Irish not-for-profit organisation that aims to help businesses comply with packaging legislation, should put in place supporting mechanisms such as funding collectors and processors, launching a national awareness campaign to facilitate the recycling of these packaging materials and ensuring that the fees paid by compostables producers support the organic recycling system.

6 Conclusions

The main objective of all stakeholders is to significantly reduce the input of contaminants, in particular plastics, into the soil as a result of the application of compost and digestate products derived from food waste. Contamination of food waste bins is undesirable because it necessitates further processing of the waste, incurs higher costs (to remove the contaminants) and/or results in a lower value recycled product. Clean food waste reduces the need for intensive sorting of the input materials and final refinement of the end product, thereby limiting the fragmentation of plastics and other physical impurities.

Following extensive engagement with trade associations, plant managers and other key stakeholders to collate relevant information and insights, 50 food waste characterisation studies were undertaken to identify trends in the types of contamination present in food waste collections, with a specific focus on plastics.

The characterisation studies found that the percentage of contamination in all household biowaste collections was 8.9%, with the contamination rates in food and garden waste collections being 9.8% and in food waste-only collections being 5.8%. The overall contamination rate in commercial food waste collections was 7.8%. The proportion of plastic contamination observed in household collections in this study was 7%, which is nearly double the rate of 4% recorded in the 2018 EPA waste characterisation study (EPA, 2018a). In commercial collections, the overall proportion was 7.8%, compared with a level of 1% found in an EPA study (EPA, 2018b).

A specialised laboratory conducted forensic analyses on a range of products, to identify the presence and types of plastics in products. Conventional plastics were found in items such as tea bags, fruit stickers, food condiment sachets (for sugar, salt and sauces), ketchup bottle seals, nappies, coffee cups, wet wipes, coffee capsules and vegetable nets.

After reviewing policies, legislation and alternatives, a suite of solutions was developed. These potential solutions were presented to stakeholders at a webinar and stakeholders voted on which solutions they believed to be most achievable.

In conclusion, this study identified numerous products containing plastics that are a hidden source of contamination in compost/digestate. Globally, this type of research has not been carried out before. The findings provide factual evidence for the presence of plastics with the potential to become microplastics in packaging products found in food waste bins. It is hoped that this evidence will put pressure on food producers to remove persistent plastics from their products and will inform policymakers during the development of policies aimed at reducing the amount of plastic in food waste collections.

The levels of plastic in food waste collection in Ireland have increased significantly since 2018, and urgent action is required now to address this problem.

A proposal for a new EU PPWR and a draft Green Claims Directive have been published by the European Commission and are progressing through the co-decision process. Depending on the final version and time frame for implementation, this EU legislation may supersede Irish regulatory options for the solutions proposed by this study. All solutions recommended are part of an integrated package aimed at solving, in the long term, the issue of plastics in food waste. The main solutions are ranked on a scale from 1 to 15 in order of ease of delivery, quickness, cost, enforcement and benefits to systems in Table 6.1 below.

In Autumn 2023, DECC put forward its proposition for a “Biowaste Forum”. This forum could be tasked to review and coordinate implementation of recommendations from this research report. This would ensure that the coordination of items to ensure national consistency in reducing the impact of plastics in soils and help increase the recycling rate of biowaste in order to meet EU recycling targets.

Table 6.1. Ranking of main solutions

Solution	Legislation level required[a]	Ability of market to deliver[b]	Cost to waste system[c]	Cost to consumers[d]	Enforcement need[e]	Benefit to system[f]	Total score	Ranking (in order of ability of market to deliver, quickness, cost, enforcement, benefits to the systems)
Continuation of the mywaste.ie national food waste recycling awareness campaign	0	0	0	0	0	0	**0**	**1**
Uniform contamination policy (e.g. National Standards Authority of Ireland standard/industry best practice) adopted by all waste collectors	1	0	1	0	1	0	**3**	**2**
Enforcement of SUP Regulation on the ban of oxo-degradable plastics	0	0	0	0	2	1	**3**	**3**
Enforcement of SUP regulation conditions on plastic bottle rings/seals by July 2024	0	0	0	0	2	1	**3**	**4**
Legally require shops to use signs at point of sale instead of fruit stickers and, legally where it is impossible to remove them from the supply chain, any stickers and adhesives should be certified compostable and meet new Irish labelling requirements	1	0	0	0	2	1	**3**	**5**
Develop specific Irish legislation on labelling for tea bags, fruit stickers, lightweight bags and similar packaging to prohibit the word biodegradable (to prevent greenwashing) and to create a scheme to validate compostable products via local field testing, to ensure compatibility with Irish processing plants	2	0	0	1	1	0	**4**	**6**
Compostable products have a specific colour/labelling scheme to be validated via local field testing to ensure compatibly with Irish processing	2	1	0	0	1	2	**6**	**7**
An Irish labelling regulation requirement, such as under the SUP Regulation, on the labelling of nappies and dog waste bags as follows: “This product contains plastics – do not place in the food waste bin”	2	1	0	0	1	2	**6**	**8**

Table 6.1. Continued

Solution	Legislation level required[a]	Ability of market to deliver[b]	Cost to waste system[c]	Cost to consumers[d]	Enforcement need[e]	Benefit to system[f]	Total score	Ranking (in order of ability of market to deliver, quickness, cost, enforcement, benefits to the systems)
National Standards Authority of Ireland to update the compost standard and develop a standard for digestate. A national-end-of-waste criteria should be developed linked to the National Standards Authority of Ireland standards. To contribute towards achieving EU recycling targets, only end-of-waste compost/digestate should count	1	2	2	0	2 0		**7**	**9**
Establish a contamination monitoring programme for processing plants	1	1	2	1	2	0	**7**	**10**
Food-related coated board and fibre to be both compostable and mechanically recyclable	2	2	0	1	2	0	**7**	**11**
From a contamination perspective, household food waste-only collections have less plastic contamination than co-mingled food and garden collections. Future collections services (e.g. apartments) should consider providing a food waste-only collection service	2	2	2	0	1	0	**7**	**12**
Waste collection permits and processing facility licences should set a contamination rate limit of 3%, with a maximum of 1% for plastics, similar limits set out in the German Biowaste Ordinance	2	1	2	1	2	0	**8**	**13**
Food condiment sachets to be banned	2	2	0	1	2	1	**8**	**14**
Establish a regulated feedstock quality control programme along the lines of that set out in the German Biowaste Ordinance. There could be scope for the Waste Enforcement Regional Lead Authorities to manage this	2	2	2	1	2	0	**9**	**15**

[a]Legisation: 0, none; 1, guidance only (government/agency); 2, statutory instrument; 3, primary legislation.

[b]Ability of market to deliver: 0, within 6 months; 1, within 1 year; 2, within 2 years; 3, unable to deliver.

[c]Cost to waste system: 0, zero cost; 1, minimal cost; 2, acceptable cost; 3, unacceptable cost.

[d]Cost to consumers: 0, zero cost; 1, minimal cost; 2, acceptable cost; 3, unacceptable cost.

[e]Enforcement: 0, no enforcement needed; 1, enforceable within existing powers and resources; 2, enforcement needs new powers and/or resources; 3, not enforceable.

[f]Benefit: 0, significant benefit; 1, some benefit; 2, little benefit; 3, no benefit.

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Abbreviations

CIC	Consorzio Italiano Compostatori
FTIR	Fourier-transform infrared spectroscopy
PE	Polyethylene
PLA	Polylactic acid
PP	Polypropylene
PPWR	Packaging and Packaging Waste Regulation
REA	Renewable Energy Association
SUP	Single Use Plastic

Appendix 1 Simplified Biowaste Characterisation Protocol for Future Use

This protocol has been developed under the EPA-financed project "Identifying the Sources and Scale of Plastic in Compost Derived from Household and Commercial Food Waste" and is intended for use on-site by those interested in characterising biowaste with specific consideration given to contamination. It is not intended for characterising biowaste itself, e.g. types of garden waste or types of food waste, but may be adapted accordingly.

Equipment Required

- personal protective equipment including sharp-proof gloves;
- camera or smartphone camera;
- reusable white board and pen;
- one 240 L wheeled bin;
- one garden fork;
- one shovel;
- two stainless steel tables;
- 12 buckets/containers;
- electronic scales with a capacity of up to 150 kg (batteries charged).

Place of Analysis

The analysis must be carried out in a suitable clean, paved, indoor area that is clearly sectioned off from the rest of the facility. Where garden waste only is being analysed, it is possible to undertake the analysis outdoors.

Health and Safety

Ensure relevant personal protective equipment is worn at all times. Depending on the environment, this should consist of the minimum required by the facility. Sharp-proof gloves are essential; face masks are recommended.

Always follow the facility's health and safety rules.

Prior to arrival, engage with the site manager to determine the operating conditions and whether or not a specific work plan and risk assessment are required before commencing the analysis.

Preparation of the Sample

1. The sample must be taken as close to delivery as possible.
2. The analysis must be performed within 48 hours of sample preparation.
3. The initial load must be documented, visually inspected and photographed to provide evidence of the level of heterogeneity. The photograph must include a white board with the date/load reference visible.
   If from the visual inspection it is clear that the load has an imbalance of impurities or feedstock types distributed within the load, further investigation of the source(s) of feedstock should be undertaken and, if necessary, the tipped load be split to enable more representative sampling and analysis.
4. The documentation must include the following information:
   i. date of collection;
   ii. date of delivery;
   iii. total weight of load;
   iv. source of load – household, commercial or mixed;
   v. source of load – area (location);
   vi. source of load – supplier (optional);

   Where possible, the following information should be recorded:
   i. whether or not it has come directly from a collection round or via a transfer station;
   ii. if the waste is sourced from households then any additional information relating to the area, e.g. route code, socio-economic categories or housing type, should be sought and recorded.

5. The minimum load to be analysed is 1000 kg.
6. All containers used for sample acquisition and separation shall be empty and weight recorded prior to commencing analysis.
7. Coning and quartering. The entire load shall be mixed/turned at least twice and spread evenly to form a circular mass. Equal amounts, e.g. one mechanical grab or bucket scoop from each side on the opposite of the diagonal shall be removed and a new heap created, from which a sample of 130 kg (± 10%) shall be taken. Where the mass is a mix of food and > 10% garden waste, it is preferable to use a grab, where the mass is mainly food waste (< 10% garden waste), a front-end loader shovel is permitted but the sample taker should take care to be random in their selection. If a load clearly contains > 90% garden waste then the procedure outlined in this point shall be followed but a sample of 250 kg (± 10%) shall be taken.

Example of quartering.

Note: any receptacle used to contain the sample must be placed on the scales and tared prior to sample weighing.

Sample Analysis

1. Empty the receptacle containing the sample into a pile and photograph. If the pile is considered to be not representative of the whole load, repeat step.
2. Using a shovel, place a quantity of the sample onto a sorting table, and separate into the fractions listed in the table below.
3. If a closed or sealed bag or other package is identified in the sample, it shall be opened and emptied by shaking three times to remove as much of the contents as possible. The bag/package/contents shall all be individually separated.
4. Repeat until the sample has been fully analysed.
5. Weigh each of the individual fractions.
    i. For specific fractions, it is recommended to both weigh and count the number of items.
6. Record the weights/counts on the survey sheet.
7. Create new piles/lines of each of the separated fractions and photograph using a white board to identify the load reference/fraction/date.

Biowaste Composition Form

Date sample collected/delivered

Date of analysis

Sample ID

Weight of sample in vehicle

Sample weight (target 130 kg)

Names of workers

Waste source

Direct or via transfer station?

Waste type	Number of items	Initial weight of container, kg	Gross weight (container plus waste), kg	Net weight, kg
Compatible				
Cré-certified waste bags				
Cré-certified packaging				
Other products identifiable as certified compostable but not Cré certified				
Uncoated paper/paperboard/tissue/hand towel/napkins				
Untreated wood				
Total				
Non-compatible				
Glass				
Metal				
Soft plastics (bags/film)				
Hard plastics (bottles/trays)				
Textiles				
Coated paper/board/Tetra Pak/cartons				
Treated wood				
Stones > 1 inch diameter				
Other				
Total non-compatible				

Notes

Signed: _____

Appendix 2 Waste Characterisation Results

The data presented in this appendix have been adapted from the EPA household waste characterisation report with permission.

Table A2.1. Collection systems and contamination levels

Type of waste collected	Direct from collection route or sample from transfer station delivered to compost plant	Contamination (%)	Organic waste (%)	Compatible materials (%)[a]
Food and garden	Transfer station	21.7	75.9	2.3
Food and garden – low-income households in a city	Direct	21.5	70.5	7.9
Food and garden	Direct	15.8	75.5	8.7
Food and garden	Transfer station	15.3	78.7	6.1
Food and garden – low-income households in a city	Direct	15.1	73.9	10.9
Food and garden	Direct	13.7	81.0	5.2
Food and garden	Transfer station	11.3	82.6	6.1
Food and garden	Direct	11.3	82.5	6.1
Food and garden – city	Direct	10.5	77.6	11.9
Food and garden	Direct	10.2	83.6	6.2
Food and garden	Transfer station	9.9	86.1	4.0
Food and garden	Direct	9.8	83.0	7.2
Food and garden	Transfer station	9.5	87.5	3.0
Food and garden	Transfer station	9.4	88.1	2.5
Food and garden	Direct	8.6	86.2	5.2
Food and garden – rural	Direct	8.3	77.1	14.6
Food and garden	Direct	8.1	86.7	5.2
Food and garden – city	Transfer station	8.3	85.3	6.4
Food and garden	Direct	8.2	80.7	11.1
Food waste only	Direct	7.9	79.0	13.1
Food waste only	Direct	7.7	88.2	4.1
Food waste only	Direct	7.4	87.0	5.6
Food and garden	Transfer Station	6.7	88.7	4.6
Food and garden	Direct	6.6	84.7	8.6
Food waste only	Transfer station	6.4	86.1	7.5
Food and garden	Transfer station	6.2	90.1	3.6
Food and garden	Transfer station	5.8	86.4	7.8
Food and garden	Direct	5.7	90.3	4.1
Food and garden	Transfer station	5.2	91.4	3.4
Food waste only	Direct	5.0	82.7	12.3
Food and garden – city	Direct	4.9	85.6	9.6
Food waste only	Direct	4.6	86.9	8.5
Food and garden	Direct	4.2	89.0	6.8
Food waste only	Direct	4.1	86.9	9.0
Food and garden	Transfer station	3.6	91.7	4.7
Food waste only – rural	Direct	3.4	93.4	3.3
All collections: average, median, range	–	8.9, 8.1, 3.4–21.7	–	–
All food and garden: average, median, range	–	9.8, 9, 3.4–21.7	–	–
All food waste only: average, median, range	–	5.8, 5.7, 3.4–7.9	–	–

[a]**Compostables include uncoated paper/paperboard/wood, tissues, hand towels, napkins (not coated) and coffee filters.**

Table A2.2. Commercial food waste collection systems and contamination levels

Collection	Contamination (%)	Organic waste (%)	Compatible materials (%)[a]
1	13.6	77.1	9.3
2	10.4	86.4	3.3
3	10.0	78.3	11.6
4	8.8	83.3	7.9
5	8.8	82.4	8.9
6	8.3	90.9	0.7
7	7.8	82.1	10.1
8	7.6	89.9	2.6
9	7.2	92.4	0.4
10	6.6	88.6	4.8
11	5.5	92.9	1.6
12	5.3	88.9	5.8
13	4.9	78.5	16.6
14	3.9	96.1	0.0
All: average, median, range	7.8, 7.7, 3.9–13.6	–	–

[a]**Compostables include uncoated paper/paperboard/wood, tissues, hand towels, napkins (not coated) and coffee filters.**

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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