Scottish Environment Protection Agency

Plastic in food waste at compost sites

Project report (November 2019)

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Cover image: Domestic food waste sample during processing (T Aspray)

Executive summary

A key aspect of a circular economy in Scotland is the separate collection and treatment of food waste through anaerobic digestion and in-vessel composting to produce a high quality fertiliser that can be used in agriculture.

In order to ensure that soil quality is protected through the use of food waste derived compost and digestate, the Scottish Environment Protection Agency (SEPA) has amended its position on plastic contaminant limits allowable in compost and digestate outputs. From the 1st December 2019 the plastic limit for outputs will be reduced to 8% of the PAS110 limit for digestates and 50% of the PAS100 limit for composts.

Currently, compost operators are expressing the greatest concern around these changes, including but not limited to those processing food waste feedstocks. Therefore, the purpose of this project was to research plastic contamination in domestic (from local authority household collections) and commercial food waste received at composting sites and make recommendations for improvement. The project also reviewed practice globally to help both develop and support the recommendations.

Domestic and commercial food wastes received at Scottish composting sites were sampled during February and March 2019 and analysed to determine the abundance of physical contaminants present (with an emphasis on plastic contaminants). Of the eight domestic samples, representing seven different local authority collections, all but one was in part or full presented in compostable caddy liners. The plastic contamination within liners or bags ranged from 1.3% to <0.1% FW. Other items of interest in the liners/bags were predominantly paper based consisting of teabags, paper towel and fruit stickers. One domestic source had very low compostable caddy liner use which requires targeted attention.

The contamination in domestic samples was also analysed on a dry weight basis which, given the high moisture content of food waste (around 70%) meant the plastic contamination was higher when reported on a dry weight basis and therefore significant in terms of achieving both PAS100 and SEPA output limits which are analysed on an ‘air dried’ basis.

Based on this, our analysis shows that feedstock with 5%, or even 1%, of contamination requires significant clean-up if the final compost is to achieve either PAS100 or the new regulatory limits. In short, achieving such reduction levels is extremely difficult.

Plastic contamination of commercial samples was variable depending on source and whether or not material was collected in large compostable ‘biobags’. Although contamination was high in one commercial mixed sample on a whole sample basis, the cause was cross contamination by separate discrete general waste bags – the actual food waste component (in biobags) being comparatively clean. Further, the direct relationship between waste producer and composting site operator (often supported by compost site operator managed collections) means the quality of inputs can be largely self-regulated.

Compost site operators all reported that compostable caddy liner/bags used for domestic and relevant commercial sources effectively degraded during composting. From other work it is known that the use of such liners/bags supports food waste recovery in terms of quantity. The work here provides some indication that the provision of compostable caddy liner/bags by local authorities may also improve quality of food waste.

Composters outside the UK all report difficulties with plastic contamination of feedstocks, and limits on acceptable levels in compost products tend to be set in local regulations. In a small number of cases, feedstock contamination levels are also set in regulation, and quality monitoring is mandated. Experience from the USA suggests that compostable food service wares present a future threat to feedstock and compost quality, with consumer confusion about the compostability or otherwise of these products and/or polymer densities that are inappropriate for composting environments. Approaches to reducing contamination rely heavily on communication tools of a type that are already in common use in Scotland.

A number of recommendations for SEPA and other stakeholders are proposed for improving domestic and commercial food waste sent to composting sites in terms of plastic contamination.

Recommendations for domestic food waste

- Through partnership working, Scottish Government should drive lower level of contamination in LA domestic composting feedstocks.
- LA's should provide compostable caddy liners to households where food waste is actively composted
- LA's select compostable caddy liner supplier with contracted composting site operator to ensure liners are easily recognisable by composting site staff
- Once a consistent approach in terms of provision of compostable caddy liners for LA domestic food waste collections is achieved, engage stakeholders to carry out Scotland wide education programme
- Engage relevant stakeholders to target common domestic 'in bag' plastic contaminants such a cucumber films and plastic (and paper-based) fruit stickers
- Develop a food waste feedstock monitoring programme. This could be overseen by a trade body (as in Italy) or become part of the regulatory framework, e.g. through a site licence or permit condition (as in California, where minimum inspection and monitoring requirements are mandated)

Recommendations for commercial food waste

- SEPA to continue to tackle food waste and physical contamination from supermarkets through the Food Waste Management in Scotland Guidance
- SEPA engage further with composting site operators, businesses and other stakeholders to understand and tackle general and non-food waste contamination of source segregated commercial food waste; to encourage closer supply-chain collaboration, leading to simplified communications and improved quality
- Composters to reject contaminated loads and report to SEPA for investigation.
- Develop a food waste feedstock monitoring programme. This could be overseen by a trade body (as in Italy) or become part of the regulatory framework, e.g. through a site licence or permit condition (as in California, where minimum inspection and monitoring requirements are mandated)

Further work will require engagement with local authorities (lacking from this project) and consideration of wider contamination issues associated with both domestic and commercial sources.

Contents

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Glossary

AD	Anaerobic digestion
BSI	British Standards Institute
DM	Dry matter
Dp	Decimal place
DW	Dry weight
FW	Fresh weight
LA	Local authority
ORG	Organics Recycling Group
PAS	Publicly Available Specification
QMS	Quality Meat Scotland
REA	Renewable Energy Association
REAL	Renewable Energy Assurance Ltd
SQC	Scottish Quality Crops
SEPA	Scottish Environment Protection Agency
WRAP	Waste & Resources Action Programme

1.0 Introduction

Scotland is a world leader when it comes to physical contaminant limits for compost and digestate outputs (Aspray et al, 2017). Initially the farm assurance schemes Quality Meat Scotland (QMS), followed by Scottish Quality Crops (SQC), were influential in driving lower physical contaminant limits. In 2017, the Scottish Environment Protection Agency (SEPA) amended its position on the acceptable level of plastic in Scottish compost and digestate outputs to align with QMS and SQC standards. For compost outputs the introduction of these levels was phased:

- From 1 December 2018 the limit for plastics >2mm is 0.08% (by air dry weight)
  - This equates to 66% of the limit for physical contaminants other than stones, as specified by PAS100:2011[1]
- From 1 December 2019 the limit for plastics >2mm is 0.06% (by air dry weight)
  - This equates to 50% of the limit for physical contaminants other than stones, as specified by PAS100:2011

The limits due to be implemented in December 2019 are thought to be particularly challenging, especially where compost facilities accept packaged food waste for processing. In addition to the above, Scotland also has ambitious targets when it comes to resource recovery. For example, the Waste (Scotland) Regulations 2012, which came into effect on 1st January 2014, initially required food businesses generating over 50 kg of food waste to present this for separate collection. On the 1st January 2016, food businesses generating 5 kg or more of food waste were also required to present this for separate collection. At the same time the Waste (Scotland) Regulations 2012 placed requirements on local authorities to collect food waste from households from the end of 2015 (although rural households and businesses are exempt from this requirement). From 2014 the Landfill (Scotland) Regulations 2003 were amended to ban any source segregated food waste from landfill and from the 1st January 2021 this ban will be extended to all biodegradable municipal waste. Although this will provide more food waste for recycling via composting and anaerobic digestion, as recognised in the Scottish Government's 'Food Waste Reduction Action Plan', the quality of food waste recycling must be improved to support this.

In 2016-2017 a SEPA funded project investigated the levels of plastic in whole digestate and separated liquor produced at Scottish anaerobic digestion (AD) sites processing domestic and commercial food waste (Aspray et al., 2017). The project found that the majority of sites were producing digestate containing physical contaminants at or close to the forthcoming 2019 levels.

In advance of the implementation of the revised limits for plastics in composts, SEPA commissioned this study – to examine the potential for different sources of food waste to be contaminated with plastics, to consider options for mitigating this and ensure that the resulting composts meet the required quality standard.

[1] The limit specified in PAS100:2011 is a maximum of 0.12% plastic on a mass / mass basis in the air-dry sample

Project objectives

The three project objectives were:

1) Research the levels of physical contaminants in food waste from commercial collections
2) Research the levels of physical contaminants in food waste from domestic collections
3) Use this information to make recommendations for reducing contamination in food waste composting feedstocks

2.0 Materials and Methods

2.1 Food waste sampling

Food waste samples were collected from PAS100 certified Scottish composting sites during February and March 2019. The sample size and number of subsamples varied depending on the nature and appearance of the sample type (Table 1). Three types of sample were collected:

1. 'domestic' from LA (Local Authority) household collections;
2. 'commercial' from a single supermarket source; and
3. 'mixed commercial' from various sources.

The 'mixed commercial' sample type included small businesses (e.g. restaurants, hotels and shops) as well as other sources (e.g. schools).

As shown below, domestic samples each comprised 20 subsamples ('intact' caddy liners/bags) to enable analysis at the household level as well as whole source. Exceptions to this were samples no. 9 and 12 where only 10 and 15 intact bags could be retrieved, respectively.

For the commercial sources, supermarket samples were 'bulk' samples of 80 litres. The other commercial samples were from mixed business collections – presented in bags – each sample of approx. 80-120 litres, from which seven individual bags were analysed per sample.

Table 1. Food waste sources, compostable liner provision and subsample numbers

Sample no.	Food waste sources	Subtype	Local authority provision of compostable liners	Composting operator provision of compostable liners	No. of subsamples
1	Domestic 1+2	Single LA source	No		10
		Single LA source	Yes		10
2	Commercial 1	Supermarket (aged)			n/a
3	Domestic 1	Single LA source	No		20
4	Domestic 2	Single LA source	Yes		20

Sample no.	Food waste sources	Subtype	Local authority provision of compostable liners	Composting operator provision of compostable liners	No. of subsamples
5	Commercial 1	Supermarket (fresh)			n/a
6	Commercial 2	Mixed commercial		Yes	7
7	Commercial 3	Mixed commercial		No	7
8	Domestic 3	Single LA source	Yes		20
9	Domestic 4	Single LA source	No		10
10	Domestic 5	Single LA source	No		20
11	Domestic 6	Single LA source	Yes		20
12	Domestic 7	Single LA source	Yes		15
13	Commercial 4	Mixed commercial		Yes	7

n/a – not applicable

2.2 Domestic source food waste processing

Individual caddy liners and bags were weighed fresh using a floor balance or 1 decimal place (dp) benchtop balance prior to cutting open and visually screening the food waste content for physical contaminants (glass, metal, plastic and 'other'). The 'other' consisted of 'man-made' materials including paper, cardboard, string etc. as described elsewhere (Echavarri-Bravo et al., 2017).

Physical contaminants were cleaned of food waste as far as practically possible including splitting open of individual teabags to empty content. Contaminants comprising mixed materials which could not be sub-categorised were placed in the most appropriate category (e.g. teabags presumed to be predominantly paper were reported as 'other').

Once all twenty bags had been processed the cleaned food waste was mixed using hand trowels and rakes to create a homogeneous sample. Two subsamples (minimum 200 g fresh weight) were subsequently taken for moisture determination. The subsamples were oven dried until stable readings were achieved.

The weight of each caddy liner/bag was weighed fresh on a certified 4 dp or 1 dp balance depending on both weight and physical size (large plastics unable to fit within the 4 dp balance housing). The total physical contaminant weight in each category (glass, metal, plastic and other) from each bag/liner was weighed.

The caddy liners/bags and associated physical contaminants were then 'air dried' at a maximum 60°C and reweighed. Caddy liners were then tested to determine whether they were conventional or compostable plastic, as described in Section 2.4.

2.3 Commercial source food waste processing

Commercial food waste samples fell into two categories (as indicated in Section 2.1) based on their presentation at composting sites and nature of the food waste. The two types of commercial food waste samples were processed differently to reflect this.

The supermarket bulk samples were weighed on a floor balance and then processed for physical contaminants. Primary packaging was the layer of material in direct contact with the food waste. Primary packaging was considered as physical contamination unless obviously certified as compostable. Secondary packaging layers were not in direct contact with the food waste and were also considered as physical contamination unless obviously certified as compostable.

The mixed commercial samples were processed in a similar manner to the domestic samples with individual bags weighed fresh using a floor balance or 1 dp benchtop balance.

For both commercial sample types, physical contaminants comprising mixed materials were split into respective categories prior to weighing (e.g. paper bread bag with a clear plastic film window). Unlike the domestic samples, contaminants from commercial samples were analysed fresh only due to sheer physical space required for drying.

Caddy liners for mixed business samples were then tested to determine whether they were conventional or compostable plastic, as described in Section 2.4.

2.4 Compostable plastic fragment determination

Once dried, caddy liner samples were tested for compostability using a simple screening test (Novamont, pers. comm.). The test was also supported by visual inspection of liner/bag labelling.

A square section (approx. 4 cm^2) of each liner/bag was cut and placed on a glass tile in a fume cupboard. A 50 µl measure of chloroform was then placed in the centre of the cut bag section and left for 5 mins. After 5 mins the sections were inspected and those with holes (or a clear chemical reaction) were recorded as compostable. An example is shown below where compostable bag numbers are underlined with marker pen following analysis (Figure 1).

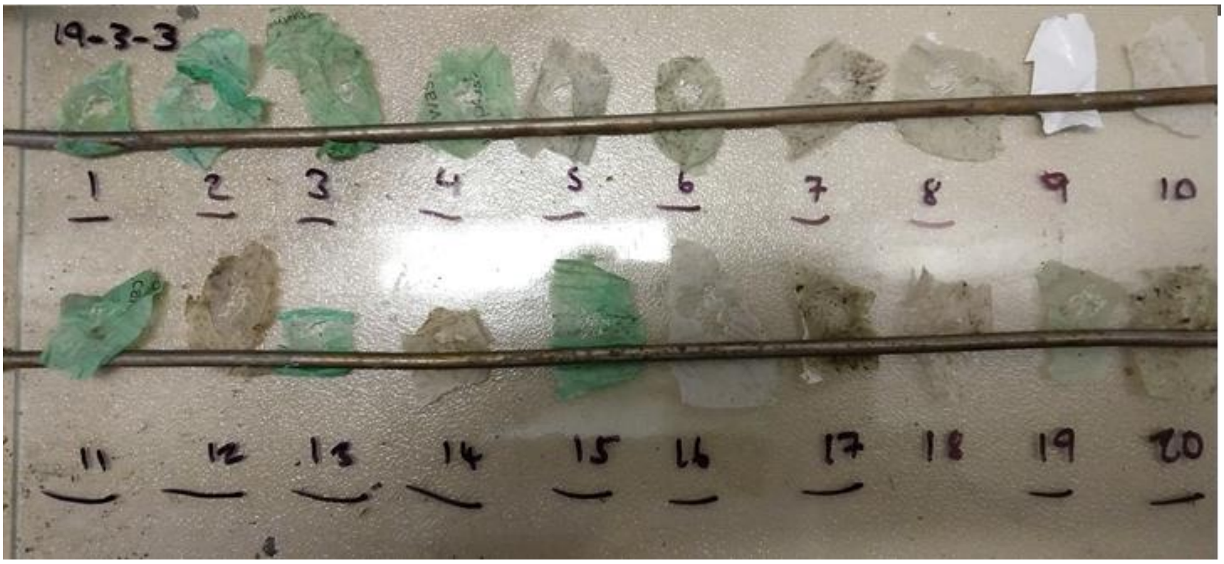


Figure 1. Chloroform analysis of individual subsample bag/liner fragments

2.5 Analysis

Contamination from domestic samples was analysed both on a fresh weight (FW) and dry weight (DW) basis and reported as % of the total FW or DW sample respectively. As indicated in Section 2.2, moisture content was practically determined for each whole domestic food waste sample – as representative aliquots could be taken after mixing subsamples. Moisture content and dry weights were not determined for the commercial samples as the nature of the food waste in these samples was considered too heterogeneous. Therefore, for the commercial samples a theoretical 70% moisture content value was assumed.

In addition to reporting the levels of contamination in feedstocks to composting sites, the generated weight and moisture content information was used to make assessments of the contaminant reduction required to achieve PAS100 and SEPA output limits for plastic contamination in finished composts. This assessment was supported by information from elsewhere on the mass reduction of material during the composting process.

2.6 Operator engagement

During the course of the project engagement was maintained with composting operators and site staff on the topic to aid interpretation of samples/results and inform our discussion/recommendations (Section 5.0).

2.7 Review of other evidence and best practice

A Rapid Evidence Assessment approach (National Archives, 2014) was adopted to systematise searches for data on contamination of food waste and best practices in addressing this issue outside the UK. The following search terms and results were utilised for this purpose:

- Food + waste + composting + plastic + contamination: 7,880,000 hits on Google. 200 abstracts reviewed
- Food + scrap + composting + plastic + contamination: 9,930,000 hits on Google. 200 abstracts reviewed
- Food + waste + plastic + contamination + compost: 38,700 hits on google scholar – no date limit. 100 abstracts reviewed. 1 additional paper downloaded.
- Food + waste + plastic + contamination + compost: 17,000 hits on google scholar – 2015 onwards. 100 abstracts reviewed.
- Food + waste + microplastic + contamination + compost: 652 hits on google scholar – 2015 onwards. 100 abstracts reviewed.

In total, more than sixty different sources of information were collected and reviewed. These identified particularly rich sources of data (in Italy) and best practice (in the USA), but despite reaching out to contacts in these countries, we received no response within the project timeframe. Our analyses and conclusions are therefore based solely on the published information.

3.0 Results

3.1 Contamination in domestic food waste

Summary results for plastic contamination in eight domestic food waste samples are shown in Table 2.

Sample 1 was deemed a mixed domestic source sample suspected of being derived from two LA sources. Within this sample, ten subsamples were compostable caddy liners (provided by one LA) and ten were non-compostable 'bags' (representing the other LA derived material) hence this sample was considered on the whole sample basis as well as on the basis of compostable liners/bags versus non-compostable bags. The results for this sample suggest plastic contamination 'in bag' was more commonly found with non-compostable bags than compostable ones. Certainly, the non-compostable subsamples for sample 1 and the whole of sample 3 (the same LA source) had two of the highest levels of 'in bag' plastic contamination.

For the other LA sources, although a few had similar numbers of subsamples (reported in percentage terms) containing 'in bag' plastic (e.g. samples 4 and 9) to the above, on a % FW basis the contamination was comparatively low. For example, in several subsamples for sample 4, a single piece of 'in bag' plastic was recognisable as clear plastic film on the end of a degrading cucumber portion.

Alongside the 'in bag' plastic contamination, data for caddy bags/liners have been reported both whole and as the non-compostable fraction only. The reason for this being that although compostable liners can be considered as 'physical contamination' in feedstock, they are reported to degrade in a properly managed composting processes – confirmed to be the case by all composting site operators. The results provide a strong indication that provision of compostable caddy liners by local authorities leads to lower plastic contamination (both in terms of the bag itself and the contents of the bag).

Moisture content was determined for each domestic food waste source sample and found to range from 65-71%. Reporting plastic contamination on both a % FW and % DW basis shows that plastic contamination was higher on a % DW basis due to the higher moisture content of food waste relative to plastic. The difference was less significant for compostable liners due to their ability to hold moisture derived from the food waste.

No obvious correlation could be found between the quantity of food waste presented for recycling and the type of caddy liner used. For example, sample 1 non-compostable subsamples had the highest average weight. However, some compostable liner/bag samples did also contain higher weights of food waste. Overall, the results show high variability of food waste weight both between and within domestic food waste sources, irrespective of the type of caddy liner used.

Table 2. Plastic contamination in domestic food waste samples

Sample number	Compostable caddy provision	Average subsample weight (g)[2]	% of subsamples containing 'in bag' plastic	Contamination (% FW)		Contamination (% DW)	
				Plastic bag/liner[3]	Plastic 'in bag'	Plastic bag/liner	Plastic 'in bag'
1	Mixed source whole sample	1201 ± 815	30%	3.5%	0.9%	7.5%	n/d
	Yes	768 ± 558	10%	3.9% (0.0%)	n/d	6.5%	n/d
	No	1634 ± 928	50%	3.4% (3.4%)	n/d	7.8%	n/d
3	No	987 ± 728	20%	3.8% (3.1%)	1.2%	5.3% (4.5%)	1.7%
4	Yes	962 ± 431	20%	3.8% (0.0%)	<0.1%	4.1% (0.0%)	<0.1%
8	Yes	1047 ± 610	15%	3.5% (0.6%)	0.5%	5.9% (1.6%)	0.9%
9	No	440 ± 114	20%	6.5% (2.7%)	0.2%	8.3% (2.7%)	0.6%
10	No	685 ± 415	10%	4.6% (1.0%)	<1.3%[4]	6.0% (1.5%)	n/d
11	Yes	1383 ± 636	5%	3.4% (0.0%)	<0.1%	n/d	<0.1%
12	Yes	873 ± 447	7%	8.5% (<0.1%)	<0.1%	7.8% (0.1%)	0.1%

n/d – not determined

[2] Average weight of subsample ± sample standard deviation
[3] Percentage in parenthesis is whole sample plastic contamination after removing confirmed compostable packaging
[4] High level of food contamination

Summary results of corresponding metal, glass and 'other' contaminants found in the eight domestic food waste samples are reported in Table 3.

The most common type of contamination associated with domestic food waste was 'other' with tea bags being the most common item of interest. Tea bags were found in every domestic food waste source and the majority of subsamples from each source. Although some tea bags are known to contain plastic, not all do, and many suppliers are actively moving to plastic-free versions. Discrimination between different types of tea bag was beyond the scope of this project. Fruit stickers, paper towel and nappies were found in up to three of the subsamples, as reported in Table 3. Although tea bags, fruit stickers and nappies have been reported as 'other' based on their predominantly paper makeup, it should be recognised that some of these items contain plastic. In the case of nappies, indications are that both biodegradable and non-biodegradable nappies were present. The suspected non-biodegradable nappy shown (Figure 2).

Only one domestic source sample (no. 11) contained metal contamination consisting of an AA type battery (i.e. not food related) in one subsample and foil (food related) in another. Similarly, only one domestic source sample contained glass (no. 8) – broken household glassware and wrapped in newspaper in a single subsample (Figure 2).

Figure 2. Non-biodegradable nappy (left) and broken glass bottle wrapped in newspaper (right)

Table 3. Metal, glass and 'other' contamination in domestic food waste bagged samples

Sample number	Compostable caddy provision	Contamination (% FW)			Contamination (% DW)			Other type(s)
		Metal	Glass	Other	Metal	Glass	Other	
1	Mixed source whole sample	0.0%	0.0%	3.2%	0.0%	0.0%	3.9%	TB, PT, FS
	Yes	0.0%	0.0%	2.4%	0.0%	0.0%	2.0%	TB, PT
	No	0.0%	0.0%	3.5%	0.0%	0.0%	4.7%	TB, PT, FS
3	No	0.0%	0.0%	1.7%	0.0%	0.0%	1.4%	TB, FS, BB
4	Yes	0.0%	0.0%	2.3%	0.0%	0.0%	1.5%	TB, FS, CF, W
8	Yes	0.0%	4.5%	3.4%	0.0%	14.9%	4.7%	TB, PT, N
9	No	0.0%	0.0%	13.1%	0.0%	0.0%	n/d[5]	TB, BN (2x), FS
10	No	0.0%	0.0%	3.6%	0.0%	0.0%	6.6%	TB, BN, PT
11	Yes	<0.1%	0.0%	0.6%	0.1%	0.0%	0.4%	TB, FS
12	Yes	0.0%	0.0%	0.8%	0.0%	0.0%	0.7%	TB, PT, FS

n/a – not applicable; n/d – not determined; TB – teabags; FS – fruit stickers; PT – paper towel; BB - bread bag (paper); CF – coffee filters; W – wrapper; N – nappy; BN – biodegradable nappy

[5] Not determined due to wet nappies

3.2 Contamination in commercial food waste

Contaminant analysis of two commercial supermarket samples is shown in Tables 4 and 5. Both samples (from the same source) show that primary plastic packaging is the most significant contaminant type followed by 'other'.

The level of primary plastic packaging is highly variable between the two samples; however, the first sample was not freshly delivered to the composting site. Instead this was taken after having been moved around so the integrity of the food packaging had been compromised by loading shovel handling. The result of this was that the plastic was contaminated with a greasy/fatty layer of food which increased its weight. The second sample was taken freshly delivered and much cleaner. The plastic contamination was lower in the second sample, however, it should be recognised that this source was highly variable in nature.

The second main type of contamination in the supermarket source was 'other' consisting of paper/card – this included food packaging, food related and non-related material. Metal contamination in both samples was foil only. No glass was found in either of these samples, although the composting site confirmed that this source has previously contained glass to greater or lesser extents.

Table 4. Aged supermarket food waste sample (no. 2)

Packaging	Contamination type	Contamination (% FW)	Example contaminants
Primary packaging	Plastic	8.4%	Aged sample – plastic contaminated with food
	Other (paper/cardboard)	1.2%	Tea / coffee bags. Plastic lined juice container
	Metal	0.2%	Coffee foil bag/packaging
	Glass	0.0%	
Secondary packaging	Plastic	0.0%	
	Other (paper/cardboard)	0.3%	Price tags. Other paper not food related
	Metal	0.0%	
	Glass	0.0%	

Table 5. Fresh supermarket food waste sample (no. 5)

Packaging	Contamination type	Contamination (% FW)	Example contaminants
Primary packaging	Plastic	3.4%	Trays for mince pies. Rigid tub
	Other (paper/cardboard)	1.4%	Soup carton, plastic lined
	Metal	<0.1%	Mince pie foil
	Glass	0.0%	
Secondary packaging	Plastic	0.0%	
	Other (paper/cardboard)	1.7%	Price tags. Other paper not food related
	Metal	0.0%	
	Glass	0.0%	

Contaminant analysis of three mixed commercial food waste samples is shown in Table 6.

Samples 6 and 13 represent food waste from businesses which have been provided with compostable bags by composting site operators and collected by these operators.

Sample 6 is presented both on a whole sample and compostable (biobag) only basis. On first impression this sample appears heavily contaminated; however, the sample included two non-compostable bags one of which contained no food waste at all. One bag was a black rubbish bag and the other a clear plastic bag (Figure 3) – as such both bags were visibly different to the green coloured biobags, suggesting an issue at the point of disposal/collection. Analysis of the biobag only fraction of sample 6 shows a much reduced 'in bag' plastic content with no metal, glass and reduced 'other' contamination.

For sample no. 6, all sampled bags were biobags provided by the composting site operator. No plastic contamination was found within the samples analysed. The only contamination within the sample was 'other' – one individual bag containing a large quantity of very wet paper towel leading to the high level of 'other' contamination reported.

The last sample (no. 7) consisted of packaged food waste with the highest 'in bag' plastic content of the mixed commercial food waste samples.

Figure 3. Clear bag alongside green biobag (left) and content of clear bag (right)

Table 6. Physical contamination in mixed business food waste received at composting sites

Sample no.	Compostable bag provision	Contamination (% FW)					Other type(s)
		Plastic bag/liner[6]	Plastic 'in bag'	Metal	Glass	Other	
6	Whole sample	3.9%	2.8%	2.0%	3.4%	11.7%	PT
	Yes	3.8% (0.0%)	0.2%	0.0%	0.0%	4.5%	
7	No	2.1% (2.1%)	2.3%	0.0%	0.0%	5.3%	PT, BB
13	Yes	4.1% (0.0%)	0.0%	0.0%	0.0%	8.6%	PT, TB

n/a – not applicable; PT – paper towel; TB – tea bags; BB – bread bags

[6] Percentage in parenthesis is whole sample plastic contamination after removing confirmed compostable packaging

3.3 Plastic contamination levels from feedstock to compost output

Given the current standard acceptable level of non-target material (contamination) in local authority organic waste contracts is 5%; an assessment was made of how plastic contamination levels in food waste feedstock could relate to those in compost outputs (Table 7).

The following assumptions were used in this basic assessment:

- Feedstock contamination is 100% plastic
- Moisture content of plastic in feedstock is 0%
- Food waste moisture content is 70%
- Food waste is composted on its own (not actual practice)
- Compost outputs assessed on a dry rather than 'air dry' basis

Compost mass reduction and compost output moisture levels informed from elsewhere (Aspray, unpublished).

Table 7. Estimated plastic contamination level in compost outputs (without removal/degradation) based on feedstock contamination levels

Feedstock contamination levels (% FW)	Compost mass reduction (%)	Compost output contamination (% DW) at different moisture content levels		
		50% moisture	60% moisture	70% moisture
5%	10	11.11	13.89	18.52
	20	12.50	15.63	20.83
	30	14.29	17.86	23.81
1%	10	2.22	2.78	3.70
	20	2.50	3.13	4.17
	30	2.86	3.57	4.76
0.1%	10	0.22	0.28	0.37
	20	0.25	0.31	0.42
	30	0.29	0.36	0.49

The results show that feedstock with 5%, or even 1%, of contamination requires significant clean-up at the output stage if the final compost is to achieve either PAS100 or the new regulatory limits. In short, achieving such reduction levels is extremely difficult. As alluded to above, it should be recognised that food waste is not composted alone, but ranging from anywhere between 5 and 60% of feedstock (ZWS, 2019), and so the level of contamination in the compost output will be affected by that in other feedstock(s) co-composted.

4.0 Review of data and best practices outside the UK

4.1 Compost input quality specifications

Whilst our evidence assessment identified various approaches to managing physical contaminants in compost products (summarised in Section 8.1) we identified only two examples where compost feedstock quality is regulated – from California and Washington State. Composting facilities accepting food waste in California must be in possession of a full solid waste material permit. These are issued on a site-specific basis, but the following general requirements apply to other types of composting facility (green waste) in the state:

- That operators conduct random load checks of feedstocks, additives, and amendments for contaminants;
- A minimum of one percent of daily incoming feedstock volume or at least one truck per day, whichever is greater, must be inspected visually. If a visual load check indicates a contamination level greater than 1.0 percent, a representative sample must be taken, physical contaminants shall be collected and weighed, and the percentage of physical contaminants determined. The load must be rejected if physical contaminants are greater than 1.0 percent of total weight (California Integrated Waste Management Board, 2009).

In Washington State, applications for a composting site permit must include a plan for rejecting feedstocks contaminated with greater than five percent physical contaminants by volume, or a plan to accept and separate contaminated loads from non-contaminated loads, and reduce physical contaminants to an acceptable level prior to composting. The regulation does not state whether sampling or simple visual assessment are required to demonstrate compliance with this limit (Washington State Legislature, 2013).

4.2 Compost output specifications

Compost quality is normally managed through a set of requirements applied to the end product. These requirements may be regulatory or voluntary, although in practice a combination of both is commonly used – particularly where the regulatory baseline may not be perceived as a sufficiently stringent by the market, which instead looks to quality assurance schemes to deliver products of a higher standard.

Reviews of compost standards have been published previously (for example, see WRAP (2002)), and it was not our objective to update these reviews. We have instead selected several standards to illustrate the variability in physical contaminant / plastic limits that are considered acceptable in different countries, to provide context for the SEPA limits. A summary is provided in this section, while further detail is presented in the Appendices (Section 8.1). The SEPA limits for plastics in compost are as follows:

- From 1 December 2018 the limit for plastics >2mm is 0.08% (by air dry weight)
    - This equates to 66% of the limit for physical contaminants other than stones, as specified by PAS100:2011[7]
- From 1 December 2019 the limit for plastics >2mm is 0.06% (by air dry weight)

[7] The limit specified in PAS100:2011 is a maximum of 0.12% plastic on a mass / mass basis in the air-dry sample

- This equates to 50% of the limit for physical contaminants other than stones, as specified by PAS100:2011

Table 8 Regulatory limits for physical contaminants in compost in various jurisdictions

Country or State	Type of compost	Lower particle size limit	Physical contaminant limit	Reference
Ontario	Category A	3mm	Total foreign matter ≤1.0% and plastic ≤0.5% (dry weight basis)	Ontario Ministry of the Environment, 2012
Ontario	Category AA	3mm	Total foreign matter ≤2.0% and plastic ≤0.5% (dry weight basis)	See above
Ontario	Category A & AA	-	No foreign matter >25mm in any one plane per 500ml	See above
North Carolina	Grade A	Not stated	Man-made inerts <6.0% (dry weight basis)	North Carolina, 2011
North Carolina	Grade B	Not stated	Man-made inerts >6.0% (dry weight basis)	North Carolina, 2011
North Carolina	Grade A & B	-	No man-made inerts >1inch in any one plane	North Carolina, 2011
New York	-	Not stated	Gross contaminants ≤2.0% (dry weight basis)	Department of Environmental Conservation, 2018
South Carolina	-	Not stated	Gross contaminants ≤2.0% (dry weight basis)	Department of Health and Environmental Control, 2014
Washington	-	2mm	Physical contaminants ≤1.0% by weight total, not to exceed 0.25% film plastic by weight (both on a dry weight basis)	Washington State Legislature, 2013
Germany	-	2mm*	Foreign matter ≤0.5% and plastic ≤0.1% (fresh weight basis)	Verband der Humus under Erdenwirtschaft – Region Nord, 2016
Switzerland	-	2mm	Foreign matter ≤0.5% and plastic ≤0.1% (dry weight basis)	Le Conseil federal Suisse, 2005
Australia	-	2mm	Glass, metal & rigid plastic ≤0.5% (dry weight)	Department of Sustainability, Environment, Water, Population and Communities, 2012

Australia	-	5mm	Light/flexible/film plastic ≤0.05% (dry weight)	See above

*Note that this limit may be reduced to 1mm, following a consultation that took place in 2018

Although precise interpretation depends on differences in moisture content between air-dry and oven-dry compost samples, we infer that the SEPA limits are broadly equivalent to the regulatory limits applied in Switzerland. Limits in Germany are similar, whilst limits in other jurisdictions tend to be higher, even where those composts are intended for multiple uses (such as Category AA in Ontario).

In addition to the regulatory limits listed in Table 8, it should be noted that area-based limits are applied to film plastics in composts in Germany, under the scheme overseen by the German Compost Quality Association (Bundesgutegemeinschaft Kompost e.V.) (Table 9).

Table 9 Area limits for film plastics in different categories of compost in Germany (BGK, 2018b)

Type of compost / market	Lower size limit for measurement	Area limit (cm^2 of plastic per litre of fresh compost)
Fresh compost	2mm	15
Finished compost	2mm	15
Substrate compost	5mm	10
Organic farming*	2mm	25

*Note that the overall limit for foreign matter in compost supplied to this market is 0.3%, as opposed to the usual 0.5%

As noted above, it is likely that the lower size limit will move to 1mm as a regulatory requirement, following consultation.

4.3 Data on food waste quality

Our evidence assessment identified a number of datasets that provide detail on contamination in food waste. In most cases these are for co-mingled collections of food waste with garden (or 'yard') wastes. However, there are data from Italy for food waste only collections, and data from previous projects that examined the quality of food wastes collected for anaerobic digestion. Full details are provided in the Appendices (Section 8.1), and a summary is provided in this section.

An organic waste composition project sampled material from various different sectors in Metro Vancouver during June and July 2016: Multi-Family Residential (MF), Single-Family Residential (SF), Industrial, and Commercial and Institutional (ICI). Co-mingled (yard and food waste) collections are in place across the city, but capture rates for the different fractions depend on the makeup of specific neighbourhoods. 47 samples of organic waste were collected, at a combined total (fresh) weight of 4,772kg. Sample sizes ranged from 50 to 125kg. Data were collected for both compostable and non-compostable fractions, with the former including compostable plastic and compostable paper (Tetra Tech, 2016). Non-compostable contaminants are listed in

Table 10.

Table 10 Non-compostable contaminants in organic waste. Percentages by fresh weight. (Tetra Tech, 2016)

Primary waste category	SF	MF	ICI
Garbage in bag*	4.4%	0.7%	0.4%
Other non-compostable paper*	0.2%	0.0%	0.0%
Film	0.2%	0.6%	0.2%
Rigid plastic (non-beverage)	0.3%	0.2%	0.0%
Treated or painted wood	0.0%	0.0%	1.1%
Other non-compostable organics*	0.2%	0.0%	0.0%
Glass	0.1%	0.1%	0.0%

*Garbage in bag = Material other than Compostable Organics contained in a plastic bag, or mixed waste contained in a plastic bag (all bags, including compostable, non-compostable, biodegradable, degradable, etc.); Other non-compostable paper = Photograph paper, tar paper, paper adhered to plastic or metal, composite paper products, paper contaminated with grease/blood or animal faeces, paint; Other non-compostable organics = Textiles, leather, rubber, multiple/composite organic materials (footwear, etc.)

During a repeat survey of multi-family households in Metro Vancouver during 2017, Tetra Tech (2017) found a contamination rate of 2% (by fresh weight).

On October 1st, 2012, the city of Surrey in British Colombia started a new residential solid waste kerbside collection service which added food waste to the existing yard and garden waste. In November 2012, TRI Environmental Consulting Inc. (TRI) was engaged to conduct a yearlong organic waste study with monthly sampling to determine the composition and volatility of the residential organic waste stream (TRI Environmental Consulting Inc, 2013). The full dataset is presented in Section 8.1, and a summary in Table 11.

Table 11 Contamination rates in co-mingled food and garden waste, sampled from Surrey City (British Colombia) between November 2012 and October 2013. Monthly averages are presented on a quarterly basis (TRI Environmental Consulting Inc, 2013)

	Nov - Jan	Feb - Apr	May - Jul	Aug - Oct
Plastics	0.53%	0.40%	0.07%	0.13%
Glass	0.00%	0.00%	0.00%	0.00%
Metals	0.03%	0.03%	0.07%	0.03%
Garbage in plastic bags	0.00%	0.40%	0.00%	0.10%
Compostable material in plastic bags	2.17%	2.17%	0.93%	1.13%
Other contaminants	0.83%	0.07%	0.03%	0.30%

During a 2016 survey of kerbside organic waste collections in Seattle, 200 samples from each of: single family households, multifamily households and commercial businesses were analysed (Cascadia Consulting Group Inc, 2018). The results for contamination are presented in

Table 12.

Table 12 Contaminants in organic waste collected from different communities in Seattle, from a 2016 survey (Cascadia Consulting Group Inc, 2018).

	Single family household	Multifamily household	Commercial property
Poly-coated paper	0.1%	0.3%	0.5%
Other paper	0.1%	0.3%	0.7%
Non-compostable plastic film	0.1%	1.5%	1.2%
Non-compostable plastic containers	0.1%	0.5%	0.4%
Other plastic	0.0%	0.2%	0.3%
Glass	0.0%	0.5%	0.3%
Metal	0.0%	0.2%	0.2%
Pet waste	0.0%	0.9%	0.1%
Diapers	0.0%	0.3%	0.0%

In 2006, CIC set up a continuous monitoring program to assess the quality of source-separated biowaste across Italy. CIC assesses the percentage (w/w fresh basis) of the non-compostable fractions present in the incoming waste (Consorzio Italiano Compostatori, 2017a). Their analysis has shown that – when household food waste collections take place in conventional polyethylene bags – the non-compostable fraction will be around 9% (on a fresh weight basis). Where collections use compostable bags, this fraction can reduce to 1.4% (Consorzio Italiano Compostatori, 2017a). On average, the non-compostable percentage of biowaste delivered to Italian composting and biogas plants is 4.8% by weight, with best-practice cases showing less than 2% contamination. The contamination comprises plastic items (42.2%) followed by plastic bags (23.4%) and a smaller percentage of metal, stones, inerts etc. (Consorzio Italiano Compostatori, 2017b)

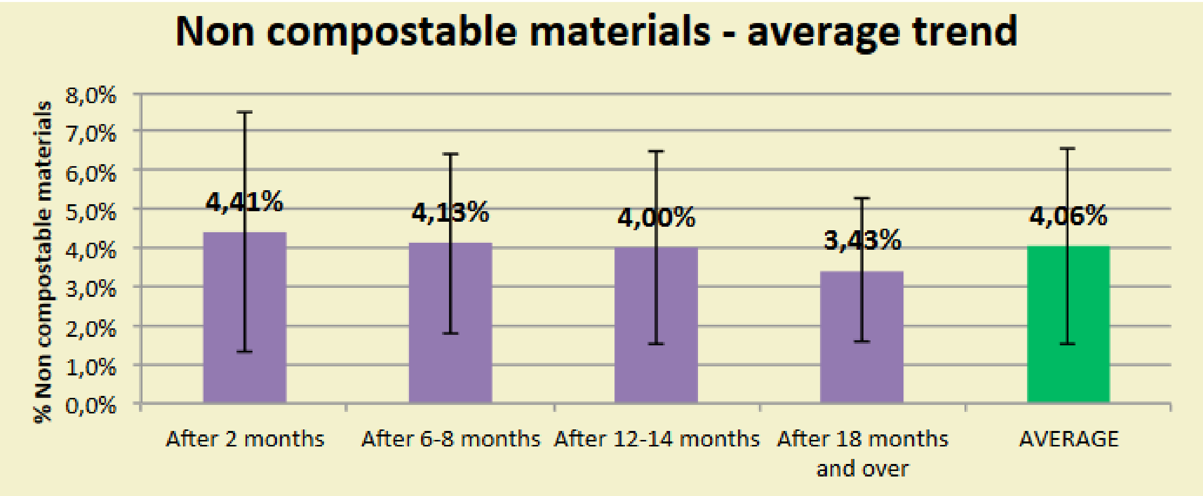
In the EU Framework 7 'Valorgas' project, kerbside food waste was tested from households in the UK, Finland, Portugal and Italy. This was part of a much wider study into the potential supply of food waste into anaerobic digestion across Europe. Results for contamination in food waste samples from Portugal are presented in Table 23.

Table 13 Contaminants (average %) from five samples of Portuguese food waste (Heaven *et al.*, 2011)

Contaminant	Average (% fresh weight)
Plastic – film	6.0
Plastic – bottles	0.2
Plastic – polystyrene	0.0
Plastic – other	0.6
Glass – packaging	0.5
Glass – non-packaging	0.0
Ferrous metals	0.2
Other metals	0.2
Composites	0.4
Textiles	0.2
Sanitary textiles	1.0
Wood	0.0
Other combustibles	0.1
Non-combustibles	0.1
Packaged organic waste	0.0
Other	0.0

Overall, film plastics are seen to be a common contaminant in compost feedstocks – whether collected as food waste only or co-mingled with garden waste. Even in cities that are recognised for their excellence in collection practice (such as Milan), composting facilities still 'expect' contamination of up to 4.8% by fresh weight. Since the full dataset behind these percentages has not been made publicly available, it is not possible to provide a breakdown of specific contaminant types. Frequent monitoring and testing, as well as communication and prohibition of non-compostable bags may all be key drivers for behaviour change in Italy that are leading to improved recyclate quality over time (Figure 7). Guidance for consumers and other producers of food waste is examined in the next section of this report.

Figure 4 Average presence of non-compostable materials in food waste at time intervals following the introduction of a collection service (Milano Recycle City, 2015)



In Oregon, in contrast, the use of compostable packaging has not provided acceptable improvements in compost quality. In 2019, the compost producer Rexius announced that it would stop accepting waste in compostable bags "until more clarity comes to the market" (Rosengren, 2019). The business had expected compostable packaging would help capture more food scraps, and that any resulting contamination could be managed effectively – but their Vice President stated that:

As we've gone through, my experience has been that's really not true. We have not been able to keep the contamination at a level that I think I would want for my product. At the end of the day, my real job is to produce a product that people will want. He went on to state:

I don't really have a beef with the non-compostability of these products. It's really how do I tell what's compostable and what's not? The elephant in the room is contamination. It lowers the perceived value and it reduces my ability to market material. My real business, it's really to sell compost. If I can't find high value in the markets I don't have a business.

This experience highlights the need to match compostability standards with commercial composting practices, and to ensure that compostable plastics do not act as a 'Trojan Horse' for non-compostable plastics. With an increasing array of compostable materials on the UK market, how can consumers be confident that they are disposing of these materials in the correct way – and not confusing them with non-compostable equivalents? And how can receiving composting facilities be confident that they are compostable and not contamination?

When piloting co-mingled collections of garden and food waste in the city of Eugene (Oregon), the official guidance went so far as to state:

Compostable/biodegradable products will not be allowed. Only food and yard debris will be accepted

The guidance also links the recycling behaviour of the waste producer with the intended use of the final compost product:

To create quality compost at the end of the food waste recycling process, it needs to be free of non-compostable material, like plastic, freezer boxes, napkins, pet waste, diapers, glass, treated wood, or other garbage and non-plant materials. Please be sure to remove stickers from produce as well, as they don't break down at the composting center. To keep the compost "clean," we ask that pilot participants include only food waste and yard debris in this program. Staff will occasionally check yard debris bins for non-compostable materials to ensure that we are able to create quality compost from the food scraps and yard debris. Yard debris bins found to have non-compostable materials will be first tagged with a yellow warning tag. If monitoring staff consistently find non-compostable materials in the bins, the resident will be responsible for calling their hauler to schedule an additional trash pickup. We hope that by monitoring these bins we can create a program that works for everyone.

(City of Eugene, 2019)

4.4 Guidance on food waste collections

Sligo County Council coordinated the national pilot scheme from the Brown Bin programme in Sligo City between July 2014 and March 2015. The aim of the project was to see how a range of educational and collection tools, such as the use of Brown Bin Waste Management Advisors and the provision of kitchen caddies to householders, could improve the capture and quality of food waste in the Brown Bin. The campaign took place in three areas across Sligo City:

- Area A was provided with solid side kitchen caddies, a roll of compostable bags, teaser leaflet, an information leaflet and an awareness talk.
- Area B received awareness work only. Due to time constraints, just half of this area received an awareness talk while the remainder received only a teaser leaflet.
- Area C was provided with vented kitchen caddies, a roll of compostable bags, teaser leaflet, an information leaflet, and an awareness talk.

Table 14 Percentage of contamination in brown bin collections before and after awareness campaign (Sligo County Council, 2019)

	Before	After	Before	After	Before	After
Type of collection	A		C		B	
25 litre food waste only	6%	1%	6%	2%	7%	3%
120 litre food and garden waste	45%	1%	24%	3%	37%	9%

With the advent of the more formalized food scraps collection programs in 2009, composting facilities in Washington State were seeing a significant increase in the amount of material needing to be processed. Along with all the newly collected food scraps, composters saw a big jump in physical contaminants. The collection programs were effective at getting the organics to the composters, but the composting businesses were seeing too much too fast and the increase in physical contaminants made the finished product difficult to market.

When contamination issues persisted, Cedar Grove – along with other composters in Washington State – were forced to adopt contamination surcharge fees to deter contamination and help to cover the costs of contamination removal. In an effort to avoid having to absorb or pass along these costs to their participants, the City of Kirkland decided to see if upstream education and initiatives – collaboratively designed and implemented – might prove an effective solution for producing cleaner feedstocks. This led to a stakeholder discussion at the Washington State Recycling Association's Annual Conference in May 2015 and ultimately led to the formation of the Washington State Organics Contamination Reduction Workgroup (OCRW). The group consists of more than 90 municipal officials, composters, regulators, and representatives of various commercial businesses whose mission is to "collaborate to eliminate contamination in organic feedstocks while expanding end products and markets." Full details of their working methods are outlined in Section 8.3.3, their key learning points being:

- Shared accountability is key. Composting is a desirable and beneficial alternative to landfilling organic materials. However, the compost bin is not a disposal bin; rather, it is an input into a manufacturing process. All members of the composting supply chain must share accountability for maintaining optimal compost quality by working together to reduce contamination.
- Jurisdictional inconsistencies contribute to participant confusion. Variability within and between jurisdictions regarding cart colours, accepted items, and audience demographics (housing type, culture, language, age, family type, etc.) creates participant confusion about what can and cannot be composted. This confusion is compounded by jurisdictional inconsistencies for participants who cross boundaries between work and home.
- Contamination management is costly but necessary. Although the ideal way to manage contamination is to prevent it from entering the compost stream in the first place, commercial composters may always need effective methods and technologies to aid them in identifying, removing, and disposing of contaminants. Unfortunately, these methods and technologies are typically expensive and their effectiveness vary widely depending on several factors.
- Not all contaminants are created equal. Film plastics are the most common contaminant; although composters do have effective means for removing some portion of these during processing, they are costly and not 100% effective. Glass is less prevalent but more problematic to composters because it is difficult to identify and remove. Glass also represents a safety concern for customers of finished compost, which is less of a concern for film plastics.
- Growing interest in compostable packaging presents both opportunities and challenges. There is a growing body of evidence that shows the use of compostable foodservice packaging may lead to an increase in food scrap diversion. Additionally, if it is used in conjunction with a full suite of best practices such as conscientious purchasing of compostable products where appropriate, outreach, and education, contamination can be measurably reduced relative to environments where packaging is not uniformly compostable and/or best practices are not applied. However, there

can be issues with consumers confusing compostable and non-compostable materials – and in some cases (such as fruit stickers / labels), composting alternatives may not yet exist.

Metro Vancouver reminds householders and business that “Plastics, including those marked biodegradable, do not belong in the compost as they do not break down properly during processing”. They go on to highlight issues with items such as plastic wrap, elastics, twist ties, straws, and swizzle sticks – which could lead to compost becoming contaminated and unusable (Metro Vancouver, 2019). This again highlights the potential for consumer confusion – in this case around the expression ‘biodegradable’.

5.0 Discussion and recommendations

5.1 Contamination in domestic food waste

Physical contamination is primarily controlled in Scotland through the application of limits on compost outputs, with samples from PAS100 sites/processes routinely taken from finished batches and analysed at commercial third party laboratories. Managing compost quality at the end of the process is an almost universal approach – and in many jurisdictions this quality is regulated, covering various aspects that include physical contaminants.

Whilst the standards due to be implemented in Scotland are strict, our review indicates that they are broadly in line with the regulatory approach in Switzerland – as well as the 'voluntary' quality assurance approach as implemented in Germany. Indeed, the limits in Germany are applied on both a weight (0.1% on a fresh weight basis) and area basis. The area basis (certain area of film plastic permitted per litre of fresh compost, varied according to the intended compost market) is extremely strict – particularly as it is due to be accompanied by a move from 2mm lower particle size to 1mm lower particle size (for all physical contaminants).

In addition to limits on compost outputs, contracts between composting site operators and food waste suppliers typically contain a pricing element to cover removal of non-target material, commonly up to 5% per load. Based on the samples analysed in this work, the 5% limit is comparatively high for source segregated food waste – only one local authority source not providing compostable caddy liners was considered at or close to this limit based on bag and 'in bag' plastic - sample 1 (non-compostable subset) and sample 3 (whole sample). Although the reason(s) for the higher level of contamination (especially 'in bag') from this source cannot be confirmed, it may be associated with the lack of compostable caddy liner provision and/or household engagement.

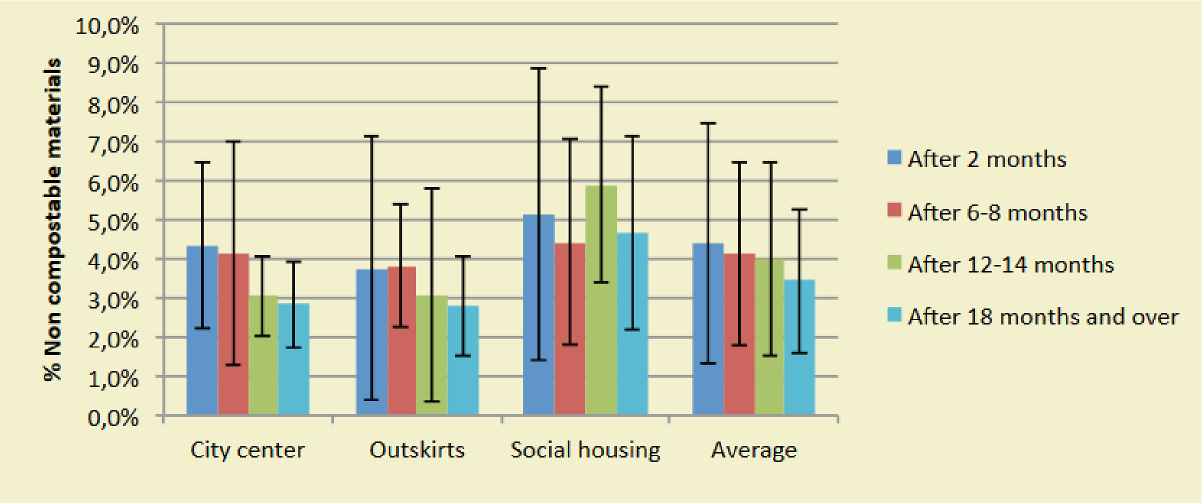
For the other LA sources, the majority of caddy liners/bags were compostable – either supplied by the LA or sourced by households. For one LA providing compostable caddy liners, use by households was 100% based on the sample analysed (sample 4) and visual assessment of material at site. Given the caddy liners themselves degrade in the composting process (confirmed to be the case by all composting site operators engaged with) the level of 'in bag' plastic contamination was never above 1.3% on a FW basis from any source and less than 0.5% for all sources providing compostable caddy liners/bags.

Although it would be preferable not to use caddy liners at all, work by others has previously demonstrated increased food recovery through the use of caddy liners (WRAP, 2016). This would support the continued use of compostable caddy liners where material delivered to composting sites is actively composted. To maximise use of compostable caddy liners by households, the supply of compostable liners by all Scottish LAs using composting for separated food waste processing should be encouraged. Such an approach would provide a more consistent message across Scotland, helping households to understand the processes used to treat their organic waste. Additional benefit in this approach for composting site staff would be in being able to efficiently target non-supplied bags/liners during floor and line picking – those considered from this work more likely to contain plastic (and other) contaminants prior to feedstock shredding activities.

Contamination of food waste intended for composting appears to be a universal issue, and all jurisdictions have wrestled with approaches to minimising or eliminating this contamination. Roll-outs of new or amended food waste collection services should be informed by pilots – ideally undertaken in the areas due to receive the new service. Pilots help to identify types and extent of contamination, as well as patterns that might be associated with (for example) different types of household. Roll-outs should be accompanied by:

- Education material for householders, including visually appealing lists and stickers of what can and what can't go into the organics bin. Clear symbols (i.e. ticks and crosses) should be used to ensure the material is easily understood[8]
- Messages should be consistent
- Compostable caddy liners should be provided. Where this is not possible, then clear guidance on how to identify (and potentially – where to purchase) compostable caddy liners should be given
- On-going public education and motivation – one-time-only approaches will fail
- Communications material for the local media, councillors, senior staff etc.
- Continuous monitoring and evaluation in problem areas through bin inspections, waste auditing and community consultation

The impacts of successful campaigns can be dramatic – the data from Sligo show reductions of contamination from as high as 45% to as low as 1%, but campaigns need to be on-going. The impacts of campaigns also need to be monitored, in the long term. Italy seems to lead the way, through the efforts of the Italian Composting Association (CIC) – which has independently taken and tested thousands of samples of feedstock over the past decade. Milan is often held up as an example of best practice – in engagement and food waste capture, and monitoring shows downward trends in contamination in all parts of the city. Monitoring also shows where there are issues, which can be addressed through more focussed activity:



Quality of the food waste collected in Milan (% non compostable materials). The vertical bars represent the standard deviation from the mean values

However, even with these intensive efforts, contamination is still present. The question is then one of acceptability at the composting site.

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[8] Examples are available here: http://zerowastepartners.org.uk/collections/134/; and http://zerowastepartners.org.uk/collections/130/

Summary of recommendations relating to domestic food waste

- Through partnership working, Scottish Government should drive lower acceptable level of contamination in LA domestic composting feedstocks.
- LA's should provide compostable caddy liners to households where food waste is actively composted
- LA select compostable caddy liner supplier with contracted composting site operator to ensure liners are easily recognisable by composting site staff
- Once a consistent approach in terms of provision of compostable caddy liners for LA domestic food waste collections is achieved, engage stakeholders to carry out Scotland wide education programme
- Engage relevant stakeholders to target common domestic 'in bag' plastic contaminants such a cucumber films and plastic (and paper-based) fruit stickers
- Develop a food waste feedstock monitoring programme. This could be overseen by a trade body (as in Italy) or become part of the regulatory framework, e.g. through a site licence or permit condition (as in California, where minimum inspection and monitoring requirements are mandated)

5.2 Contamination in commercial food waste

Contracts between composting site operators and commercial food waste sources appear generally less formal than for domestic sources. With this, relationships between a composting site operator and commercial food waste producer(s) tend to also be more straightforward. This appears to be especially the case for the mixed commercial sources where problematic individual food waste producers (particularly small businesses/organisations) can be easily managed by composting site operators. The composting site operator is able to take different courses of action as necessary including direct education, increased fees or termination of 'contract'. For the biobag mixed commercial food waste sources, composting sites offering this service tend to use their own collection vehicles and staff so are also able to deal with issue directly at the source site, including the ability to refuse collection. As such these sources are largely self-regulated. Food waste received from businesses via third party collections are harder for composting site operators to manage.

Although relatively few biobag subsamples from mixed commercial sources were looked at as part of this work (represented by samples 6 and 13), the biobag contents were found to be virtually free of plastic contamination. The key issue for source sample 6 was general waste or non-food waste either originating from food waste producers or introduced into the food waste by others. These general waste bags would be fairly easy for composting site staff to separate if on the top of the pile at reception, due to their large physical size and their clear difference in colour from the biobags (one black rubbish bag and one clear plastic bag). However, in the middle of a pile and requiring mechanical handling due to size/weight, this would be more difficult. Further work would be needed to understand and manage the routes of contamination into the commercial food waste.

The other types of commercial food waste studied in this work were packaged food waste from mixed commercial businesses and material from a single supermarket chain. Both types of food waste require mechanical depackaging to prepare them as feedstocks for composting. As assessment of the effectiveness of mechanical depackaging to remove plastic contamination from food waste was beyond the scope of this project, further work would be needed to understand plastic contamination in mechanical de-packager outputs. Our review did not identify any data from any jurisdiction where packaged supermarket waste was processed for composting, and we assume that this material is instead sent for anaerobic digestion.

Summary of recommendations for commercial food waste

- SEPA to tackle food waste and physical contamination from supermarkets, possibly through continued use of fixed monetary penalties
- SEPA engage further with composting site operators, businesses and other stakeholders to understand and tackle general and non-food waste contamination of source segregated commercial food waste; to encourage closer supply-chain collaboration, leading to simplified communications and improved quality
- Composters to reject contaminated loads and report to SEPA for investigation
- Develop a food waste feedstock monitoring programme. This could be overseen by a trade body (as in Italy) or become part of the regulatory framework, e.g. through a site licence or permit condition (as in California, where minimum inspection and monitoring requirements are mandated)

6.0 Conclusions and further research

6.1 Conclusions on plastic in domestic food waste

- Local authorities are collecting food waste in a combination of compostable and non-compostable caddy liners
- Evidence suggests compostable caddy liners are capable of holding food waste of comparable weights as found in non-compostable liners/bags
- 'In bag' contamination was lower when compostable caddy liners were provided by LAs or widely used by households (the latter potentially evidence of greater household engagement)
- Compostable caddy liners were considered compatible with all composting processes engaged in this project
- Since non-compostable liners would need to be removed before, during or after composting – and since such removal can never be 100% effective, switching to only compostable liners would be highly desirable
- Jurisdictions outside the UK also struggle with compost quality, particularly with plastic contamination. The rise in compostable food service wares has caused consumer confusion, as has the use of the expression 'biodegradable'. In some cases this has led to composters prohibiting the inclusion of any kind of plastic in their food (& garden) waste collections. In other cases it has led to the publication of positive lists of suppliers of acceptable compostable plastic products

- Communication and consistency are key to improving feedstock quality – but even good performers (such as Milan) struggle
- Our data showed the contamination levels (in bag) were low – and certainly below the accepted 5% limit. However, the composting process 'concentrates' non-biodegradable inputs, and the input threshold may need to be much lower to achieve the desired output quality
- Although strict, the SEPA limits are not extraordinary
- Formal feedstock quality monitoring (whether mandated – as in California, or delivered by an appropriate trade body – as in Italy) would give all parties robust evidence with which to inform future regulatory or contract changes

6.2 Conclusions on plastic in commercial food waste

- Supermarket waste and other commercial waste need to be considered separately, since the former is usually packaged while the latter is usually not. Packaged food waste is normally processed via mechanical means for processing by either composting or anaerobic digestion, and the scope of this project did not allow us to judge the impact of such practises on compost quality
- Where compost operators arrange and manage their own commercial waste collection rounds, then communication and quality control are relatively simple. Collection of waste by third parties is harder to manage
- The quality of commercial waste (as opposed to supermarket waste) was broadly in line with the quality of household food waste
- There was evidence of littering / addition of residual waste (in bags) to the compostable stream. The scale of this issue could not be determined in this project
- Communications should be improved to reduce / eliminate littering
- Formal feedstock quality monitoring would give all parties robust evidence with which to inform future regulatory or contract changes

6.3 Further research

Avenues for future related research include:

- Assessing the effectiveness of mechanical depackaging equipment to remove plastic
- Assessing levels of plastic contamination in other composting feedstocks (e.g. green waste)
- Developing greater understanding on the effectiveness of 'advanced' technologies such as air separation to remove plastic from composted material
- Researching compostable plastic service ware use and compatibility with Scottish composting infrastructure

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8.0 Appendices

8.1 Compost output specifications

Where our evidence review identified compost quality specifications these were either regulated or part of a best practice / industry-led certification scheme. Overall, standards applied to compost outside the UK are not so stringent – either as PAS100:2011 or the SEPA limits. The notoriously strict requirements for compost quality in Germany and Switzerland are broadly similar to the Scottish limits (Section 8.1.3).

8.1.1 Canada

Statutory compost standards are in place in Ontario, under the Environmental Protection Act (347) (Ontario Ministry of the Environment, 2012). These standards set out three categories of compost quality (AA, A and B), and while there are PTE limits in both composts and feedstocks, limits on physical contaminants ("foreign matter") apply to the compost outputs only. For foreign matter, the same limits apply to Category AA and A composts (Table 15).

Table 15 Regulated foreign matter limits for different classes of compost in Ontario

Parameter	Categories AA and A	Category B
Foreign matter	Total foreign matter greater than 3mm ≤1.0% (DW basis) and plastic ≤0.5%. No foreign matter >25mm in any one plane per 500ml	Total foreign matter greater than 3mm ≤2.0% (DW basis) and plastic ≤0.5%. No foreign matter >25mm in any one plane per 500ml
Sharp foreign matter	No material that can reasonably cause human or animal injury	Maximum 3 pieces of sharp foreign matter per 500ml. Maximum dimension of any sharp foreign matter is 12.5mm in any one plane

British Columbia's Organic Matter Recycling Regulation (OMRR) has similar foreign matter limits to the Ontario regulation. However, the following recommendations were made during a 2018 review:

- Replace the 1 percent by weight limit on foreign matter content for retail-grade and "managed organic matter" with a new limit by weight of 0.5 percent dry weight for foreign matter content, to support compost quality; and,
- Introduce a plastic limit of less than or equal to 0.25 percent dry weight.

(Ministry of Environment and Climate Change Strategy, 2018)

8.1.2 USA

National (USCC) standards

The main US Composting Council (USCC) compost certification programme standard does not include specific restrictions on physical contaminants (USCC, 2018). However, there are various requirements in the associated landscape architecture / design specifications for compost use (USCC, 2005). These are for classification of physical contaminants larger than 2mm in any one plane.

Table 16 USCC limits for physical contaminants in compost by compost use

Compost use	Physical contaminant limit (% DW)
Turf Establishment with Compost	1
Planting Bed Establishment with Compost	1
Compost as a Landscape Backfill Mix Component	1
Compost as a Landscape Mulch	0.1

In addition to the various uses listed in Table 16, the USCC landscape specifications also include compost for use as a soil blanket (for erosion control) and as a filter berm (for sediment control). In both cases, the upper physical contaminant limit is 1% (on a dry weight basis) (USCC, 2005).

North Carolina

In North Carolina, state legislation recognises two grades of compost:

- Grade A compost has unlimited, unrestricted distribution and may be distributed directly to the public;
- Grade B compost is restricted to land and mine reclamation, silviculture, and agriculture (non-food crops only)

The limits for contaminants ('manmade inerts') for these two grades are as specified in Table 17. Such contaminants must not exceed 1 inch in any one plane (North Carolina, 2011).

Table 17 Limits for manmade inerts in composts in North Carolina

Compost grade	Limits on manmade inerts (% DW)
A	<6
B	>6

New York and South Carolina

In New York state, an upper particle size limit of one inch is applied to compost (with the exception of any added woodchips), which must not contain more than 2% (dry weight basis) of 'gross contaminants' (Department of Environmental Conservation, 2018). The same 2% limit also applies in South Carolina (Department of Health and Environmental Control, 2014)

8.1.3 Europe

European Compost Network (ECN)

The 2018 Quality Assurance Scheme for Compost includes limits for 'impurities' of >2mm in size, set at 0.5% on a dry matter basis. This is the same as PAS100:2005. While the scheme allows composters to accept biodegradable kitchen & canteen wastes, other types of food waste (such as former foodstuffs / supermarket waste) are not permitted (European Compost Network, 2018).

The ECN limit for impurities (glass, metal and plastics) in compost used in growing media is set at 0.25% on a dry matter basis (European Compost Network, 2018). This is the same as PAS100:2011.

Germany

There are limits for foreign matter in composts within the German fertiliser regulations: not more than 0.5% by weight (fresh basis), of which film plastics cannot exceed 0.1% (Verband der Humus unde Erdenwirtschaft - Region Nord, 2016). These limits apply on a dry weight basis in Switzerland (Le Conseil fédéral suisse, 2005).

In addition to these weight limits, film plastics are subject to limits on an area per unit volume basis. The acceptable area of plastic varies, depending on the compost category as defined by the German Compost Quality Association (BGK) (Table 18).

Table 18 Area limits for film plastics in different categories of compost in Germany (BGK, 2018b)

Type of compost / market	Lower size limit for measurement	Area limit (cm^2 of plastic per litre of fresh compost)
Fresh compost	2mm	15
Finished compost	2mm	15
Substrate compost	5mm	10
Organic farming*	2mm	25

*Note that the overall limit for foreign matter in compost supplied to this market is 0.3%, as opposed to the usual 0.5%

If the assumptions for plastic thickness and density are used, as set out in Aspray et al. (2017), then $10cm^2$ of LDPE (low density polyethylene) at a density of $0.94g/cm^3$ and thickness of 12.5µm would weigh 0.00125g. $1m^3$ of fresh compost could therefore contain just 1.25g of LDPE.

In 2018, a consultation was undertaken around various proposed amendments to the German fertiliser regulations. These included a reduction in the lower limit for particle sizes captured within the definition of foreign matter – to 1mm. The reasons given for this proposed change are “precautionary… in view of the unclear environmental effects in particular of microplastic particles”.

In their response to this consultation, BGK acknowledge that the current test method for physical contaminants was capable of detecting the smaller particles, but that it was possible that those particles could be mis-described (eg hard vs film plastic). They added that “Nonetheless, the BGK does not oppose the intended lowering of the reference limit. However, a transitional period until 31.12.2020 is recommended for adapting the method… and the subsequent qualification of the test laboratories, which is only possible in the interlaboratory comparisons for 2020.” [google translation of German original] (BGK, 2018a)

Australia

The Australian Standard for Composts, Soil Conditioners and Mulches (AS 4454-2012) stipulates the following physical contaminant limits for unrestricted use of recycled organic products:

Glass, metal, rigid plastic	≤ 0.5% (w/w) (>2mm particle size)
Plastics – light, flexible or film	≤ 0.05% (w/w) (>5mm particle size)

(Department of Sustainability, Environment, Water, Population, and Communities, 2012).

8.2 Data on food waste quality

8.2.1 Vancouver

An organic waste composition project sampled material from four different sectors in Metro Vancouver during June and July 2016: Multi-Family Residential (MF), Single-Family Residential (SF), Industrial, Commercial and Institutional (ICI) and Drop-Off (DO). Results for the first three are presented below.

Table 19 Number of samples per sector (Tetra Tech, 2016)

Sector	Number of separate samples
Single-Family Residential (SF)	25
Multi-Family Residential (MF)	6
Industrial, Commercial and Institutional (ICI)	16
Total	47

47 organics samples totalling 4,722 kg were sorted. The target sample size was 100 kg and sample weights ranged from 50 kg to 125 kg. This variation was because samples were visually estimated to be 100 kg prior to sorting and the actual weight was not confirmed until after each sample was sorted. The average sample weight was 100.5 kg. (Tetra Tech, 2016). Note that in this city, organic waste collections comprise a mix of garden and food wastes – with the proportions varying considerably, depending on the specific type of household source (Table 20).

Table 20 Organic waste composition results by sector. Percentages by fresh weight. (Tetra Tech, 2016)

Primary waste category	SF	MF	ICI
Garbage in bag	<1%	1%	4%
Compostables in bag	2%	<1%	3%
Compostable paper	1%	2%	12%
Plastic	<1%	1%	1%
Compostable plastic	<1%	<1%	<1%
Yard & garden waste	88%	17%	10%
Food waste	6%	79%	68%
Clean wood	1%	<1%	1%
Non-compostable organics	1%	<1%	<1%

Table 21 Non-compostable contaminants in organic waste. Percentages by fresh weight. (Tetra Tech, 2016)

Primary waste category	SF	MF	ICI
Garbage in bag*	4.4%	0.7%	0.4%
Other non-compostable paper*	0.2%	0.0%	0.0%
Film	0.2%	0.6%	0.2%
Rigid plastic (non-beverage)	0.3%	0.2%	0.0%
Treated or painted wood	0.0%	0.0%	1.1%
Other non-compostable organics*	0.2%	0.0%	0.0%
Glass	0.1%	0.1%	0.0%

*Garbage in bag = Material other than Compostable Organics contained in a plastic bag, or mixed waste contained in a plastic bag (all bags, including compostable, non-compostable, biodegradable, degradable, etc.); Other non-compostable paper = Photograph paper, tar paper, paper adhered to plastic or metal, composite paper products, paper contaminated with grease/blood or animal faeces, paint; Other non-compostable organics = Textiles, leather, rubber, multiple/composite organic materials (footwear, etc.)

During a repeat survey of multi-family households in Metro Vancouver during 2017, Tetra Tech (2017) found a contamination rate of 2% (by fresh weight).

8.2.2 British Colombia

On October 1st, 2012, the city of Surrey in British Colombia started a new residential solid waste kerbside collection service which added food waste to the existing yard and garden waste. In November 2012, TRI Environmental Consulting Inc. (TRI) was engaged to conduct a yearlong organic waste study (November 2012 to October 2013) with monthly sampling in the city to determine the composition and volatility of the residential organic waste stream. The samples originated from kerbside yard and food waste collection bins in each pilot neighbourhood. Each sample was sorted into 19 categories (TRI Environmental Consulting Inc, 2013)

Table 22 Number of households sampled during project (TRI Environmental Consulting Inc, 2013)

Month	Number of households sampled
November	100
December	300
January	500
February	500
March	250
April	125
May	100
June	100
July	125
August	150
September	150
October	125

Data are summarised in Table 23, showing that the percentage of contaminants in the total organic waste stream ranged from 0.6% to 9.7% over the year. Discounting compostable materials in plastic bags, this range changes to 0.2% to 7.4%. Other than material in bags, the main contaminant was ‘dirt and stones’, with peaks in May & October. Plastic contamination comprised up to 0.9% by weight (during January).

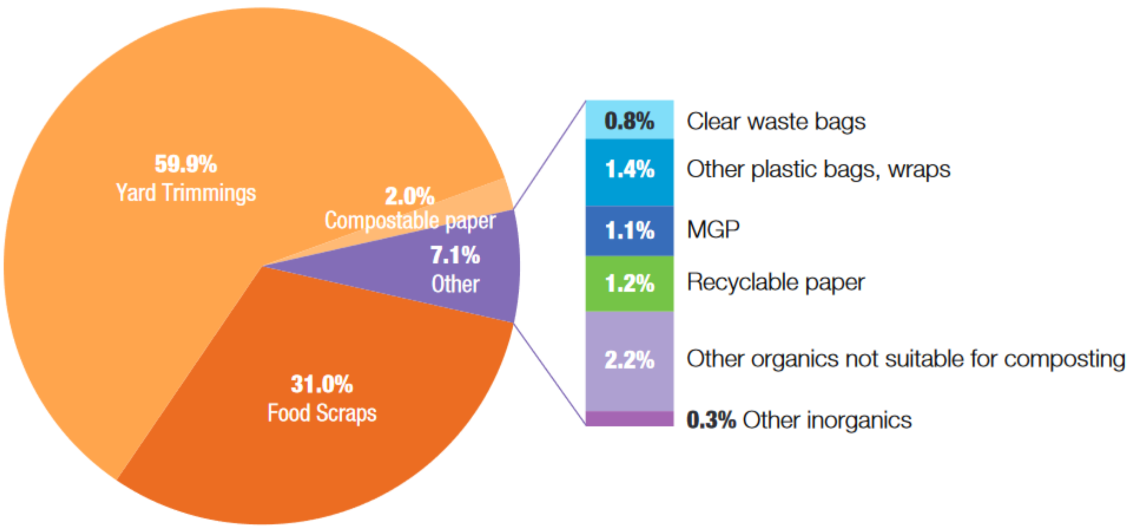
Table 23 Organic waste composition (monthly averages) for kerbside samples from the city of Surrey (TRI Environmental Consulting Inc, 2013)

	November	December	January	February	March	April	May	June	July	August	September	October
Grass clippings (green)	0.4%	0.1%	0.0%	1.1%	18.8%	31.6%	8.7%	47.9%	0.3%	39.7%	62.3%	2.4%
Grass clippings (brown)	0.0%	0.0%	0.0%	0.0%	20.4%	0.5%	43.4%	2.3%	51.5%	4.9%	0.0%	3.1%
Leaves (green)	1.3%	3.8%	5.8%	2.5%	1.6%	1.2%	0.5%	20.9%	0.6%	0.0%	0.2%	7.6%
Leaves (brown)	64.4%	27.3%	15.7%	17.7%	8.3%	0.2%	7.5%	3.5%	2.7%	0.1%	2.0%	36.3%
Other vegetation (green)	3.8%	2.2%	0.4%	1.7%	0.4%	41.5%	12.7%	6.7%	9.3%	30.8%	19.5%	5.8%
Other vegetation (brown)	2.6%	0.6%	2.0%	33.3%	0.1%	0.8%	4.5%	0.0%	9.1%	5.2%	7.3%	2.7%
Sticks and branches	2.2%	12.1%	4.7%	14.3%	12.1%	6.9%	3.2%	3.1%	8.3%	4.7%	1.0%	24.3%
Wood	0.0%	0.0%	0.1%	0.6%	10.3%	0.4%	0.2%	0.4%	0.1%	2.6%	0.3%	2.0%
Food scraps (backyard compostable)	14.7%	24.4%	59.0%	15.6%	11.7%	4.6%	5.0%	9.1%	8.7%	5.4%	2.2%	2.5%
Food scraps (not backyard compostable)	1.8%	14.0%	2.5%	2.2%	6.0%	1.4%	2.0%	2.1%	2.9%	2.5%	1.4%	0.7%
Soiled paper	3.4%	11.7%	8.1%	7.7%	7.2%	7.6%	4.8%	1.7%	4.2%	2.2%	3.0%	2.9%
Plastics	0.1%	0.6%	0.9%	0.3%	0.2%	0.7%	0.1%	0.0%	0.1%	0.1%	0.0%	0.3%
Glass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Metals	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%
Dirt / stones	0.3%	0.1%	0.0%	0.0%	0.3%	0.0%	6.9%	1.1%	0.7%	0.6%	0.0%	6.4%
Pet waste	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Garbage in plastic bags	0.0%	0.0%	0.0%	1.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%
Compostable material in plastic bags	3.7%	2.8%	0.0%	1.8%	2.5%	2.2%	0.1%	1.2%	1.5%	0.9%	0.3%	2.2%
Other contaminants	1.2%	0.2%	1.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.3%	0.2%	0.4%

8.2.3 New York

In 2013, the Department of Sanitation for New York City (DSNY) introduced a pilot program to collect source separated food scraps, food-soiled paper and yard waste from households in northern Staten Island. Since then, the NYC Organics kerbside collection program has expanded to neighbourhoods in the Bronx, Brooklyn, Queens and Staten Island. A 2017 study sampled and characterized collections from districts where kerbside collections had been rolled out, to establish a baseline composition. Although DSNY paired the roll out with extensive public education, there was found to be a steep learning curve for residents who had never previously been asked to separate and store food scraps for recycling. The majority of organics collected for recycling consisted of yard waste at 60% followed by food scraps at 31% - with contamination representing the remaining 7% (considered 'low' by the report's authors). Contamination consisted primarily of misplaced recyclables, organic materials not accepted in the program (such as nappies, textiles and construction wood), plastic bags and food wrappers, and a variety of other inorganic materials. Clear recycling bags are accepted as liners for the brown bins used to hold organic waste prior to collection (Figure 5) (DSNY, 2017).

Figure 5 Composition of kerbside organic waste in a 2017 survey of New York neighbourhoods (DSNY, 2017). MGP = Metal, Glass and Plastic



8.2.4 Seattle

During a 2016 survey of kerbside organic waste collections in Seattle, 200 samples from each of: single family households, multifamily households and commercial businesses were analysed. The results are presented in Table 24.

Table 24 Organic waste composition in Seattle, from a 2016 survey. (Cascadia Consulting Group Inc, 2018)

	Single family HH	Multifamily HH	Commercial
Compostable paper	5.8%	10.7%	11.7%
Mixed recyclable paper	0.4%	1.1%	1.0%
Compostable plastic	0.8%	2.6%	1.7%
Vegetables (unpackaged)	8.6%	36.3%	33.6%
Vegetables (packaged)	0.1%	0.6%	0.3%

Other food (unpackaged)	3.9%	20.3%	38.8%
Other food (packaged)	0.2%	2.2%	2.4%
Grass / leaves	73.6%	18.8%	5.3%
Prunings	5.0%	1.5%	0.4%
Other compostable organics	0.8%	0.2%	0.3%
Polycoated paper	0.1%	0.3%	0.5%
Other paper	0.1%	0.3%	0.7%
Non-compostable plastic film	0.1%	1.5%	1.2%
Non-compostable plastic containers	0.1%	0.5%	0.4%
Other plastic	0.0%	0.2%	0.3%
Glass	0.0%	0.5%	0.3%
Metal	0.0%	0.2%	0.2%
Pet waste	0.0%	0.9%	0.1%
Diapers	0.0%	0.3%	0.0%

8.2.5 New Zealand

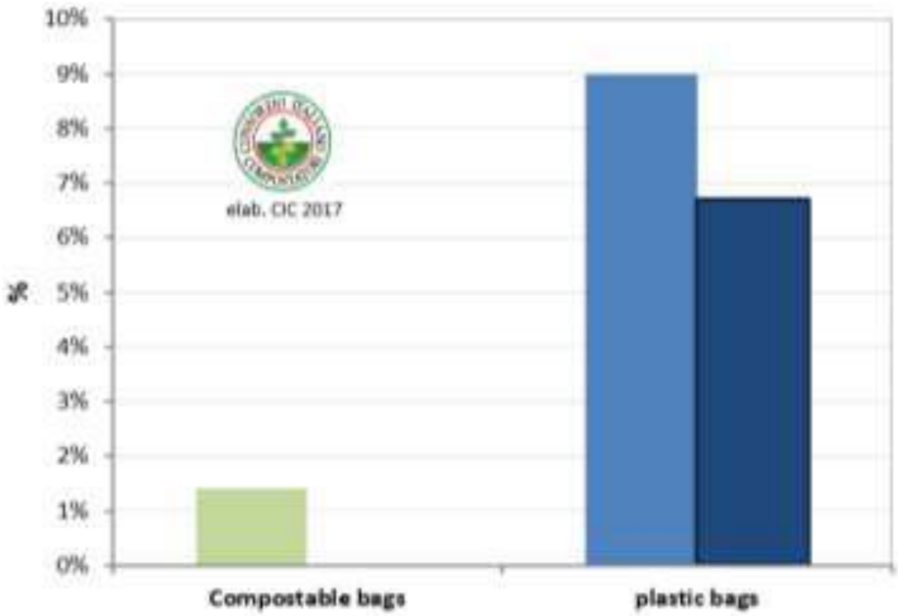
From January to April 2017 Beyond the Bin conducted a survey of 27 composting facilities throughout New Zealand about their experiences with processing compostable food packaging including compostable coffee cups. Composters face significant difficulty in identifying compostable food packaging – partly due to the absence of a NZ compostability standard for food packaging. Other common issues were: contamination of the waste stream; lack of education around what can be composted; the number of items in the marketplace which are mislabelled as compostable or biodegradable which are not.

Some facilities discussed the issues they had experienced receiving contaminated organic waste that included compostable packaging – which had to be diverted to landfill. This had in some instances resulted in a facility deciding to reduce or restrict their intake of this waste stream. Among the 12 facilities that provided a figure for the maximum level of contamination, the average maximum level of contamination was 4.25% (Ecoware, 2017).

8.2.6 Italy

Several nations have demonstrated that the use of compostable bags for separate collection of food-waste can improve the quality of organic waste. According to the results of the CIC (Italian Composting Network) analyses of food waste composition as a function of the type of bags used, when collection at households is carried out with PE-bags, the expected content of non-compostable materials (NCM) is about 9% (fresh weight), while if the collection is performed with compostable bags the level of NCM can drop to 1,4% (Figure 6) (Consorzio Italiano Compostatori, 2017a).

Figure 6 Content of non-compostable materials inside food-waste collected with different bags and liners; the non-compostable material content is expressed as a percentage of the incoming food-waste. (note that the original text does not explain the different blue bars – although we assume that one applies to food waste alone, and another to food + green waste collections) (Consorzio Italiano Compostatori, 2017a)



In 2006, CIC set up a continuous monitoring program to assess the quality of source-separated biowaste across Italy. Up until 2015, this program had performed about 5000 waste composition analyses. CIC assesses the percentage (w/w fresh basis) of the non-compostable fractions present in the incoming waste (Consorzio Italiano Compostatori, 2017a). In 2015, CIC performed about 835 waste audits on food-waste; their data show that – on average – the non-compostable percentage of biowaste delivered to Italian composting and biogas plants is 4.8% by weight, with best-practice cases showing less than 2% contamination. The contamination comprises plastic items (42.2%) followed by plastic bags (23.4%) and a smaller percentage of metal, stones, inerts etc. (Consorzio Italiano Compostatori, 2017b)

This national picture is mirrored in Milan, where the occurrence of non-compostable materials in food waste is consistently below 5% (fresh weight) and decreasing – even 18 months after the introduction of separate food waste collections (Figure 7). Although levels of contamination tend to be slightly higher in collections from social housing, the overall trend of reduced contamination over time also applies to this category (Figure 8).

Figure 7 Average presence of non-compostable materials in food waste at time intervals following the introduction of a collection service (Milano Recycle City, 2015)

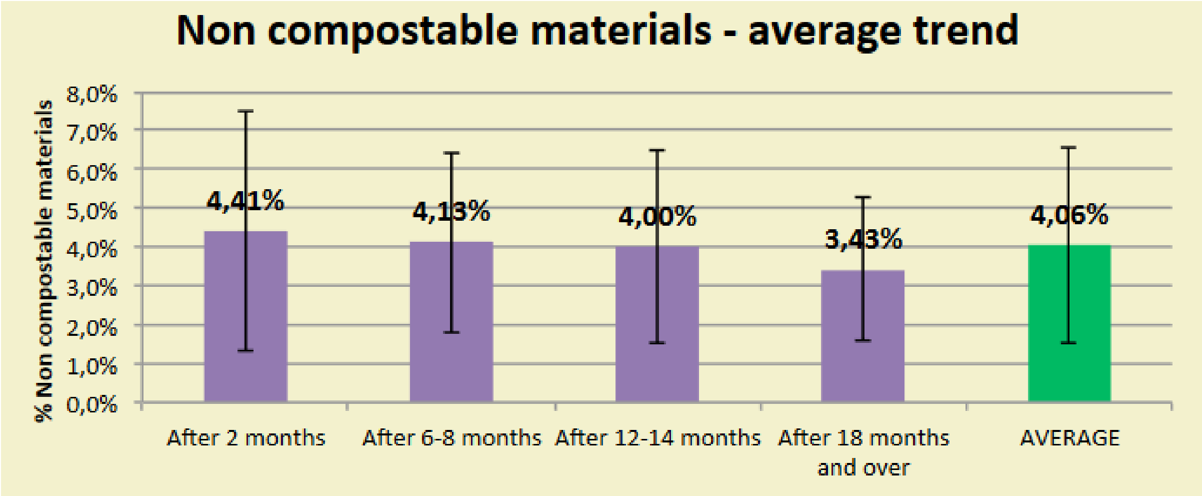
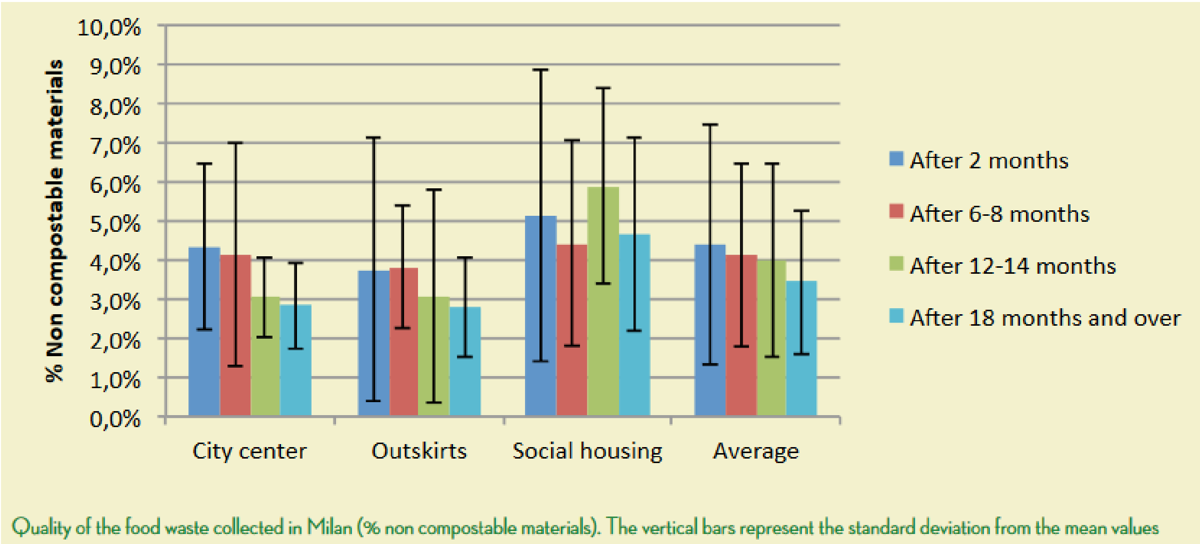


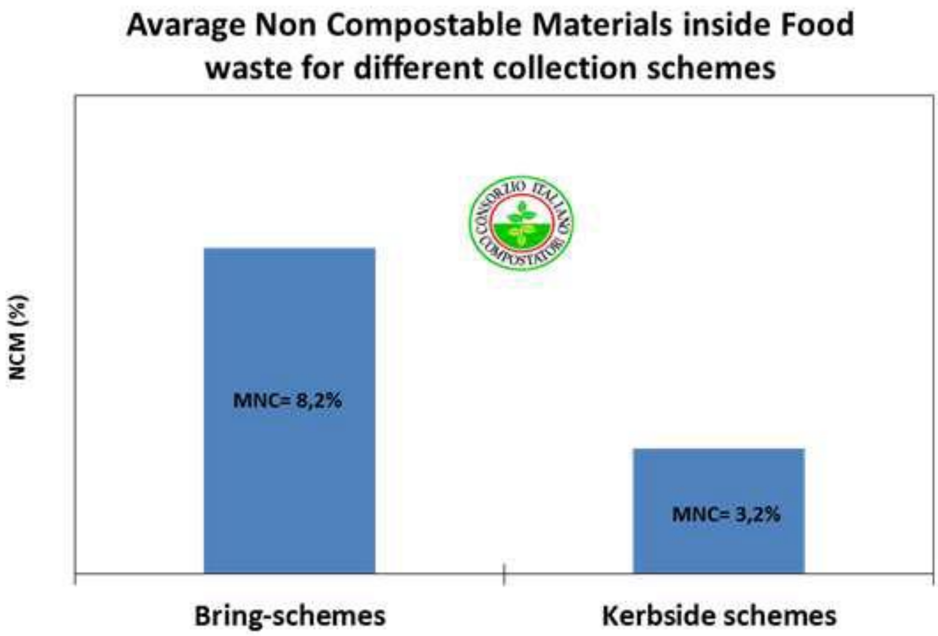
Figure 8 Average presence of non-compostable materials in food waste at time intervals following the introduction of a collection service in different areas of Milan (Milano Recycle City, 2015)



From 2011, food waste placed for collection before biological treatment in Italy must be contained in compostable bags. In January 2018, the Italian Government completely banned the use of lightweight, non-biodegradable plastic carrier bags in supermarkets and grocery stores for the purchase of various goods (especially loose fruit and vegetables), requiring the stores to replace them with bags that are compostable. Nevertheless, a recent survey conducted by the Italian Composting Network (CIC) has shown that nearly half of the bags delivered to composting and anaerobic digestion plants for the treatment of food waste are still manufactured from conventional, petroleum-based plastics (Calabrò and Grosso, 2018).

CIC's waste-audits also allow comparison of the effectiveness of bring schemes and kerbside schemes in terms of keeping contamination low. An assessment in 2015 clearly shows how kerbside schemes significantly reduce the need for pre-sorting of delivered biowaste (Figure 9).

Figure 9 Comparison of the percentage contamination (MNC) in food waste collected under bring and kerbside schemes in Italy (Consorzio Italiano Compostatori, 2017a)



8.2.7 Valorgas project

In this EU Framework 7 project, kerbside food waste was tested from households in the UK, Finland, Portugal and Italy. This was part of a much wider study into the potential supply of food waste into anaerobic digestion across Europe.

Table 25 Collection types and numbers for some of the UK sites (Zhang *et al.*, 2013)

Location	Collection type*	Number of samples
Ludlow	A	15
Craven Arms	A	3
Church Stretton	A	6
Presteigne	A	2
Ceredigion	B	2
Leatherhead	C	1
Central Bedfordshire	A	1
Ealing	C	1
Richmond	C	1
Surrey	C	1
Hounslow	C	1

*A = small (5 or 7 litre) kitchen caddies with larger (25 litre) kerbside bins collected weekly. Cornstarch bags supplied free of charge on request; B = as for A, but householders must buy bags or wrap waste in newspaper. Only waste in bags was analysed in this project; C = as above, but householder must pay for cornstarch bags

In Finland, all houses with five or more apartments, and stores and restaurants with more than 20 kg week^{-1} have to source-segregate food waste. Collection is usually once per week [the authors omit to note whether biodegradable or compostable bags are provided in Finland].

In Portugal, waste is collected daily from 120litre bins serving a number of properties (e.g. apartments): each property has an individual bin, and biodegradable plastic bags are not provided.

In Italy, the collection system in the city is based on the provision of a centralised bin serving several houses for the collection of source segregated organic materials: waste is generally disposed of in plastic bags [the use of compostable plastic bags was not compulsory at the time the fieldwork for this project was undertaken] (Zhang *et al.*, 2013).

Table 26 Contamination in kerbside food waste from various UK areas (Heaven *et al.*, 2011)

	Contamination (kg)	Total weight of collected waste (kg)	Contamination (%)
Presteigne	0.2	131	0.15
Ceredigion	0.6	190.7	0.31
Leatherhead	4.2	198.4	2.12
Central Bedfordshire	3.9	135.7	2.87
Ealing	5.6	181.4	3.09
Richmond	4.9	194.6	2.52
Surrey	3.3	109.1	3.03
Hounslow	0.3	187.3	0.16
Ludlow			0.4
Craven Arms			0.2
Church Stretton			0.3

Table 27 Contamination in a single sample of Finnish food waste (Heaven *et al.*, 2011)

Contaminant	% (by fresh weight)
Garden waste	6.5
Paper and card	17.5
Plastic bags	0.2
Glass	0.3
Pet litter	0.9
Other (eg textiles)	1.4

Table 28 Contaminants (average %) from five samples of Portuguese food waste (Heaven *et al.*, 2011)

Contaminant	Average (% fresh weight)
Plastic – film	6.0
Plastic – bottles	0.2
Plastic – polystyrene	0.0
Plastic – other	0.6
Glass – packaging	0.5
Glass – non-packaging	0.0
Ferrous metals	0.2
Other metals	0.2
Composites	0.4
Textiles	0.2
Sanitary textiles	1.0
Wood	0.0
Other combustibles	0.1
Non-combustibles	0.1
Packaged organic waste	0.0
Other	0.0

Table 29 Contamination in a single sample of Italian food waste (Heaven *et al.*, 2011)

Contaminant	% (by fresh weight)
Biodegradable bags	3.7
Garden waste	15.2
Paper and card	13.8
Plastic containers	0.3
Plastic film	2.2
Metals	0.35
Glass	0.14
Other	12.8

Overall results from this survey were as follows:

1. UK - The average contamination was low at < 2% of the total sample weight, although the sites could be broadly grouped as low (2-3%: Leatherhead, Central Beds, Ealing, Richmond, Surrey) and very low contamination (< 0.5%: Ludlow, Craven Arms, Church Stretton, Flintshire, Hounslow), possibly reflecting how long the various collection schemes had been established;
2. Finland - The proportion of non-food waste in the sample was high at 27.5% of the total weight. The two main components categorised as contaminants were 'Paper and card' (17.5%) and 'Garden waste' (7.2%). Both of these materials are accepted for processing in the local recycling scheme, as is pet litter; the term 'contaminant' is therefore only relevant in the context of a pure food waste collection. Other types of contaminant (plastic bags and containers, glass, metals, and miscellaneous or composite items) made up <2% of the total waste or around 2.5% of the food waste component, indicating a reasonably low degree of contamination;
3. Portugal - The sample included a proportion of 'Paper and card' (6.3% of total weight) and a very small amount of 'Garden waste' (0.8%). The main contaminant was plastic bags (6.0%): as biodegradable bags are not provided in this scheme, this represents a considerable input of contamination and a reduction in the potential for energy recovery from the biodegradable plastic. The remaining contaminants (plastic bottles, polystyrene foam and other plastics, glass, metals, composites, textiles, combustibles and special items) made up around 3.6% of the total weight, indicating that the degree of contamination without taking into account plastic bags was reasonably low. The sorters reported finding batteries in the collected sample on two separate occasions;
4. Italy - The collected material contained a large amount of 'Garden waste' and 'Paper and card', at 15.2 and 13.8% of the total sample respectively. It also contained 3.0% of contaminants including plastic containers and film, metals, and glass, and 12.8% of unclassifiable materials (mainly a mixture of organic and inert fines). With a further 3.7% being biodegradable plastic bags, the food waste made up only 51.5% of the incoming material (wet weight basis).

These results may reflect physical and logistical aspects of the collection systems (e.g. bin size, collection frequency) as previous authors had noted that reduction in bin size led to an improvement in the proportion of food waste collected. The length of time for which source segregated collection systems have been operating may be a factor as well: the UK had only recently introduced source segregation for domestic organic wastes at the time of the study. Overall, the degree of contamination was flagged as a cause for concern for AD – including the risk of introducing potentially toxic elements (PTE) from the presence of batteries as reported in the sample from Portugal (Zhang *et al.*, 2013).

8.3 Guidance on food waste collections

8.3.1 Republic of Ireland (Sligo)

Sligo County Council coordinated the national pilot scheme from the Brown Bin programme in Sligo City between July 2014 and March 2015. The aim of the project was to see how a range of educational and collection tools, such as the use of Brown Bin Waste Management Advisors and the provision of kitchen caddies to householders, could improve the capture and quality of food waste in the Brown Bin. The campaign took place in three areas across Sligo City:

- Area A was provided with solid side kitchen caddies, a roll of compostable bags, teaser leaflet, an information leaflet and an awareness talk.
- Area B received awareness work only. Due to time constraints, just half of this area received an awareness talk while the remainder received only a teaser leaflet.
- Area C was provided with vented kitchen caddies, a roll of compostable bags, teaser leaflet, an information leaflet, and an awareness talk.

In each of these three areas, collection rounds are undertaken by two different service providers. One collects co-mingled food and garden waste in 120 litre bins, whilst the other collects food waste in 25 litre caddies. Summary results are provided in Table 30 and the impacts on overall contamination rates are listed in Table 31.

Table 30 Overall summary results from Sligo project (Sligo County Council, 2019)

Parameter	Sligo City	Area A Awareness + solid caddies + 52 compostable liners	Area B Awareness	Area C Awareness + vented caddies + 52 compostable liners
Households which do not have a Brown Bin collection, but should	24%	17%	26%	27%
Change in participation	+25%	+51%	+8%	+16%
Capture of organic waste from participating households (kg/HH/week)	3.01	2.93	2.44	3.25
Overall capture of organic waste after awareness from all households (kg/HH/week and (% change))	+0.95kg (+59%)	+1.6kg (+76%)	+0.36kg (+45%)	+0.77kg (+47%)
% contamination in Brown Bin before	18%	23%	20%	14%
% contamination in Brown Bin after	2.5%	1%	6%	3%

% change in contamination	-86%	-96%	-70%	-79%
Reduction of organics in residual bin After Trial		-6%	-11%	-10%

Table 31 Percentage of contamination in brown bin collections before and after awareness campaign (Sligo County Council, 2019)

	Before	After	Before	After	Before	After
Type of collection	A		C		B	
25 litre food waste only	6%	1%	6%	2%	7%	3%
120 litre food and garden waste	45%	1%	24%	3%	37%	9%

8.3.2 Vancouver City, USA

Metro Vancouver provide the following guidance:

- Plastics, including those marked biodegradable, do not belong in the compost as they do not break down properly during processing. Paper bags and newsprint can be used to line your kitchen container. Keep plastics and plastic bags (even those marked biodegradable) out of the green bin.
- Double check with your municipality to find out what is and is not accepted in your municipality's green bin program.
- Plastics, including those marked biodegradable, and similar items (such as plastic wrap, elastics, twist ties, straws, and swizzle sticks) contaminate compost and reduce its value – keep them out of the green bin. Remove them for re-use, or put them in the garbage.
- If non-compostable material is included in the green bin, the entire load may be rejected and sent to a landfill for disposal. If the load is processed, the resulting compost will contain plastic that is not valued for landscaping and would therefore be unusable.

(Metro Vancouver, 2019)

8.3.3 Washington, USA

With the advent of the more formalized food scraps collection programs in 2009, composting facilities in Washington State were seeing a significant increase in the amount of material needing to be processed. From 2009 to 2013, the amount of pre-consumer food composted rose from about 3,609 tons to about 65,550 tons; the amount of post-consumer food composted increased from about 850 tons to about 65,221 tons. Commingled food and yard debris are not included in these composting totals.

Along with all the newly collected food scraps, composters saw a big jump in physical contaminants. The collection programs were effective at getting the organics to the composters, but the composting businesses were seeing too much too fast and the increase in physical contaminants made the finished product difficult to market.

What are the contaminants of concern and where are they coming from? To answer these questions, a group of local government employees, composters and haulers were invited by Washington Department of Ecology staff to discuss the issue. Overall conclusions were:

- While any non-compostable item is undesirable in collected organics, the physical contaminants of most concern to composters are: plastics, glass and produce stickers. Other contaminants such as shoes, tools, treated wood, balls, wire, and occasionally, the random engine block or kitchen sink, are received and, while annoying, are more easily removed from the feedstock or finished compost. That is not the case with the first three.
- Plastic tends to be the biggest problem due to its volume and variability. Hard and soft plastic containers, bags in various sizes and colours, and plastic-coated paper products break down into ever smaller pieces while never completely decomposing.
- Once mixed with compost, the plastic fragments may be almost invisible. However, after the compost is applied, at the first rainfall or irrigation little plastic pieces begin to appear as the compost is "washed". Aside from the trashy visual appearance, animals, birds and bugs may mistake the plastic for food and eat it, or the pieces could flow into a local water body where fish and other animals could eat them.
- Consumers can be confused when reading labels claiming that a plastic product is "compostable," "biodegradable" or "degradable." Even if a plastic product truly is compostable, each composting facility has its own timeframe for processing organics, which impacts the rate of disintegration. Whether in the government decision making process or at composting facilities, it's very important to know the products. If "compostable" items are accepted in the organics collection program or if vendors at public events are required to carry compostable serviceware, make sure to specify compostable products that are accepted at the facility servicing the program. If product bans are implemented on restaurant takeout packaging (such as Styrofoam or polypropylene containers), local governments and composting facilities should identify alternative packaging that is acceptable to the composter so that an unacceptable product is not chosen by the vendor.
- Glass is a problem because nobody wants to reach into a bag or pile of compost and get cut on a shard that made it through the screening process. Also, farmers have voiced concerns that compost containing glass (or hard plastic) applied to root crops could result in the glass or plastic being incorporated into a root vegetable such as a potato. Produce stickers are small, sturdy, water-resistant and brightly coloured. They do not break down in the composting process, typically get through the screening process and act like colourful contamination flags in the finished compost (Harrington, 2015)

Figure 10 Key messages from Washington State composter workshops (Harrington, 2015)

In 2013 the Department of Ecology updated Washington's organics management rule: reducing acceptable contamination levels in collected organics (to <5% by volume) and regulating the quality of finished composts (including a limit on film plastic of 0.25% w/w (dry weight)). This set the stage for subsequent attempts by various stakeholder groups to address contamination at the source.

Cedar Grove, a composter near Seattle, started composting post-consumer residential and commercial food scraps in 2004. After observing an increase in contamination associated with the newly accepted food scraps, Cedar Grove attempted to reduce contaminant levels through a multifaceted, collaborative approach including:

- Engaging municipal stakeholders via periodic stakeholder meetings.
- Holding large stakeholder events for supply chain vendors, commercial end users, and cities.
- Investing in technology that provided a feedback loop with haulers by enabling photos to be attached to route loads.
- Offering facility tours for various cities and haulers to show the level of investment in labour and technology that had been added over time to deal with contamination.
- Daily feedback to generators regarding contaminated loads.
- Rejecting contaminating loads as a last resort.

As participant awareness of the availability of composting services continues to grow, well-meaning participants unwittingly contaminate feedstocks based on the assumption that any errors will be fixed during processing. This behaviour – and its subsequent impacts on contamination removal costs and product quality – is analogous to “wishful recycling” often found in the recycling industry. Unfortunately, because it is a natural product whose intended purposes include growing food, finished compost has an even lower tolerance for contamination than do recycled commodities.

When contamination issues persisted, Cedar Grove—along with other composters in Washington State—were forced to adopt contamination surcharge fees to deter contamination and help to cover the costs of contamination removal. In an effort to avoid having to absorb or pass along these costs to their participants, the City of Kirkland decided to see if upstream education and initiatives—collaboratively designed and implemented—might still prove an effective solution for producing cleaner feedstocks. This led to a stakeholder discussion at the Washington State Recycling Association's Annual Conference in May 2015 and ultimately led to the formation of the Washington State Organics Contamination Reduction Workgroup (OCRW). The group consists of more than 90 municipal officials, composters, regulators, and representatives of various commercial businesses whose mission is to "collaborate to eliminate contamination in organic feedstocks while expanding end products and markets."

OCRW organized itself to tackle contamination issues strategically across the supply chain, not just at the post-consumer stage. To achieve this, the group defined four goal areas, developed objectives, and formed subcommittees to strategize how to meet those objectives:

- The **Contractual Policies** subcommittee was formed to research and recommend policy options and contractual best management practices to contribute toward the elimination of contaminants in the residential and commercial organics streams.
- The **Participant Education and Outreach** subcommittee was formed to identify gaps in perceived versus actual contaminants and develop an Organics Educator Toolkit to aid in bridging those gaps.
- The **Upstream Systems** subcommittee was formed to seek opportunities to connect the dots between known approaches while exploring new strategies across the entire product manufacturing supply chain, including but not limited to packaging design and related participant sorting behaviour.
- The **Processing** subcommittee was formed to identify and recommend contaminant removal best management practices at processing facilities.

Figure 11 Overview of the four goals of the OCRW (WSOR, 2017)

Below is a summary of the group's key findings and recommended next steps for reducing contamination of composting feedstocks:

Shared Accountability is Key

Composting is a desirable and beneficial alternative to landfilling organic materials. However, the compost bin is not a disposal bin; rather, it is an input into a manufacturing process. All members of the composting supply chain must share accountability for maintaining optimal compost quality by working together to reduce contamination. As such, contracts between municipalities, haulers, and composters are a crucial tool for building shared accountability and minimizing contamination. Contract enforcement can be hampered by a variety of factors, including automated collection methods, limited staff availability in smaller jurisdictions, and participant confusion. However, cart tagging programs that incorporate consistent, audience-focused education, are an effective and efficient tool for changing participant behaviour, enforcing contracts, and ultimately minimizing contamination.

Jurisdictional Inconsistencies Contribute to Participant Confusion

Variability within and between jurisdictions regarding cart colours, accepted items, and audience demographics (housing type, culture, language, age, family type, etc.) creates participant confusion about what can and cannot be composted. This confusion is compounded by jurisdictional inconsistencies for participants who cross boundaries between work and home. One strategy does not fit all: program inconsistencies present challenges for educators trying to implement consistent regional education strategies on limited budgets.

An Ounce of Prevention is Worth a Pound of Cure

Contamination prevention through program education and enforcement prior to collection is more effective than contamination removal during the composting process. Unfortunately, education and enforcement tactics can be resource-intensive, and jurisdictions often have limited budgets.

Contamination Management is Costly but Necessary

Although the ideal way to manage contamination is to prevent it from entering the compost stream in the first place, commercial composters may always need effective methods and technologies to aid them in identifying, removing, and disposing of contaminants. Unfortunately, these methods and technologies are typically expensive and their effectiveness vary widely depending on several factors. Composters scored Airlift Separators, picking stations, and proper screening as the most effective methods for removing low-density materials such as film plastics. Picking stations also provide the added bonus of facilitating removal of other easily identifiable contaminants.

Not All Contaminants are Created Equal

The four most common contaminants in the organics stream are (non-compostable) plastic film, plastic garbage bags, rigid plastics, and glass. While agreeing that the goal is to eliminate all non-compostable items from composting feedstocks, the workgroup explored the concept of common versus problematic contaminants. For example, film plastics are the most common contaminant; although composters do have effective means for removing some portion of film plastics during processing, they are costly and not 100% effective. Glass is less prevalent but equally problematic to composters because it is difficult to identify and remove, especially when composting feedstocks are ground early in the composting process. Glass also represents a safety concern for customers of finished compost, which is less of a concern for film plastics.

Growing Interest in Compostable Packaging Presents both Opportunities and Challenges

There is a growing body of evidence that shows the use of compostable foodservice packaging may lead to an increase in food scrap diversion. Additionally, if it is used in conjunction with a full suite of best practices such as conscientious purchasing of compostable products where appropriate, outreach, and education, contamination can be measurably reduced relative to environments where packaging is not uniformly compostable and/or best practices are not applied. At the same time, packaging can present challenges for composters, including:

- Difficulty in discerning between compostable and non-compostable items that look alike.
- Non-compostable products that are labelled and tinted in such a way that participants assume they are compostable when in fact they are not.
- Requirements that food distributors and vendors apply stickers to pre-packaged food containing nutrition and allergen information. Although there are compostable stickers available, the market has not yet reached sufficient scale to provide a viable alternative to conventional stickers.

The workgroup is encouraged by the depth and breadth of dialogue occurring on these topics, both within the workgroup and elsewhere in the industry. However, there remains a lack of consensus among all stakeholders regarding the best path forward (WSOR, 2017).

Table 32 Contamination removal methods and technologies scored by Washington State commercial composters (WSOR, 2017)

Technology	Sortable Material Types	Specific Sortable Possibilities	Average Score
Air Lift Separators	Density-specific materials	Plastics, paper	7.4
Picking Station	Large visible materials	Plastics, wood, cans, bottles	7.4
Star Screens	Size-dependent materials	Size fractions larger / smaller	7.25
Hand Sorting	Large visible materials	Plastics, wood, cans, bottles	6.6
Conveyor Separation with air	Density-specific materials	Plastics, glass	6.5
Flotation Separation	Floaters / Sinkers	Rocks, glass, metals, plastics	6.5
Air Classifiers (generic)	Density-specific materials	Plastics, paper	6
Gravity Separation (Oliver)	Density-specific materials	Rocks, glass	6
Magnets	Metals	Ferrous metals	6
Trommel Screens	Size-dependent materials	Size fractions larger / smaller	6

Through its discussions with composters, the subcommittee determined that contract language between composters and feedstock generators is a crucial tool for minimizing contamination. Effective contract language places the responsibility for minimizing contamination with the generator by requiring remuneration to the composter for the removal and disposal of contaminants.

The overall approach to handling contamination is as follows:

- Any load with contamination will be documented, including date, time, material and a photo displaying volume and contaminating material (contaminating material is anything that is not organic as defined by the National Organic Standards Board, including: plastic glass, metal, rubber, rocks, sod or dirt).
- Contamination is measured in 'picks' and/or volume, whichever is greatest. 'Picks' are pieces of contamination that can be picked-up with one hand at one time. The volume of contamination is measured in gallons.
- Charges will apply, as set out in Table 33.

Table 33 Extent of contamination response under the WSOR guidelines (WSOR, 2017)

Extent of contamination	Process and charge to the customer
0 – 5 gallon / 20 picks	None
6 – 20 gallon / 21 – 50 picks	Load is accepted, date, material, time are logged and a photo is taken of the contamination. A $25 contamination fee will be charged to the customer
21 – 50 gallon / 51 – 80 picks	Load is accepted, date, material, time are logged and a photo is taken of the contamination. A $50 contamination fee will be charged to the customer
51 – 100 gallons / 81 – 120 picks	Load is accepted, date, material, time are logged and a photo is taken of the contamination. A $100 contamination fee will be charged to the customer
101 – 200 gallons / 121 – 150 picks	Load is accepted, date, material, time are logged and a photo is taken of the contamination. A $200 contamination fee will be charged to the customer
Over 200 gallons / 150 picks	Load is rejected. If the material is already dropped on the pad, it will be re-loaded at a charge of $150 / hr loading fee. A minimum of 1 hour will be charged

8.3.4 San Francisco

In 2009, San Francisco introduced the 'Mandatory Recycling and Composting Ordinance'. This legislation made it compulsory for everyone in San Francisco – including residents, businesses, government and even tourists – to properly recycle and compost their waste. Anyone who is found not separating recyclables and compostables from their refuse can be subject to a fine.

The city takes a staged approach to enforcement of the Ordinance. It carries out audits of refuse bins to identify whether they contain any recyclable or compostable materials. Where these materials are found, the auditor leaves a tag on the bin with a note documenting the occurrence and a first warning of a fine for noncompliance. If the offender is found to continue placing recyclable and/or compostable materials in their trash bin, they are issued a second warning. It is only upon the third identified occurrence that they are issued a fine of $100.

The city charges residents and businesses for collection of their bins based on the volume of waste presented, which is a function of both bin size and frequency of collection (Table 34).

Differential pricing for residents is set depending on the stream, with fees for collection of the residual waste bin about 10 times higher than fees for the recycling and compostables' bins. If contamination is repeatedly found in a resident's compostable or recycling bins, then they are can be charged at 50% of the rate of the residual waste bin.

Table 34 Example collection charges for residents of San Francisco under different pricing regimes (Heinrich, 2017)

Example monthly residential bill	
Service	Container size & price
Dwelling unit base fee	$5.16
Compost	$2.06 (32 gallon)
Recycling	$2.06 (32 gallon) OR $4.12 (64 gallon)
Residual waste	$25.90 (32 gallon) OR $51.80 (64 gallon)
Total monthly bill	$35.18

Example small trash bin option	
Service	Container size & price
Dwelling unit base fee	$5.16
Compost	$2.06 (32 gallon)
Recycling	$2.06 (32 gallon)
Landfill	$16.19 (20 gallon)
Total monthly bill	$25.47

Businesses are billed an amount based on the size of their bin(s) and the number of times each bin is presented for collection. They can obtain a diversion credit based on their use of the recycling and compostables' bins. If a business's recycling and/or compostables' bin is found to be consistently contaminated, then they are not awarded the diversion credit. If compostables' and/or recyclables are repeatedly found in the residual waste bin, businesses can also be charged 50% of the rate of the residual waste bin (Heinrich, 2017).

Another essential component behind the city's success with food waste composting is a comprehensive education program. This includes delivery of advice to residents and businesses on how to use the bins (via door knocking and information sessions), feedback on composting performance via tags on audited bins, as well as bin signage indicating what items belong in each bin. Furthermore, the city has consistent bin colouring across (green for compostables, blue for recycling and black for trash) (Heinrich, 2017).

8.3.5 Australia

The following guidance was provided by the government of New South Wales to municipalities considering kerbside organic waste collections (whether green waste only, co-collected green and food waste, or food waste only) (NSW, 2012).

The major contaminant in a food organics collection service is plastic bags. These are used by residents to line the kitchen caddies and transport the food organics to the kerbside organics bin. Residents may not be able to differentiate the look and feel of compostable bags from other types of bags or differentiate between the terms degradable, biodegradable and compostable. Householders are often confused by the plethora of environmental based messaging on the packaging of bin liners. In addition, compostable liners for kitchen caddies or bins are often not readily available in retail outlets.

A comprehensive contamination prevention and management plan should be developed prior to roll out of a combined food and garden organics service. Planning should be informed by the pilot trial results and local experience with contamination. It should include at least:

- Education material for householders, including visually appealing lists and stickers of what can and what can't go into the organics bin. Clear symbols (i.e. ticks and crosses) should be used to ensure the material is easily understood.
- On-going public education and motivation.
- Communications material for the local media, councillors, senior staff etc.
- Arrangements with waste collection personnel regarding contaminated bins and use of contamination tags for non-compliant households.
- Arrangements with the processor regarding contaminated material for the initial roll out of the service and on-going maintenance of the service. This may include penalty payments if contamination levels exceed a certain threshold.
- Continuous monitoring and evaluation in problem areas through bin inspections, waste auditing and community consultation.

It is often very hard and costly to remedy a situation where collected organic material has unacceptably high contamination levels. Hence, adequate resources need to be made available to prevent this from occurring. Particular issues related to combined food and garden organics collections include:

- Whether Councils should elect to promote compostable plastic liners, paper liners or no liners.
- If liners are promoted whether they will be supplied by council (how many for how long) or if residents have to provide their own.
- Whether plastic bags and other large impurities are going to be handpicked and removed at the processing facility or not. Hand sorting of incoming material increases processing costs and may also require colouring or marking compostable bin liners so they can be easily differentiated from other plastic bags.
- Whether a bag shredder will be deployed to rip open compostable bin liners to release food material. This may result in small pieces of non-compostable plastic within the end product if the incorrect types of bags are used by the householder.
- Whether kerbside collected garden and food organics be shredded, as this will result in small pieces of plastic that are hard to separate from the finished compost and mulch.
- Whether contaminated bins will be identified, remedial action taken with the individual household and the service ultimately removed if contamination continues. Community and council support for the service may influence acceptance of various options for dealing with households unable or unwilling to correctly use the service.

(NSW, 2012)