Unwrapping the biowaste potential

Operational, environmental and economic benefits of reducing plastic pollution in biowaste, compost and digestate in the EU

SECOND EDITION, NOVEMBER 2022

Contents

Research commissioned by

EUROPEAN CIRCULAR BIOECONOMY POLICY INITIATIVE

This research is endorsed by

EEB European Environmental Bureau

EUROPEAN BIOECONOMY BUREAU

cré Composting & Anaerobic Digestion Association of Ireland

ZERO WASTE EUROPE

CONSORZIO ITALIANO COMPOSTATORI

Foreword

In a town, city and community in your country, both in Europe and in other nations globally, local authorities and waste managers are implementing or have already implemented separate collections of food waste. In Europe this follows a specific legislative mandate but we see countries as diverse as Korea, China, Australia, and states in the USA such as New York and California, also focusing on food waste collections.

Many are approaching the topic for the first time and let's be fair, collecting food waste appears a daunting task. Food waste is wet, smelly and rots quickly. But it is often the largest municipal waste stream nations have and is that which produces undesired, harmful methane or CO2 emissions if not treated in composting or biogas installations.

Collecting Europe's extra 60 million tons of food waste provides daunting logistical challenges, but enormous opportunities too – more efficient waste logistics, higher overall recycling rates, cleaner dry waste streams, energy to substitute imported natural gas and fertilisers and organic carbon for depleted soils. Indeed we forget that food waste is a unique waste stream: it is the only waste whose outputs are deliberately destined to be used in the open environment, on soils. Therefore the importance of clean outputs (compost and digestate) spread to soil without contamination, becomes an issue not just of waste and emissions management, but of soil health, biodiversity and agricultural production. The overwhelming burden on food waste treatment facilities is the amount of plastics they receive in collection systems and this report concentrates attention on the costs of this contamination, and how to reduce it – for the benefit of treatment systems, soil health and to reduce costs for EU citizens.

Whilst daunting, thankfully we have experiences to refer to and the authors of this report, Dr Enzo Favoino and Dr Michele Giavini, who we thank, have been personally instrumental in implementing successful food waste systems across the world for more than 25 years.

We also thank those associations that have wanted to endorse this report and hope it provides useful guidance to policy makers in the European Community and worldwide.

David Newman, Roberto Ferrigno
Founders, European Circular Bioeconomy Policy Initiative (ECBPI)

Authors:
Dr Enzo Favoino, Dr Michele Giavini, Scuola Agraria del Parco di Monza

Relevance of biowaste and the importance of reducing its plastic contamination

With the adoption of an obligation for the separate collection of biowaste, as stipulated by article 22 of the Waste Framework Directive, the European Union (EU) has taken a firm stance on the need to secure circularity in the management of organic resources. Organic waste represents a large part of European Municipal Solid Waste (MSW) and its recycling, by means of composting and anaerobic digestion, is pivotal to maximising recycling rates and meeting EU targets for material recovery. It will also give full shape to the 'left wing' of the Circular Economy 'butterfly', which addresses biological materials. Biowaste sits at the intersection between other environmental policies, including climate (contributing to potential sequestration of carbon in soils and reduction of methane emissions from landfills), agriculture, and all related instances vis-à-vis fertility, resilience against floods and erosion, minimisation of eutrophication due to loss of nutrients from fast-release chemical fertilisers, etc.

While EU strategies aim at boosting capture, recovery, and recycling of biowaste, including organic matter and nutrient content, one must concurrently consider the potential contaminants. Separate collection has proven effective in minimising all avoidable contamination with heavy metals, organic pollutants, and physical impurities such as glass, metals, plastics and the like. Still, particular attention should be paid to further minimisation of plastics: as a matter of fact, various factors may increase, albeit marginally, the presence of plastics in collected biowaste, e.g.:

- mistaken behaviour of producers (e.g. wrong interpretation of "kitchen waste" by households, or hasty management by large producers, e.g. restaurants)
- poor performing collection systems, such as schemes that are not sufficiently ensuring a focus on individual responsibility
- Contamination of biowaste with non-biodegradable material, introduced into the system, e.g.
    a. the use of conventional plastic bags (instead of compostable ones) and plastic wrappers as a collection tool to make collection more user-friendly, avoid nuisance for households, and keep receptacles clean (caddies, buckets, bins)
    b. material strongly connected to biowaste such as coffee pods, food stickers, sauce sachets etc.

The presence of conventional plastics is of particular concern, given the need to divert them from the composted and digested mass suitable for application in farmlands. They also have an inherent tendency to fragment into microplastics, which may eventually increase the total discharge of microplastics into soils (besides the background primary carriers that constitute the largest sources of microplastics in agriculture, such as water, atmospheric fall-out, fragmentation of mulch films, and microplastics intentionally added to e.g. fertilisers). Needless to say, compost and anaerobic digestion (AD) sites are well resourced, with operational arrangements to extract plastics from biowaste and compost (e.g. primary screens - whatever their operational type, final drum screens, density refiners, etc). This, though, brings some downsides such as:

- increased operational costs
- increased volumes of rejects, thereby impinging on gate fees for composting/AD

One should also consider the fact that screening and refining imply the diversion of segments of biowaste and compost as rejects, trimming the total tonnages of composted and digested outputs, while inflating the volume and cost of reject disposal. The ratio rejects:impurities is also known as the "dragging factor" and it magnifies the importance of having the cleanest input feedstocks possible, reducing costs while maximising the agricultural, environmental, and economic benefits of compost/biogas schemes and strategies.

With all the foregoing duly considered, this report aims to provide information on the typical and range values of plastic impurities, with key factors affecting them, and related "dragging factors", so as to finally calculate related figures in terms of total tonnage of discarded materials and related costs, basing calculations on the total potential capture of biowaste across the EU. Also, cost savings potentially incurred by shifting from highest to lowest contamination rates will be calculated, so as to provide policy- and decision-makers with a magnitude of benefits.

Methodology

In order to assess the total tonnage of avoidable rejects, and related monetary value, this study builds on the following information, and related calculations:

- the starting point will be the total potential capture of biowaste at EU level
- then, the presence of plastics, as a percentage of biowaste, will be assessed and considered
- the "dragging factor" will then be discussed and included in the calculation, so as to ascertain the total amount of rejects (including biowaste and compost) stemming from plastics to be screened out
- finally, total tonnages of rejects will be multiplied by the disposal costs, so as to bring up the total potential savings

In carrying out the foregoing assessments and related calculations, the following will be assumed and used:

- concerning potential captures the latest reference surveys will be discussed and used. The "maximum theoretical potential" will be adopted, instead of the "operational potential", since the goal of the calculation is to assess the potential beneficial impact of shifting to good practices in collection and processing. The study will also focus in particular on food waste and related contamination, since this is the type of biowaste where plastic contamination is shown to be highest, and where there is large potential of improvement thanks to:
    a. adoption of performing kerbside schemes
    b. use of appropriate tools for collection (compostable bags)

Although garden waste may also show some level of plastics contamination, this looks rather negligible relative to food scraps, and it is mostly related to littering of plastics, hence unrelated to optimisation of collection. For instance, in a national survey carried out by CIC in Italy in 2019-20, contamination rates for garden waste were ranging from 1 to 2%, compared to that of food waste (collected single stream, hence with no "dilution" of impurities by garden waste) which averaged 5.2% (but, as we'll see in a dedicated section on the influence of type of schemes, it may be ranging from as little as 2% to as much as 15% in various regions around the EU.)

- concerning plastic contamination, range values (min-max) will be examined, and related calculations will be carried out. Then, moving on to calculation of economic impact, the difference of the two will be highlighted and adopted, given the goal of the survey (i.e. assessing total potential savings of shifting from poor performing collection schemes to well performing ones)
- concerning the "dragging factor", range values (min-max) will be examined. Then, in related calculations, a "typical/average" value will be adopted, remarking the importance of optimising operational lay-outs so as to move towards the lowest values
- concerning disposal costs for rejects, typical range values (min-max, basically corresponding to some CEE Countries and Western Europe) will be considered, with related influencing factors and cost drivers. Then, a reference EU total value will be calculated, based on the trending cost that tends to align with highest ones due to:
    a. full implementation of provisions included in the Landfill Directive 99/31
    b. tighter emission standards for incineration, and likely inclusion in the Emission Trading Scheme (which will amplify the total costs)
    c. lack of further EU grants for infrastructure dedicated to incineration and landfilling

EU policy drivers and the "untapped potential"

With Directive 2018/851, amending Directive 2008/98 (Waste Framework Directive)[1] the EU has adopted an obligation for each Member State to adopt and implement strategies for the separate management and recycling of biowaste.

Article 22(1) stipulates:

> *Member States shall ensure that, by 31 December 2023 and subject to Article 10(2) and (3), bio-waste is either separated and recycled at source, or is collected separately and is not mixed with other types of waste.*

As specified by article 22(2), besides management on-site by means of home composting, recycling of biowaste includes both composting and anaerobic digestion; also, Member States must ensure a "high level of environmental protection" through composted products that meet "relevant high-quality standards". It goes without saying, this addresses the need to achieve low levels of impurities in collected biowaste and to adopt performing screening and refining systems, so as to rid compost of contaminants.

Also noteworthy is the second part of article 22(1), which states the possibility of co-collecting materials that meet relevant standards on compostability.

> *Member States may allow waste with similar biodegradability and compostability properties which complies with relevant European standards or any equivalent national standards for packaging recoverable through composting and biodegradation, to be collected together with bio-waste.*

Hence, tools and materials that meet requirements of the reference standards (e.g. EN 13432 and EN 14995) are not considered as "impurities" and may be included in strategies to maximise captures and quality of collected biowaste.

Previous surveys have investigated the theoretical and operational potential, in terms of tonnage, of the collection of biowaste. An EEA report[2] in 2020, based on compositional analyses of MSW, calculated for the EU28 that some 86 Mt of biowaste is produced a year, with 42% (or 71 kgs/person/year out of 168 kgs/person/year) of that being separately collected and managed.

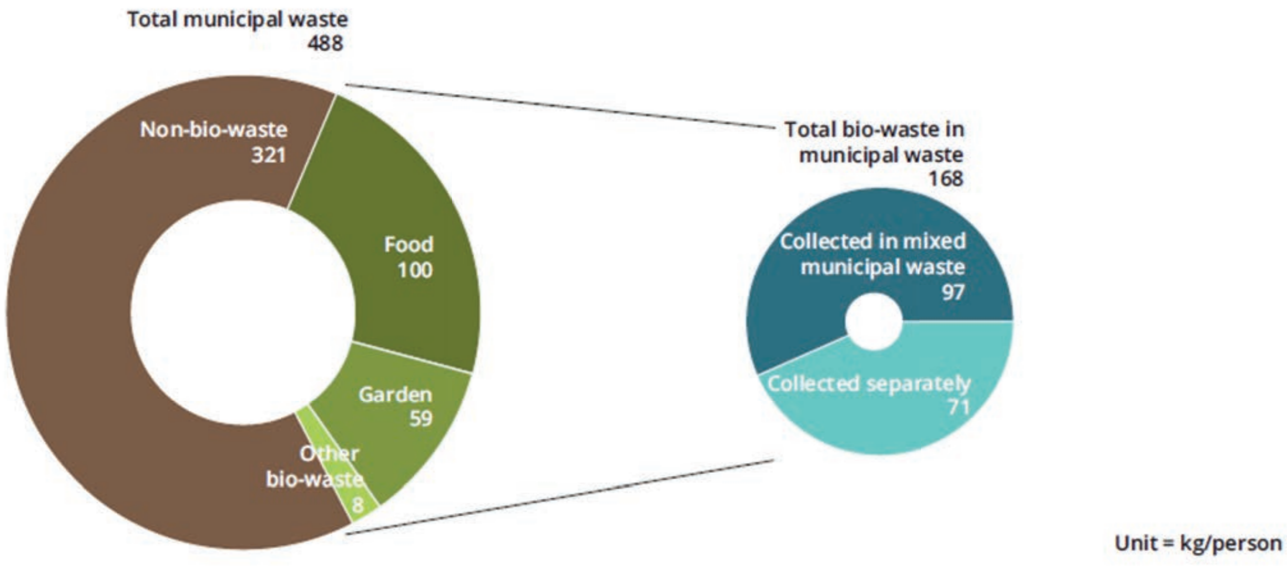

Figure 1: biowaste in MSW and current separately collected share according to EEA, 2020

[1] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

[2] EEA (2020): Bio-waste in Europe — turning challenges into opportunities

A joint ZWE/BIC study[3], also issued in 2020, through different calculations, based on reported datasets from different Member States and assumptions on the potential generation of garden waste, assessed a total theoretical potential of some 113.8 Mt/year in EU 27+ (i.e. including UK and Norway); the study also included a specific calculation for food waste, estimated at 59.9 Mt/year.

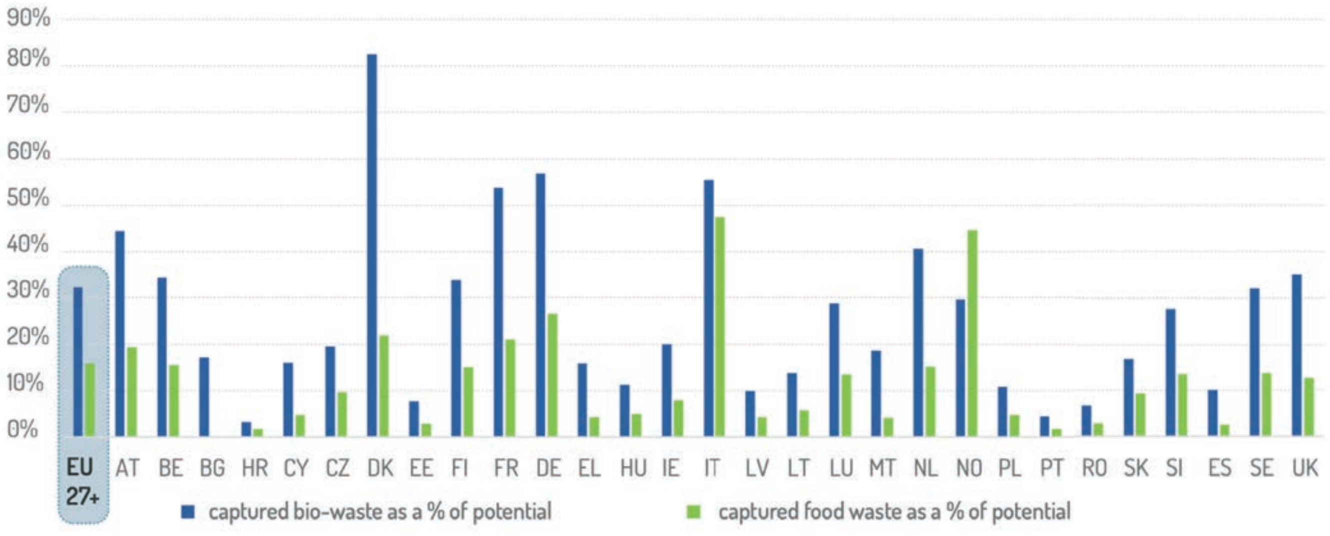

Figure 2: captures of biowaste and food waste in the EU 27+ and various Countries, in proportion to the theoretical potential

It is worth noting, the study had a separate assessment of current capture rates, relative to the theoretical potential, for food waste: while biowaste (which also includes garden waste) already showed a capture rate of 34% (lower, but comparable with the EEA estimate) food waste was at a much lower 16%. The study therefore drew attention to the need to increase and maximise collection of food waste as the actual challenge for the near future; the survey also singled out those countries showing the highest levels of captures of food waste (e.g. Norway, Italy), and subsequently dwelt on tools (e.g. use of biobags) and operational strategies (e.g. design of the scheme with dedicated collection rounds for food scraps only, collection frequency) which are shown to be instrumental in this respect.

With regard to the scope of the present survey, the starting point of calculation will be the total theoretical potential of food waste, since this is the type of resource where strategies for optimisation have the highest potential, on account of the following reasons:

a. unlike garden waste, food waste shows a marked difference in quality depending on the optimisation of collection schemes
b. food waste may benefit from use of bags to maximise related captures, and this may cause remarkable differences in contamination, whether they are compostable bags or not
c. as much as garden waste may show some contamination with plastics, too, this looks rather negligible relative to food scraps, and mostly related to littering of plastics (hence unrelated to optimisation of collection schemes)
d. for garden waste, there are often additional bring schemes working simultaneously, and they are typically supervised, which decreases the risk for contamination (e.g. at specific seasonal bring points and/or recycling centres).

Our starting figure will therefore be the total theoretical amount of food waste generated, hence targeted by separate collection, in EU 27+ (i.e. including UK and Norway) as calculated by BIC/ZWE (2020):

Theoretical potential collection (generation) of food waste in EU27+	59,936,725 t/year

[3] BIC, ZWE (2020): Bio-waste generation in the EU: Current capture levels and future potential

Typical/average rates of contamination

Separate collection of biowaste, and more specifically that of food waste, already has a long track record across Europe. General provisions for separate collection have long been defined e.g. by Central European countries, and specific regions as e.g. Catalonia (Spain); collection schemes are ubiquitous in Italy, in Wales, and pilots are being implemented in other countries, including Central Eastern Europe e.g. Romania and Slovakia. This allows assessment, benchmarking, and comparison of performances, also with regard to quality and contamination of collected food waste.

In this respect, the following factors seem to be most impactful:

- the type of collection: collection at the doorstep seemingly shows remarkably higher quality of collected food waste (besides unit captures, in kgs/person) than bring schemes. Apparently, this relates to mechanisms giving emphasis to individual responsibility, related monitoring, and theoretical possibilities for sanctioning, all of which is missing in bring banks.
- the adoption of certified biodegradable and compostable bags; (also worded as “biobags”. The EU reference standard is EN13432, which deals with compostability in aerobic conditions, until or unless a new standard is available defining biodegradability in wet AD).
- while biobags are primarily aimed at making collection user-friendly, thereby maximising participation and captures, they also prevent use of conventional plastic bags, which, seemingly, in turn attracts higher contamination of other conventional plastics (e.g. food wrappers, cheese bags and the like).

Influence of operational patterns of schemes

As already emphasised, the type of scheme seems to exert a relevant influence on the level of contamination. This may be e.g., retrieved from surveys that report on contamination levels from municipalities in the same region, so as to rid the assessment of other societal, operational, climatic, or regulatory influence.

One such survey that is noteworthy is the overview of performances by ARC, the Catalan Waste Agency[4]. The summary table below shows a markedly higher performance for collection at the doorstep than for bring banks (road containers with “smart locks”), both from the quantitative angle (captures) and the qualitative one (level of contamination – 1805 samples).

How?
Door to door

How?
Road containers

MODEL	Kg organics/ year	g organics/ day
Door to door (DtD)	112	306
Road containers (RC)	42	114.5
Mixed (DtD & RC)	68.5	188
AVERAGE	47	128

Source: ARC Data 2020

MODEL	% impurities
Door to door (DtD)	4.68
Road containers (RC)	13.48
AVERAGE	12

1,805 samples/year Characterisation annual campaign

MODEL	Kg organics/year	% impurities
Door to door (DtD)	112	4.68
Road containers (RC)	42	13.48

Figure 3: comparison of performances of collection of biowaste door-to-door vs. road containers in Catalonia: the summary table (bottom) retrieved from the original slide (top)

[4] Guerrero, T. (2022): Efficient biowaste collection methods – experiences from Catalonia, Presentation for the Policy Learning Platform, Interreg Europe

A similar survey was carried out at national level by CIC, the Italian Composting Association, in 2017[5]. The weighted average of the contamination rate was at 4.9%, but at a deeper level of analyses, it ranged from an average 4.5% for door-to-door collection (largely prevailing in the Italian context) to an average 10.3% for bring banks based on road containers.

MODEL	% contamination w/w
Door to door	4.5
Hybrid	6.9
Road containers	10.3

Figure 4: Average contamination rates under different types of schemes in Italy, 2017

Influence of biobags

Biobags are bags made of biodegradable materials (typically, paper or compostable plastics), that may be composted (or digested) at dedicated sites[6].

Biobags reportedly exert a large influence on quality of collected biowaste, in that they seem to reduce its contamination level:

- by avoiding use of conventional plastic bags (direct effect) and, in turn,
- reducing the level of confusion triggered by use of conventional plastic bags, that would otherwise also enhance delivery of other conventional plastics as food wrappers and the like

These effects were clearly reported in the collection trials in Sligo[7] (Ireland) that compared:

1. a conventional scheme, only supported by awareness raising (educational) campaigns
2. a scheme adopting biobags + solid kitchen caddies and awareness raising
3. a scheme adopting biobags + vented kitchen caddies[8] + awareness raising

From the table below, one may highlight not only the significantly higher increase in captures in areas using the biobags (connected in turn to higher change in participation) but also the difference in contamination rates after rolling out the schemes; in all three areas contamination dropped well below 10% (from 14-23% in various areas before implementing the trials) but impurities were lower in Area A and C, provided with biobags (1-3%), than in Area B, without biobags (6%).

Parameter	Sligo City	Area A Awareness and solid caddies with 52 compostable liners	Area B Awareness	Area C Awareness and vented caddies with 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/household/week	3.01	2.93	2.44	3.25
Overall capture of organic waste after awareness from all households	+0.95 kg/household/ week +59%	+1.6 kg/household/ week +76%	+0.36 kg/household/ week +45%	+0.77 kg/household/ week +47%
% contamination in brown bin before	18%	23%	20%	14%
% contamination in brown bin after	2.5%	1%	6%	3%
% change of contamination	-86%	-96%	-70%	-79%
Reduction of organics in residual bin after trial		-6%	-11%	-10%

Parameter	Area A (Solid caddies + awareness + biobags)	Area A (Awareness only)	Area C (Vented caddies +awareness + biobags)
Contamination	1%	6%	3%

Figure 5: findings from trials in Sligo: the summary table (bottom) reports on key contamination indicator, retrieved from the original slide (top)

[5] Centemero, M (2017).: Accordo di programma Assobioplastiche, CIC, CONAI, COREPLA: resoconto sintetico delle attività di monitoraggio

[6] A specific EU standard (EN 13432) addresses "compostability" at industrial compost sites, and it has long been used as a reference for bags accepted at compost sites in many Countries. That standard is already considered and accepted at many anaerobic digestion (AD) sites, too, when such sites are based on e.g. dry-batch systems or have a post-composting step; a specific standard may be needed, though, to address digestion at AD sites without such operational arrangements, and the definition of one such standard seems to be in the pipeline of CEN activities.

[7] Sligo City Council (2015): National Brown Bin Awareness Pilot Scheme in Sligo City, Final Report

[8] the use of vented kitchen caddies is diffused in many areas where biobags are used, so as to exploit the capacity of biobags to evaporate excess water

Evidence is also available from similar surveys carried out by CIC (Italian Composting Association) in 2015[9], on 480 sampled bags which correlated the level of contamination of collected biowaste with the type of bag in which it was collected.

Figure 6: comparison purity/type of bag as assessed by CIC: content of the bag vs. type of bag

That survey also highlighted a noticeable decrease of contamination, detected in compositional analyses of biowaste collected in different municipalities, with increasing percentages of compostable bags in the municipal scheme.

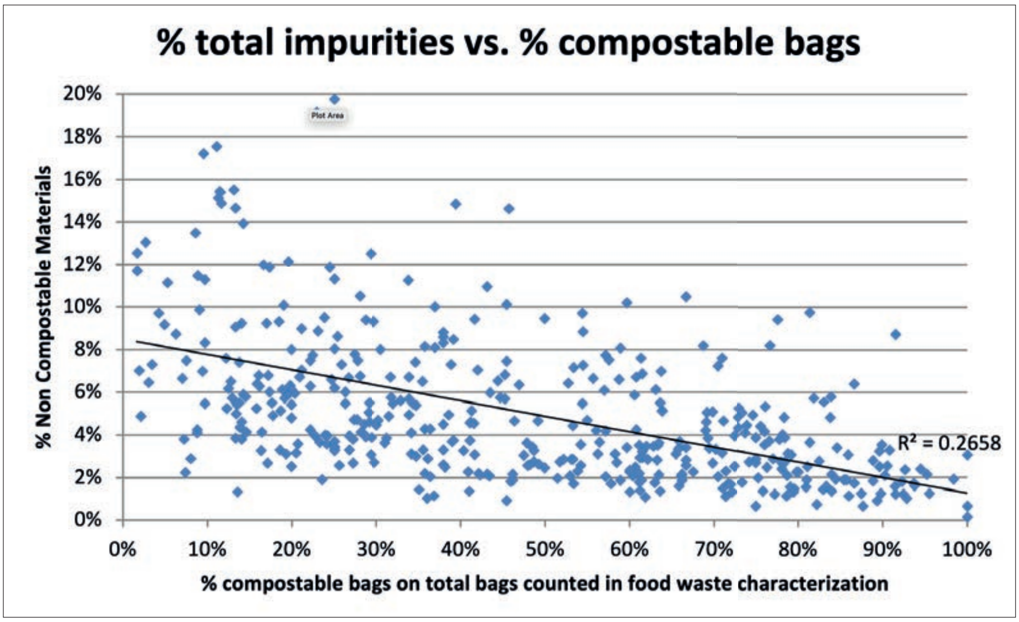

Figure 7: correlation purity/type of bag as assessed by CIC: average purity in the municipality vs. percentage of compostable bags in the municipality

As one may notice, while the trend is fairly visible, the R2 is only 0.25, which shows a correlation that may be said to be relatively weak: this means that while the use of compostable bags tends to improve the quality of collected biowaste in a given area, also other factors may influence quality, as e.g. education, behavioural traditions, and the like. However, a more defined cluster may be singled out when looking at subsamples with more than 60% of biobags, which shows a lower value of impurities and a narrower variability.

All duly considered, one may infer that the use of compostable bags tends to improve the quality of collected biowaste in a given area, all the other factors being equal; however other tools, as awareness raising/education, supplement the role and effect of biobags, and should be duly taken into account in order to maximise quality.

[9] Centemero, M. (2020): Biowaste - risorse per l'economia circolare, ed. Ambiente

Magnitude of potential plastic contamination and the importance of promoting quality

Backed by evidence collated in the previous section, the total tonnage of contaminants in EU27+, and more specifically that of plastic ones, may be defined. With due consideration for percentages of contaminants as reported in the studies that were sourced, we assumed the following contamination range values:

CONTAMINANTS	%	Reference scenario
Min	2	Door-to-door, use of compostable bags
Max	15	Bring banks, no obligation to use compostable bags

Table 2: contamination rates, adopted range values (best and worst scenario)

Given the specific focus of this study, though, plastic contaminants should be singled out, instead of general contamination. For that to be done, one may refer to datasets from CIC[10], which reported the average percentage of plastics in contaminant, from the nationwide survey, at 59.62%.

Hence, the total amount of plastic contaminants in EU27+, may be calculated as:

59,936,725 t/year (total potential collection of biowaste) x
2 ÷ 15% (min/max value) x
59.62% (average share of plastics in contaminants)

Which would finally yield the following range values (min-max):

TOTAL POTENTIAL PLASTIC CONTAMINATION AT:	t/year
2%	714,685
15%	5,360,641
Difference	4,645,456

Table 3: total potential plastic contamination (t/y in EU27+) in best and worst scenario, and related difference

The calculation above is eye-opening in three fundamental aspects:

1. it provides information on the potential magnitude of the problem
2. above all, it illustrates the magnitude of difference between the worst and best case scenario, hence the operational and environmental benefit EU may incur (some 4,650,000 t/y) promoting strategies to move closer to the latter from the former
3. it indicates the enormous transfer of resources (plastics) that could perhaps have been recycled or collected separately, or, in fact, not produced at all, from food waste collections to disposal

[10] CIC (2020): Sintesi dei risultati del programma di monitoraggio CIC-COREPLA (2019-2020)

Calculation of operational and economic benefits

Avoiding plastics in collected biowaste and in composted/digested products, needless to say, implies remarkable environmental benefits. It minimises disposal of rejects, while reducing potential presence of plastics and microplastics in compost. Compost/digestate isn't a source of plastics/microplastics in soils, but may rather be regarded as a carrier[11]; as much as it is not one of main carriers (tyre and shoes abrasion, fall-out, water, fertilisers, mulch films, etc. being relevant sources and carriers), reducing the amount of plastics it may potentially carry along is of course important.

However, ridding compost of plastics (just as every impurity) does not come without cost: mechanical separation, whatever the option (primary screens, final trommel refiners, densimetric refiners, etc.), cannot be 100% perfect, and implies also discarding some biowaste and compost.

Hence, besides the cost of disposal of impurities themselves, one should consider the "dragging factor", i.e., the proportion of biowaste and compost that gets discarded, relative to impurities. This was calculated, in comprehensive nationwide analyses run by CIC[12] with sampling and mass balances at 27 sites, ranging from 150% to 600% (i.e. 1.5-6 times more rejects than impurities, excluding "outlying data"), and an average calculated at 275%, i.e. 2.75 t of rejects per each ton of impurities. It is worth noting that the average factor is remarkably closer to lowest end values than highest end ones, which may be interpreted as:

1. Evidence of maturity of the composting/biogas industry in optimising their lay-outs, and
2. Possibility for compost/biogas sites to adopt operational lay-outs that optimise separation, hence minimising dispersion of valuable resources (biowaste and compost/digestate) in a comparatively easy way

Adopting the values of total plastic contamination calculated in Table 3 (which simply factors impurities attributable to plastic contamination, i.e., disregarding other contaminants), and factoring the average dragging factor (2.75), the total tonnage of rejects connected to plastic contaminants only gets calculated as follows:

TOTAL POTENTIAL PLASTIC CONTAMINATION AT:	t/year
2%	1.965,384
15%	14,740,378
Difference	12,774,994

Table 4: total potential tonnage of rejects that may be attributed to plastic contaminants, under the best/worst contamination scenario (and related difference) and assuming an average "dragging factor" (t/y in EU27+)

The "dragging factor", it goes without saying, also amplifies costs potentially incurred for disposal of such rejects, besides the environmental implications of diverting some resources from recovery to disposal. In order to ascertain the economic impact, the differential value (max-min) of rejects, which represents the potential operational benefit of moving from poor performing scenarios for collection to well performing ones, may be multiplied by some reference disposal costs for rejects, in the current situation and its foreseen evolution.

In this respect, one may note the following:

1. Disposal options may basically refer to main options of landfilling and incineration. Other options, such as chemical recycling or further material recovery from rejects (e.g. plastics) are either not consolidated at operational level, or marginally adopted
2. Apparently, the cost of disposal for rejects, which is codified as "special waste", hence not strictly planned in most situations, is influenced by dynamics of a free market, hence tends to align with main disposal options (incineration and landfilling)
3. The cost of landfilling is driven mostly by the following factors:

[11] See e.g. Kranert, M. (2021): Mikrokunststoffe in Komposten und Gärprodukten aus Bioabfallverwertungsanlagen und deren Eintrag in Böden-Erfassen, Bewerten, Vermeiden, Bioabfallforum 2021
[12] CIC (2020): Sintesi dei risultati del programma di monitoraggio CIC-COREPLA (2019-2020)

   a. provisions of the Landfill Directive 99/31, with particular reference to the obligation on pretreatment; in a few Member States, this is still not fully complied with (see e.g. the EU April Infringments Package)
   b. EU grant programmes for waste infrastructure, which in the past also funded management of mixed/ residual MSW, thereby keeping the cost of disposal comparatively low

4. The combination of 3a and 3b apparently exerts influence on costs of disposal in quite a few Member States, including Central Eastern and Southern European ones, where landfilling is still a relevant option for managing residual waste. As much as rejects may be considered as already "pretreated", their landfilling is most often costed at the same gate fees as waste that still must be pretreated (e.g. through MBT)
5. The cost of incineration, which is a major option for residual waste in many Western and Northern EU Countries, is driven upward by:
   a. tightening emissions standards as defined in the Incineration Directive, BATs, and BREFs
   b. carbon taxes, already adopted by a few Member States, and likely to cover incineration all over Europe in the mid term . It was calculated that the likely inclusion of incineration in the ETS may e.g., increase the cost of incineration, at current prices of CO2, by some 35-85 €/t
   c. similar to landfills, incineration was so far funded through EU grant programmes for waste infrastructure, thereby keeping the cost of incineration comparatively low
6. One of the most remarkable cost drivers in the near future is the fact that under all new EU granting programmes for waste infrastructures (e.g. Recovery Funds, Just Transition Funds, Regional Development Funds, apart from limited exceptions), mixed/residual waste management options will not be eligible for funding. Therefore, together with alignment of various Member states with requirements of the Landfill Directive, one may assume that trending costs across Europe will progressively align at higher levels than today.

With due consideration for all the foregoing points, the current "typical/average" cost of disposal of rejects, which are typically ranging from 50 €/t (in some Central Eastern and Southern European districts) to 120-150 €/t in some Western and Northern European districts (but also in most Regions in Italy), may be considered as temporary/transitional.
The ongoing trends, and foreseen effects of the cost drivers that were mentioned (inclusion of incineration in ETS, full enforcement of obligations stemming from the Landfill Directive, no grants available for either option any more etc.), will likely exert their effect while Europe fully deploys the potential of capturing food scraps, levelling costs of disposal of rejects at a higher level. For the sake of our calculations, we therefore adopted a reference/trending cost of 150€/t.

This is the final multiplier we may adopt to assess the potential economic benefit of grading the system up, from poor performing to well performing collection schemes, according to the following table.

Total potential trending cost (@ Eur 150/t) of disposal of rejects due to plastic contaminants:	€/year
2%	294,807,600
15%	2,211,057,000
Difference	1,916,249,400

Table 5: total potential savings moving from highest to least plastic contamination scenario (Eur/y in EU27+)

Recommendations

This study brings up evidence on the potential magnitude of environmental, operational, and economic impacts that might affect management of biowaste (and specifically, food waste) in the EU (+ UK and Norway). The difference between the worst and best scenario represents related potential benefits and savings, once strategies to minimise plastic contamination and rejects are properly defined and adopted. The magnitude of potential operational benefits (around 13 million tons/year of plastics that may more appropriately be reduced or recycled, instead of becoming rejects in compost/biogas sites, dragging a corresponding volume of biowaste and compost/digestate towards disposal) and economic benefits (which is in the region of 2 billion €/year) shows the issue isn't negligible at all, and it recommends a specific focus at EU level, in each country, and by local decision-makers.

Throughout this report, we have highlighted the factors that exert the highest influence on the issue. Correspondingly, we may define a set of recommendations in order to minimise contamination, related rejects, connected losses of biowaste and compost from the system, and related costs for disposal. They may be listed as follows:

1. **Adopt schemes that more solidly preserve the overarching principle of individual responsibility when delivering waste. In this respect, it is important to notice:**
   - door-to-door systems have largely proved to be remarkably better performing than bring banks, with regards to quality of collected materials (and to unit captures of food waste, too).
   - the foregoing is well displayed by studies that have compared performance indicators of either system in similar areas, as e.g. the Catalan and the Italian surveys mentioned in this report.
   - also, the design of performing schemes should always be supplemented by the needed education of households/users. Whilst education is not able to deliver high quality and maximized captures by itself, neither are kerbside schemes, if not supported by awareness-raising programs. Optimised design and operation of the scheme, and education of users should always supplement and reinforce each other.

2. **Ban the use of conventional plastic bags. Since in many local schemes dedicated bags are considered in order to maximise convenience, participation by households and subsequent captures, in such case mandate that such bags be biodegradable and may be composted or digested in dedicated sites to process organics. In regards to composting, they should be EN 13432-certified compostable bags (paper or compostable plastics); EU and CEN may wish to develop a similar standard for bags that may be processed at wet AD sites. Reported results from trials e.g., in Ireland have shown the tight correlation between adoption of biobags and reduced contamination levels. Also, national surveys from Italy seem to indicate (figure 6) lowest contamination when biobags are provided by municipalities, followed by schemes when compostable shopping bags are recommended for collection after use as a carrier bag, while highest contamination rates are connected to use of conventional plastic bags. Experiences in densely populated areas, such as Greater Milan, where 100% of municipalities have already implemented kerbside collection of food waste, confirm that low contamination rates may also be achieved in cities and densely populated areas, still with a fundamental role of biobags.**

3. Design out problem plastics that are more likely to be included in food waste. Items that after use are inherently including, or attached to, food waste, should be made compostable in accordance to standard EN 13432. Based on items most frequently found in food waste this may cover items such as:
   - fruit stickers
   - plastic tea bags
   - plastic coffee capsules/pods
   - sauce sachets

4. Adopt operational lay-outs at compost and biogas sites, that may minimise the "dragging factor", hence may rid biowaste and compost of impurities, while having least losses of biowaste and compost. Operational arrangements may differ in compost and AD sites, depending on the type of AD technology and related pretreatments, and on typical level and type of impurities in the given context.

5. The most impactful strategy of general validity will, however, be making management of rejects (and of unrecyclable waste in general) significantly more expensive, which should happen on account of the trending cost factors for incineration and landfilling highlighted in the previous section. Together with new targets for "preparation for reuse and recycling", which are based on the actually recycled materials and require to subtract process rejects, this may drive commitment by municipalities and site managers on quality of collection and operational efficiency of sites.

ECBPI is registered in the EU Transparency Register # 513420241041-72
Web: www.ecbpi.eu
Contacts:
newman@ecbpi.eu
ferrigno@ecbpi.eu