



**POLITECNICO**  
MILANO 1863

DIPARTIMENTO DI  
INGEGNERIA CIVILE E AMBIENTALE



**mater**

materia & energia da rifiuti  
materials & energy from refuse



Assessment on WAste  
and REsources

# HOW ARE BIOPLASTICS AFFECTING WASTE MANAGEMENT, PROCESSING AND WTE?

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10th CEWEP Waste-to-Energy Congress

*Berlin, June 16th, 2023*



## **Bioplastics NEWS**

### **Are Compostable Plastics Biodegradable and the Plastic Haters (FREE)**

Why are biobased and biodegradable plastic not part of the solution to reduce plastic waste?

Checking the facts!

### Managing and recovering bioplastics

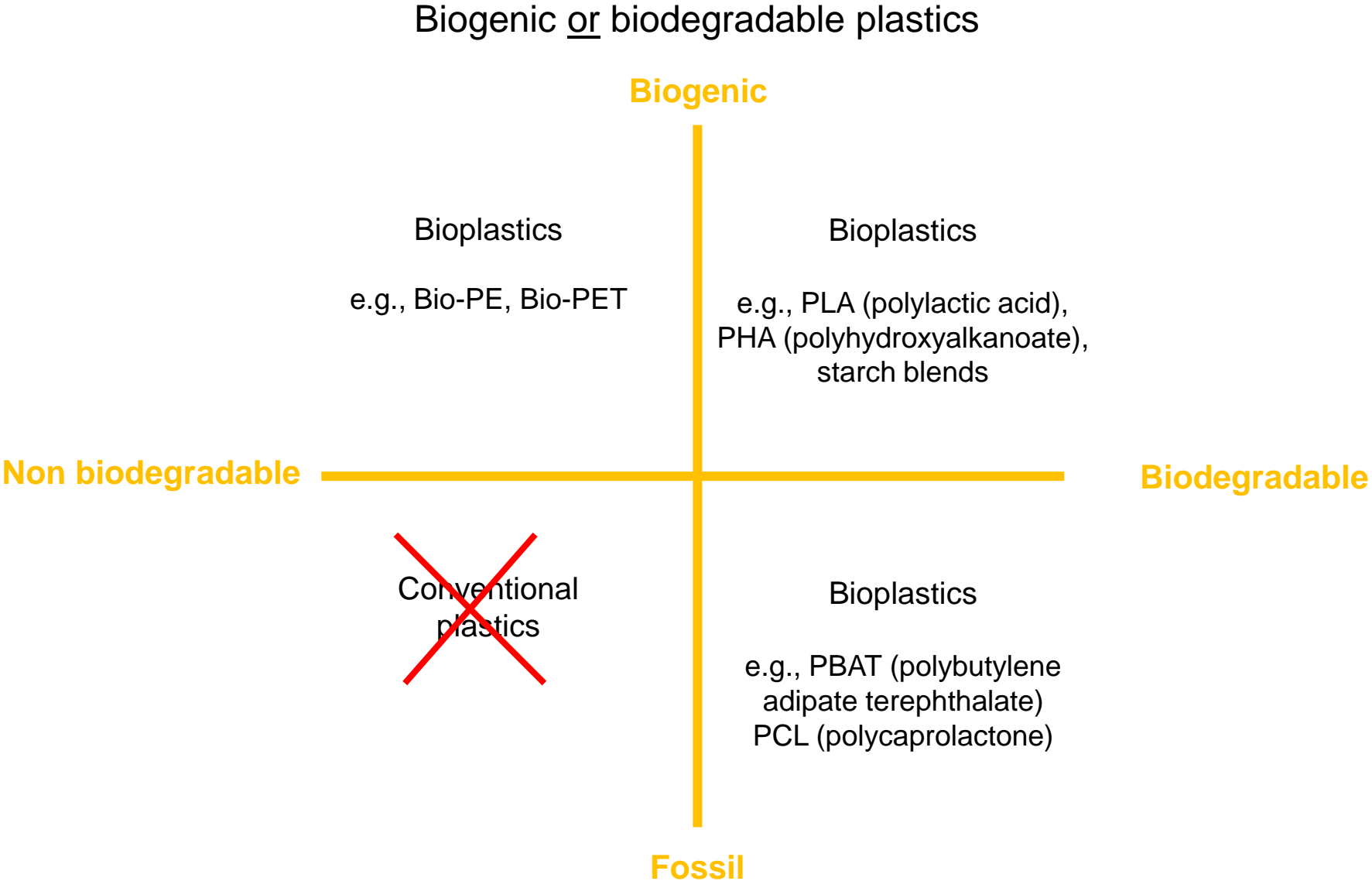


Utilitalia Position Paper adopted on January 21 2020  
by the Environment Board

*Since this option involves either designing new “greenfield” processes or technologies, or revamping old “brownfield” plants, it is clear that **no decision shall be made without ex-ante consultation with those who are responsible for managing waste.***

*Bioplastics need to be dealt with from all angles looking at all their implications, so as to shed light on **their real potentials as new materials**, without seeking to hide their **criticalities that have already propelled them to the forefront of the public agenda** in an attempt to achieve a shared strategy and an efficient management of their end-life cycle*

# Bioplastics





1. Food waste collection bags



2. Shoppers (bags used for the overall shop at the supermarkets)



3. Lightweight carrier bags ( $< 15 \mu\text{m}$ ), mainly for loose food

Ban of the use of conventional plastic bags

Decree 205/2010 and Law 28 of 24<sup>th</sup> March 2012 (2.)

Law 123 of 13<sup>th</sup> August 2017 (3.)



4. Bioplastic packaging (especially in the food sector) and disposable products, such as coffee capsules and tableware

EU Directive 2019/904 (**Single-Use Plastic Directive**) to reduce marine littering, primarily associated with the use of disposable plastic items

Ban of specific disposable plastic items, which can be replaced by other equivalent items available on the market  
(e.g., cutlery, straws, food and drinks containers)



Bioplastics products have been soaring significantly  
(allowed by the Italian transposition of the EU Directive\*)

Products made of compostable bioplastics:  
+120% (yearly) 2018-2020

\* according to the EU Directive no distinction is made between single-use biobased and conventional plastic products



### How can we manage the compostable bioplastic waste?

#### EUROPEAN UNION

According to the EU Directive 2018/851

*“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”*



#### ITALY, SPAIN

Biodegradable and compostable bioplastics **MUST** be conferred together with the organic waste



#### GERMANY, THE NETHERLANDS

Bioplastics packaging **NOT** allowed in the organic waste

The amount of compostable bioplastic managed by the Italian organic waste management system has rapidly increased

27,000 t - 1.5% of organic waste (2016)



**83,000 t - 3.9% (2019)**

**+ 210%**

The organic waste management system was not designed for bioplastics management



**Several issues arise:**

- **food waste collection**
- **pre-treatments**
- **biological processes**





## Bioplastic waste management: collection

Bioplastics have a **specific weight significantly lower** than that of organic waste (their volume per weight unit is considerably higher)



In the long term it could lead to **increasing waste collection costs**



Bioplastics are penalising when sent to a wet or semi-dry anaerobic digestion process



**Bioplastics must be generally removed before the digestion**



Removed bags show a relevant “**drag effect**”: among the residues there is a considerable amount of organic substance dragged due to bags shape



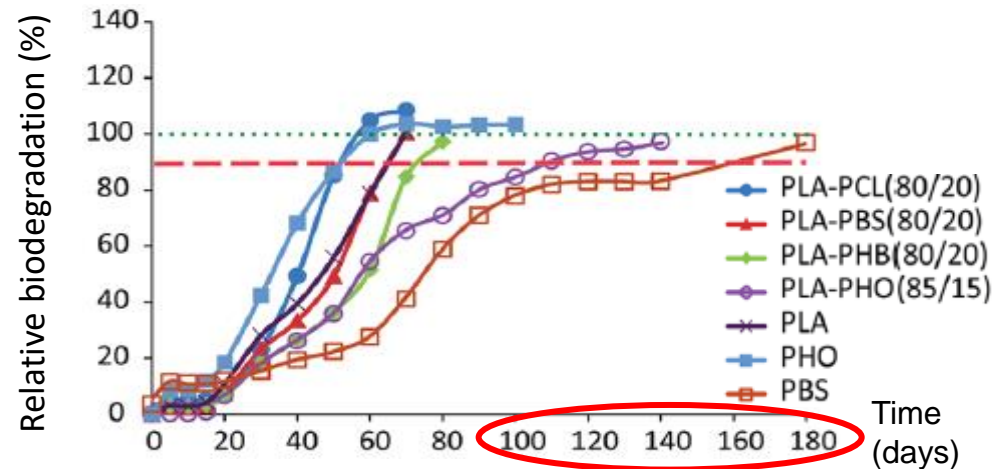
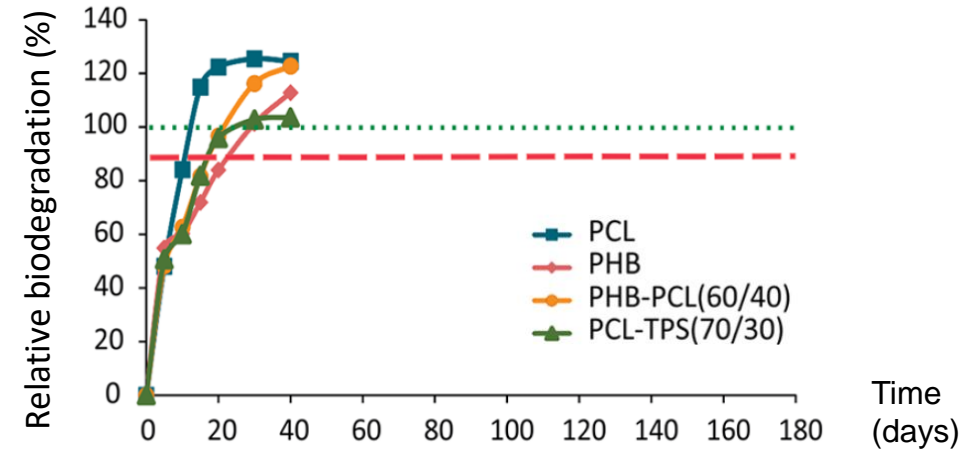
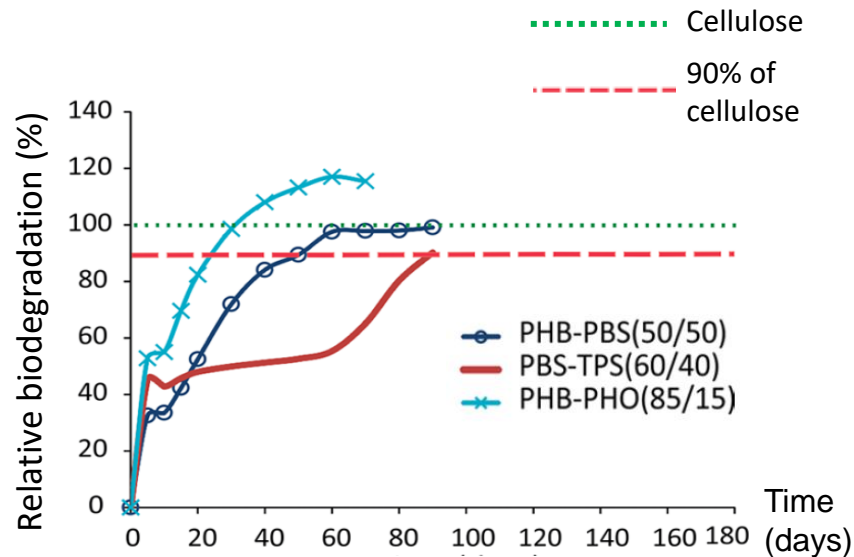
**RESIDUES of PRE-TREATMENTS → up to 20-25%**

# Bioplastic waste management: biological processes - composting

## Industrial composting

(UNI EN ISO 14855, 58°C, 180 days  
target: 90% of cellulose degradability)

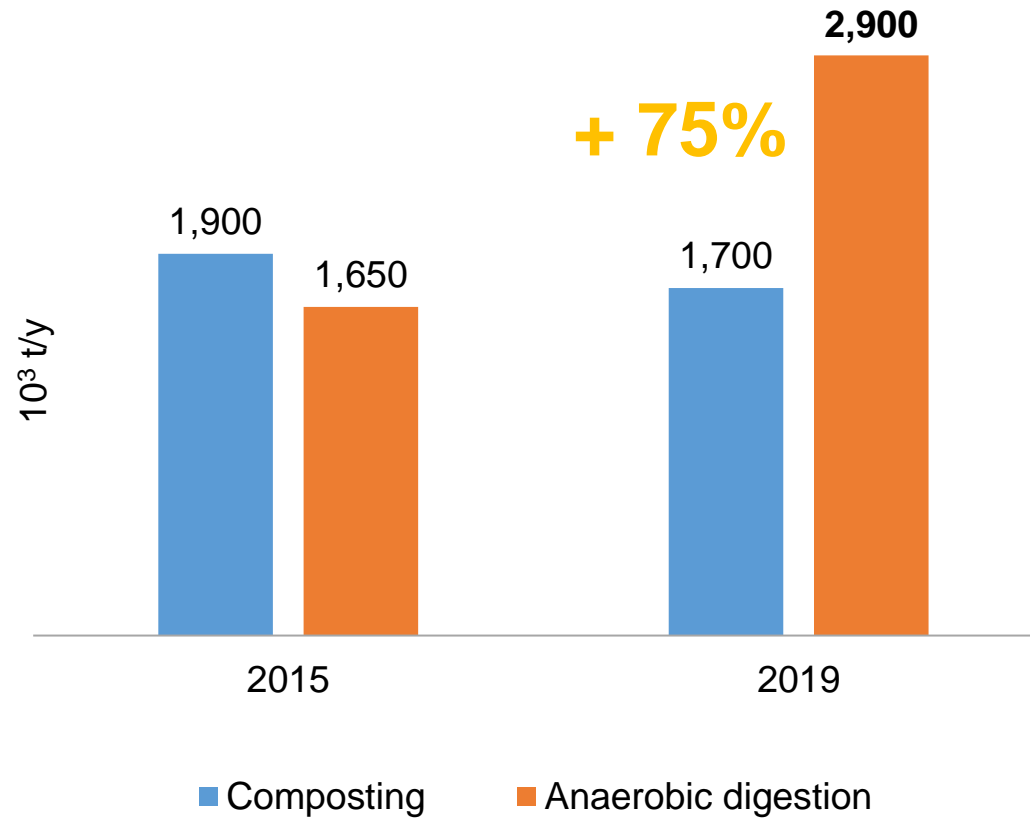
**All tested bioplastics  
achieve the biodegradation  
standard (but very different  
kinetics!)**



Narancic et al., 2018. Biodegradable Plastic Blends Create New Possibilities for End-of-Life Management of Plastics but They Are Not a Panacea for Plastic Pollution. Environ. Sci. Technol. 52, 10441-10452.

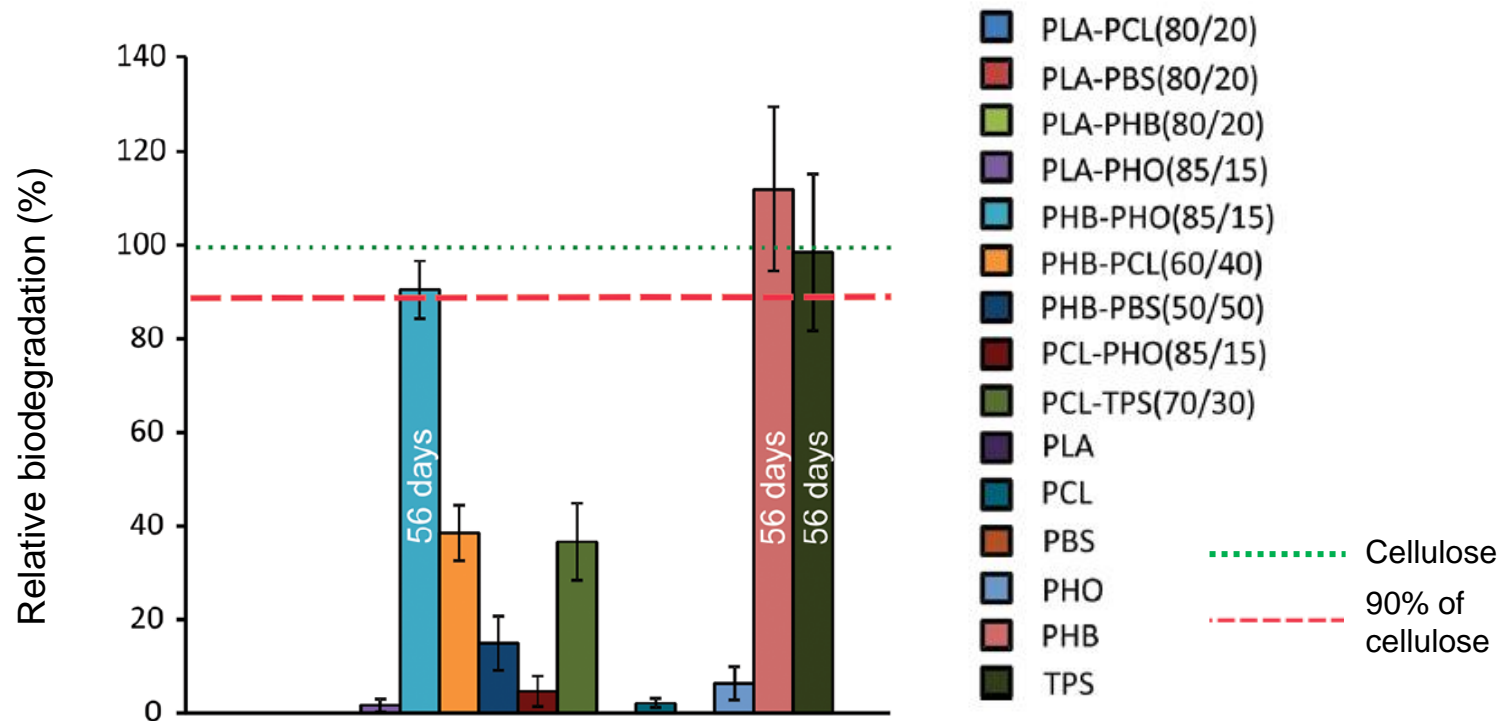
# Bioplastic waste management: biological processes - anaerobic digestion

In the last years, an increase of the amount of food waste sent to anaerobic treatment was observed in Italy (due to a more favourable energy balance and to the presence of economic incentives)



## Anaerobic digestion

(UNI EN ISO 14853:2018, mesophilic @35°C, wet)

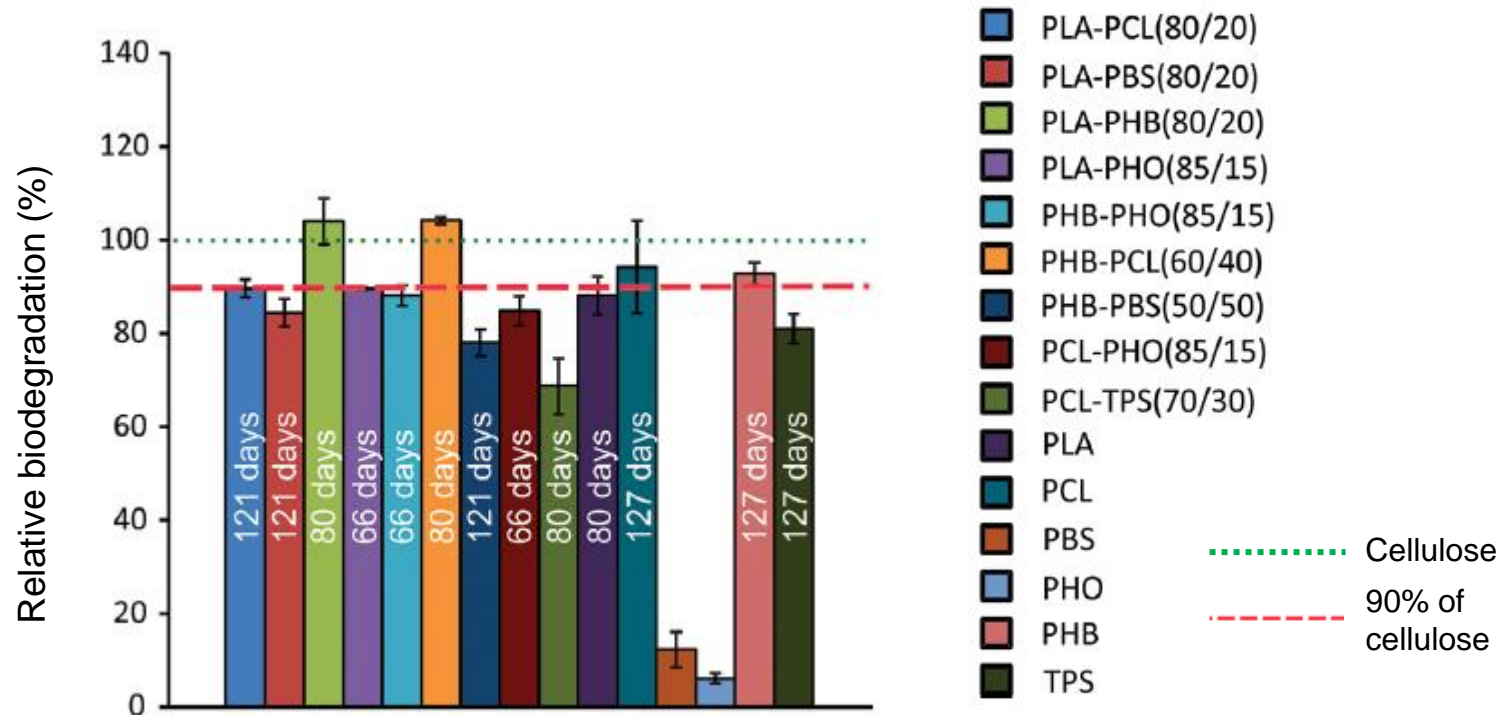


**Very limited degradation**

Narancic et al., 2018. Biodegradable Plastic Blends Create New Possibilities for End-of-Life Management of Plastics but They Are Not a Panacea for Plastic Pollution. Environ. Sci. Technol. 52, 10441-10452.

## Anaerobic digestion

(UNI EN ISO 15985:2018, termophilic @52°C, dry)

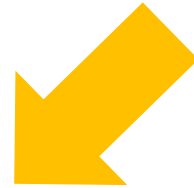


**Degradation time three to six times longer than the retention time in anaerobic digestion plants**

(20 - 30 days under thermophilic conditions)

Narancic et al., 2018. Biodegradable Plastic Blends Create New Possibilities for End-of-Life Management of Plastics but They Are Not a Panacea for Plastic Pollution. Environ. Sci. Technol. 52, 10441-10452.

Items made of compostable bioplastics are hardly distinguishable from products made of conventional plastic



Conventional plastic erroneously conferred with **organic waste** in Italy:

from 65,000 t (2017) to 90,000 t (2020)



Wrong deliveries of compostable bioplastics **in the flow of conventional plastics sent to material recovery**, generating **inefficiencies in the recycling processes**

## Are compostable bioplastics only found in the organic waste?



- Survey delivered to:
- 3 composting plants
  - 4 anaerobic digestion plants
  - 13 WTE plants
  - 11 plastic sorting plants

### SELEZIONE PLASTICA

Da compilare per ciascun anno

ANNO DI RIFERIMENTO	
---------------------	--

CARATTERISTICHE GENERALI DELL'IMPIANTO

Origine tipologia/quantità del rifiuto in ingresso a digestione (urbani, speciali, ecc) (*)		t/anno
---	--	--------

(\*) Esistono analisi del materiale in ingresso? Sono disponibili tali analisi?  
 E nota la quantità di bioplastica in ingresso all'impianto? \_\_\_\_\_  
 Come sono gestite le bioplastiche in impianto? \_\_\_\_\_

PRODOTTI E SCARTI DELL'IMPIANTO

Scarti (destinazione: _____) (**)		t/anno
-----------------------------------	--	--------

Output dell'impianto (specificare)

		t/anno
--	--	--------

(\*\*) Sono caratterizzati tali scarti (es: contenuto di bioplastiche)? Sono disponibili scarti sono trattati prima di essere inviati a successivo recupero/smaltimento? \_\_\_\_\_

### INCENERIMENTO

Da compilare per ciascun anno

ANNO DI RIFERIMENTO	
---------------------	--

CARATTERISTICHE GENERALI DELL'IMPIANTO

Origine tipologia/quantità del rifiuto in ingresso a digestione (urbani, speciali, ecc) (*)		t/anno
---	--	--------

(\*) Sono disponibili analisi merceologiche del rifiuto in ingresso in cui è rilevata la quantità di bioplastica in ingresso all'impianto? \_\_\_\_\_

Sono disponibili analisi di contenuto biogenico del rifiuto in ingresso? \_\_\_\_\_

### COMPOSTAGGIO

Da compilare per ciascun anno

ANNO DI RIFERIMENTO	
---------------------	--

CARATTERISTICHE GENERALI DELL'IMPIANTO

Tipologia di impianto (secco/semisecco/umido)		t/anno
---	--	--------

Origine tipologia/quantità del rifiuto in ingresso a digestione (frazione umida da RD, fanghi, ecc) (\*)

		t/anno
--	--	--------

Tipologia e quantità del rifiuto in ingresso a post-compostaggio

		t/anno
--	--	--------

Temperatura operativa digestione (°C)

		giorni
--	--	--------

giorni

in ingresso? Sono disponibili tali analisi? \_\_\_\_\_  
 compostabile? \_\_\_\_\_  
 ingresso all'impianto? \_\_\_\_\_  
 in ingresso all'impianto? \_\_\_\_\_  
 in impianto? \_\_\_\_\_

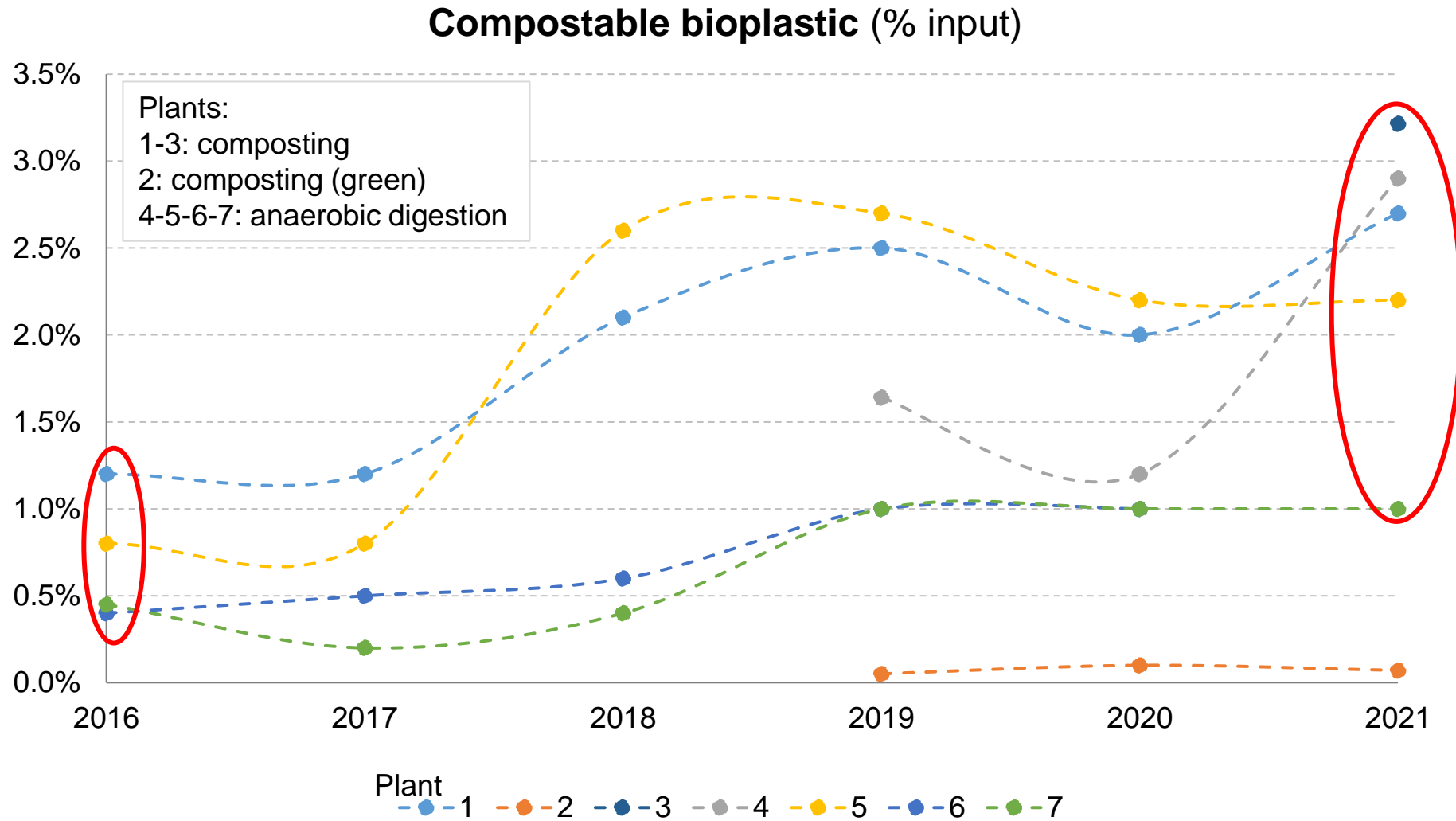
IMPIANTO

se: _____) (**)		t/anno
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bioplastiche)? Sono disponibili tali recupero/smaltimento? \_\_\_\_\_

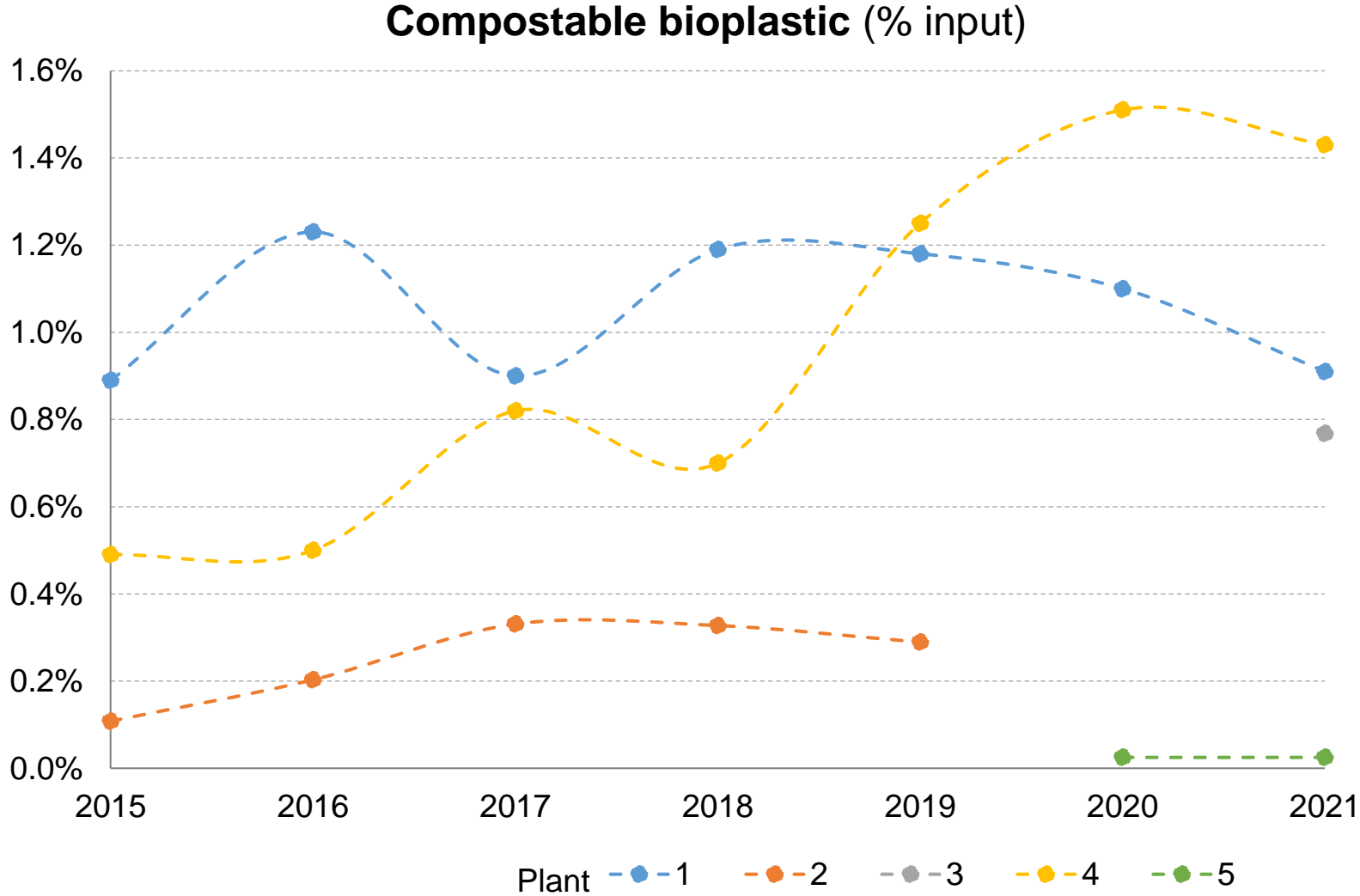


# Bioplastic in the waste management: composting and anaerobic digestion



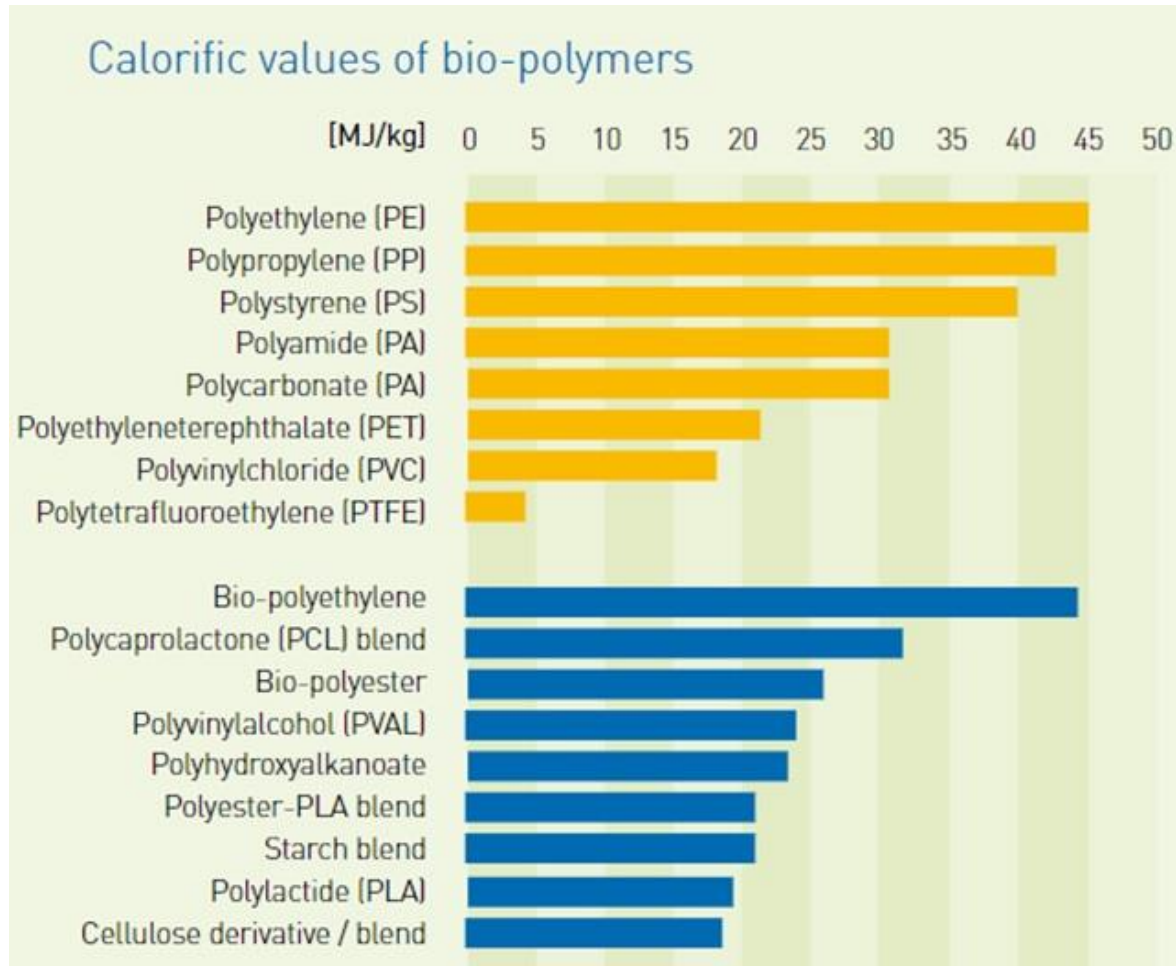
**Significant increase (up to 3.0%)**

# Bioplastic in the waste management: WTE plants



Significant increase / stable (up to 1.5%)

## Bioplastics sent to waste-to-energy plants



← Lower heating values (LHV) comparable/lower vs fossil polymers

**No issues on the operation of the plant!**

**Emission of biogenic CO<sub>2</sub> if biogenic origin**

Items made of compostable bioplastics are not always easily distinguishable from products made of conventional plastic



1.3% compostable bioplastics in the plastic separately collected

Existing sorting plants are not designed to implement their separation!

In PET and PP recycling  
1% of PLA → lower strength of PET and PP

In PET recycling  
0.1% of PLA → PET opacification  
0.3% of PLA → PET yellowing

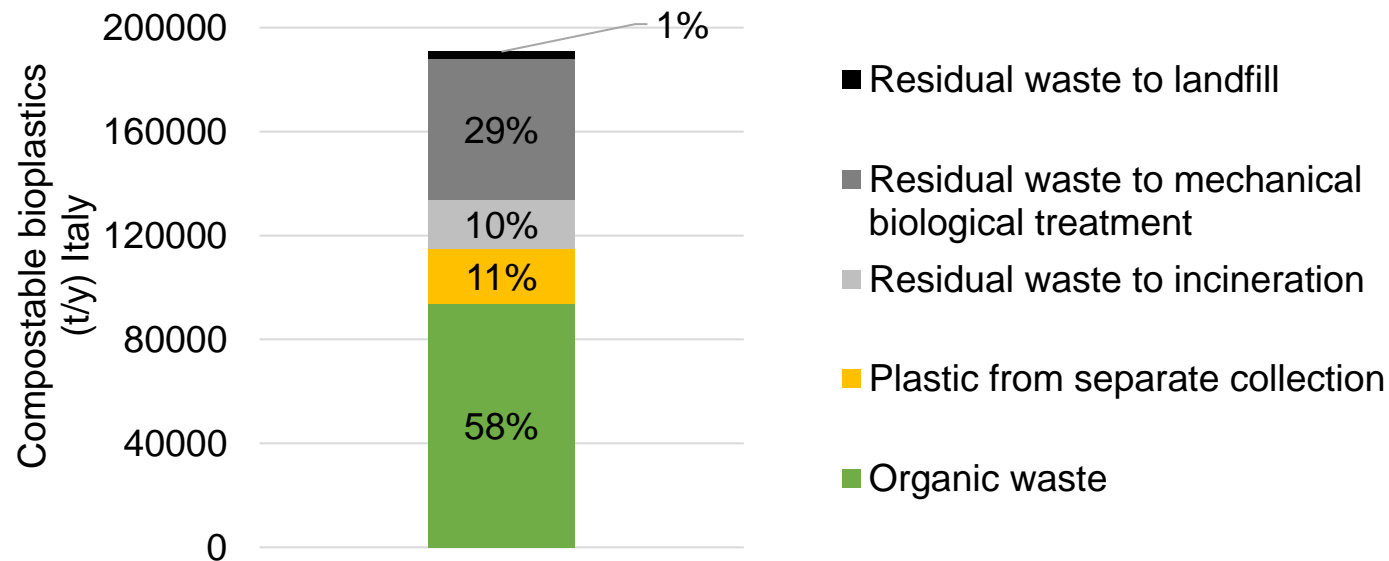
Wojnowska-Baryła I. et al., 2020. Effect of Bio-Based Products on Waste Management. Sustainability 12 (5), 2088.  
<https://doi.org/10.3390/su12052088>

Zhao X. Et al., 2020. Narrowing the Gap for Bioplastic Use in Food Packaging: An Update. Environmental Science & Technology 54, 4712-4732.  
<https://dx.doi.org/10.1021/acs.est.9b03755>

# Bioplastic in the waste management

Are compostable bioplastics only found in the organic waste? **NO**

FRACTION	COMPOSTABLE BIOPLASTICS	DESTINATION
Food waste	2.0%	Composting Anaerobic digestion
Residual waste	0.7%	WTE MBT (Mechanical-Biological Treatment) Landfill
Plastics from separate collection	1.3%	Plastic sorting



**Only 57% of compostable bioplastics to biological treatment!**  
**BAD?**  
**GOOD?**

ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale, 2021. Rapporto rifiuti urbani edizione 2021.

[https://www.isprambiente.gov.it/files2022/pubblicazioni/rapporti/rapporiorifiutiurbani\\_ed-2021-n-355-conappendice\\_agg18\\_01\\_2022.pdf](https://www.isprambiente.gov.it/files2022/pubblicazioni/rapporti/rapporiorifiutiurbani_ed-2021-n-355-conappendice_agg18_01_2022.pdf)

## Take home messages

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Bioplastic items are causing issues on the organic waste management system and in the plastic sorting

Biological processes should be adapted, mainly in terms of temperatures and residence times (thermophilic processes are more effective)

The combination of biological processes with thermal processes such as the hydrothermal carbonization can be effective

When alternatives are available, materials more compatible with biological treatments should be considered (e.g., paper bags for the food waste collection)

Other options for the management of bioplastics waste should be examined (e.g., incineration with energy recovery or material recovery)

The evaluation of the environmental aspects is essential (life cycle thinking perspective)

Editorial

## The challenges of bioplastics in waste management

# WM&R

Waste Management & Research  
1-2

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# THANKS YOU FOR YOUR ATTENTION!

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Dolci G., Venturelli V., Catenacci A., Ciapponi R., Malpei F., Turri S.E.R, Grosso M. 2022. Evaluation of the anaerobic degradation of food waste collection bags made of paper or bioplastic. *Journal of Environmental Management*, 305, 114331

Dolci, G., Catenacci, A., Malpei, F., Grosso, M. (2021) "Effect of Paper vs. Bioplastic Bags on Food Waste Collection and Processing" *Waste and Biomass Valorization*, 12(11), pp. 6293–6307

Dolci, G., Rigamonti, L., Grosso, M. (2021) "Life cycle assessment of the food waste management with a focus on the collection bag" *Waste Management and Research*, 39(10), pp. 1317–1327