EVALUATION OF THE PERFORMANCES OF PAPER AND BIOPLASTIC BAGS IN THE MANAGEMENT OF FOOD WASTE

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Framework of the research

The organic fraction (mainly constituted by food waste) is the most important municipal waste stream separately collected in Italy

Year 2018 ≈ 6,300,000 tonnes of organic waste

Different bag typologies, have an influence on the household storage and on the collection. Moreover, their interaction with the food waste treatment processes can be different

Materials currently employed for food waste collection bags in Italy:
- 56.2% bioplastic
- 0.5% paper
- 43.3% plastic (not suitable for the subsequent treatments)


Examined bag typologies

- **Bioplastic** bags:
  - specifically designed for the food waste collection ➔ DEDICATED
  - conventional shopping bags that can be re-used for the collection of food waste ➔ SHOPPER

- **Bags made of recycled paper** with reinforced cartonboard bottom manufactured for the food waste collection
Household storage analysis

Evaluation of the waste weight loss for paper and bioplastic bags
(more than 140 domestic tests performed in parallel)

Before each bag filling:
• homogenisation of generated food waste;
• subdivision of food waste in two portions with the same weight;
• discharge of the two portions in the paper and in the bioplastic bag

After the end of each test (120 hours), the weight loss with respect to the inserted waste is evaluated

This aspect affects the amount and potentially the quality of waste that is subsequently collected, transported, and sent to treatment plants
Household storage analysis - results

**Weight loss**

**WINTER**: +40% (paper vs dedicated) +63% (paper vs shopper)

**SPRING**: +29% / +49%

**SUMMER**: +17% / +42%

**AUTUMN**: +31% / +39%
Food waste treatment analysis

In the last years, an increase of the amount of food waste sent to integrated (anaerobic + aerobic) or anaerobic treatment was observed in Italy:

1,630,000 tonnes (2015) ➔ 2,390,000 tonnes (2017) + 47% 

This amount has gone over the amount of food waste sent to aerobic treatment (composting):

1,900,000 tonnes (2015) ↔ 1,920,000 tonnes (2017)

Evaluation of the collection bag influence on the anaerobic digestion process

Food waste treatment analysis - BMP tests

Evaluation of the anaerobic degradability of collection bags

**BMP (Biochemical Methane Potential) tests**

Evaluation of:
- the potential biomethane production under anaerobic conditions
- the degradation kinetics

Two different **TEMPERATURE** conditions:
- mesophilic (35° C)
- thermophilic (50° C)

**SUBSTRATES** cut in square pieces of 0.5 cm side:
- paper bag
- bioplastic dedicated bag
- bioplastic shopper bag
BMP tests - **mesophilic** conditions - results

Significant difference between the two examined materials

Kinetics → paper: 90% BMP in the first 10 days

<table>
<thead>
<tr>
<th>Bioplastic vs paper</th>
<th>Bioplastic shopper</th>
<th>Bioplastic dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>-68%</td>
<td>-79%</td>
<td></td>
</tr>
</tbody>
</table>
BMP tests - thermophilic condition - results

Final BMP of paper and bioplastic dedicated bags very similar (but different kinetics).

Important difference between paper and bioplastic shopper bags still observed.

<table>
<thead>
<tr>
<th>Bioplastic vs paper</th>
<th>Bioplastic shopper</th>
<th>Bioplastic dedicated</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>-51%</td>
<td>-0.1%</td>
</tr>
</tbody>
</table>
Evaluation of the environmental performances of the overall food waste treatment chain

LIFE CYCLE ASSESSMENT methodology

Comparative study for the two typologies of collection bag (paper and bioplastic dedicated / shopper)

FUNCTIONAL UNIT: the management of 1 ton of food waste generated (i.e. inserted into the collection bag) at the household

Non-compostable materials discarded together with food waste by mistake are excluded because their amount is assumed not to be affected by the different compared bags
LCA - system boundary

Bioplastic production → Bag packaging production → Transportation → Collection bag manufacturing and packaging → Paper bag production

Collection bag distribution

Collection bag use

Food waste collection and transportation to treatment plants (anaerobic digestion)

Food waste anaerobic digestion → avoided electricity generation (biogas energy recovery)

Discarded bag transportation (including food waste dragged by the bag)

Residues incineration → avoided electricity and heat generation / landfill → avoided electricity generation

Only for the paper bag system

Only for the bioplastic bag system

Food waste → avoided mineral fertilisers and peat use (compost use)

Bioplastic production

Recycled paper production

Bioplastic bag production

Collection bag manufacturing and packaging

Paper bag production

Collection bag distribution

Collection bag use

Food waste collection and transportation to treatment plants (anaerobic digestion)

Discarded bag transportation (including food waste dragged by the bag)

Residues incineration → avoided electricity and heat generation / landfill → avoided electricity generation
## LCA - results

<table>
<thead>
<tr>
<th>Impact category</th>
<th>BIOPLASTIC DEDICATED vs REC. PAPER * EPD approach (Environmental Product Declaration)</th>
<th>BIOPLASTIC DEDICATED vs REC. PAPER * PEF approach (Product Environmental Footprint)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>+19%</td>
<td>+12%</td>
</tr>
<tr>
<td>Ozone depletion</td>
<td>+44%</td>
<td>+28%</td>
</tr>
<tr>
<td>Ionising radiation, human health</td>
<td>+150%</td>
<td>+84%</td>
</tr>
<tr>
<td>Photochemical ozone formation</td>
<td>+20%</td>
<td>-1%</td>
</tr>
<tr>
<td>Respiratory inorganics</td>
<td>+18%</td>
<td>-13%</td>
</tr>
<tr>
<td>Human toxicity, non-cancer effects</td>
<td>+117%</td>
<td>-3%</td>
</tr>
<tr>
<td>Human toxicity, cancer effects</td>
<td>+66%</td>
<td>+47%</td>
</tr>
<tr>
<td>Acidification</td>
<td>+92%</td>
<td>+12%</td>
</tr>
<tr>
<td>Eutrophication, aquatic freshwater</td>
<td>+78%</td>
<td>+16%</td>
</tr>
<tr>
<td>Eutrophication, aquatic marine</td>
<td>+104%</td>
<td>+77%</td>
</tr>
<tr>
<td>Eutrophication, terrestrial</td>
<td>+28%</td>
<td>-3%</td>
</tr>
<tr>
<td>Ecotoxicity freshwater</td>
<td>+107%</td>
<td>+70%</td>
</tr>
<tr>
<td>Land use</td>
<td>+452%</td>
<td>-53%</td>
</tr>
<tr>
<td>Water use</td>
<td>+1350%</td>
<td>+231%</td>
</tr>
</tbody>
</table>

Potential impact change = (Bioplastic system - Paper system) / |Paper system|

**BIOPLASTIC DEDICATED vs PAPER**

Relevant **impacts increase for all the impact categories** (EPD approach)

Impacts increase for most of the impact categories (PEF approach)
Conclusions

Tests (household storage + BMP) and LCA results: different behaviour between paper and bioplastic bags

Future steps: evaluation of the influence of the collection bag typology on the full scale anaerobic digestion process

Plastic and bioplastic bags are penalising when food waste is sent to a wet or semi-dry anaerobic digestion process

They must be generally removed before the digestion dragging a considerable amount of organic substance due to bags shape.
THANK YOU FOR YOUR ATTENTION

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