Combining circularity and LCA: Quality assessment and substitutability of recycled plastic from HHW

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Combining circularity and LCA: Quality assessment and substitutability of recycled plastic from household waste

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**Substitutability and plastic waste**

Plastic from household waste (HHW) is heterogeneous and dirty → reduced quality or functionality

The substitutability, \( \alpha \), is important for environmental performance of plastic recycling and depends on the functionality, \( \phi \) (Vadenbo et al., 2016).[^1]

\[
\alpha_{\text{rec:disp}} = \frac{\phi_{\text{rec}}}{\phi_{\text{disp}}} \quad \text{(Recycled plastic)} \quad \frac{\phi_{\text{disp}}}{\phi_{\text{disp}}} \quad \text{(Dispelled plastic)} \quad \text{(virgin)}
\]

Functionality = ability to fulfill the demands on the market (Eriksen et al., 2018).

Quantified from the quality, \( Q \), (step 1) and market shares, \( MS \), (step 2):

\[
\alpha_{\text{rec:disp}} = \frac{MS(Q)_{\text{rec}}}{MS(Q)_{\text{disp}}} \quad \text{(Always for virgin plastic)}
\]

* For use in LCA. Also called substitution ratio, B-factor, etc.

**Step 1: Quality identification**

- **Quality = potential applicability** of the recycled plastic (in what applications can the material substitute virgin plastic?)
- Eight applications were divided into three quality levels based on strictness of legislation regarding chemical composition (see table).
- The applicability can be found from contamination of plastic waste after sorting and before reprocessing

<table>
<thead>
<tr>
<th>Applications</th>
<th>Quality</th>
<th>Legislation strictness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food packaging</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Toys, electronics, pharmaceuticals</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Construction, Non-food packaging, automotive, all others</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

The table shows:
- The market share [%] of the different applications on the individual polymer markets relevant for plastic in HHW.
- The corresponding MS value [-] for \( Q = \) high, medium and low for all recycled polymers.

The MS value represents the part of the market in which the material in question can substitute virgin material and thereby close the loop.

**Step 2: Quantification based on market shares - Example**

The table shows:
- The market share [%] of the different applications on the individual polymer markets relevant for plastic in HHW.
- The corresponding MS value [-] for \( Q = \) high, medium and low for all recycled polymers.

The MS value represents the part of the market in which the material in question can substitute virgin material and thereby close the loop.

**Example (PET from HHW):**

Source separated mixed PET from HHW (including high quality plastic in food packaging and low quality in bottles for soaps) recycled into low quality PET.

\[
Q_{\text{rec}} = \text{Low}, \quad Q_{\text{disp}} = \text{High}
\]

\[
\alpha_{\text{rec:disp}} = \frac{0.43}{1} = 0.43
\]

**Discussion and conclusion**

- Recycling of plastic from household waste into high, food-grade quality is necessary to close the individual polymer loops.
- Especially, a large part of the PET and LDPE market rely on high quality food packaging → the substitutability for medium and low quality recycled material is considerably lower than values previously used in LCA literature.
- Mixed plastic from HHW are currently not recycled into high quality -> separate collection through refund deposit systems does.

**References**


**Acknowledgement and contact**

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