ENVIRONMENTAL CONSIDERATIONS ON MSW COLLECTION:
A LOCAL CASE OF STUDY THROUGH LCA APPLICATION

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Case of study

- Life cycle assessment of residual MSW collection in the city of Aveiro (Portugal)
  - Located in Atlantic coast
  - Medium sized city in Portugal: 80,000 inhabitants
  - Industrial, trade, academic and touristic hub
Case of study

• The city is currently interested in a transition towards a *pay-as-you-throw* pricing scheme for mixed MSW collection.

• A neighbourhood (Forca Vouga), separated from main urban core, was designated as pilot testing area.

• Residential area: roughly 1200 inhabitants, mainly young medium-income families. There are also some shops, offices and bars / cafes
Goal and scope

• Prior to the implementation of the new policy, a thorough assessment of the waste management environmental performance is required in order to set a starting baseline.
• This study represents the first part of the environmental assessment, encompassing only the residual MSW collection system.
• Environmental impacts of residual MSW collection system were analysed for a one year timeframe.
Goal and scope

- The selected functional unit corresponds to the annual production of residual MSW in the neighbourhood.
- During four days, the daily residual MSW generated were collected by a single vehicle and weighted.
- The experimental values were then extrapolated to a whole year generation. Historical data records were requested from the municipality to take into account weekly and monthly variations.
- Result: 347 tonnes MSW per year (estimated density: 75 kg/m³).
Goal and scope

- The residual MSW collection process was disaggregated into its main constituent elements to allow separate analysis.
- Definition of the studied system with boundaries:
Life cycle inventory

• Data concerning MSW collection process were obtained from the municipality of Aveiro at whole city level, and then adapted to the scale of the studied neighbourhood.

• All other information relative to raw materials, production processes and pollutant emissions associated to the elements previously described was obtained from the respective producers and reference lifecycle databases, namely ecoinvent 3.3.
## Life cycle inventory

<table>
<thead>
<tr>
<th>Unit process</th>
<th>Weight per unit</th>
<th>Units per FU</th>
<th>Lifespan</th>
<th>Materials</th>
<th>Amount per FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier bags (30L)</td>
<td>8.7 g</td>
<td>154,222</td>
<td>----</td>
<td>HDPE</td>
<td>1370 kg</td>
</tr>
<tr>
<td>Household bins (30L)</td>
<td>0.75 kg</td>
<td>776</td>
<td>7 years</td>
<td>PP</td>
<td>83.6 kg</td>
</tr>
<tr>
<td>Street containers (800 L)</td>
<td>43 kg</td>
<td>26</td>
<td>14 years</td>
<td>HDPE</td>
<td>70.3 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Steel</td>
<td>8.2 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aluminium</td>
<td>1.0 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rubber</td>
<td>2.5 kg</td>
</tr>
</tbody>
</table>

- 23% of carrier bags is assumed to be recovered for recycling, while the rest is landfilled.
Life cycle inventory

<table>
<thead>
<tr>
<th>Unit process</th>
<th>Components</th>
<th>Consumption rate</th>
<th>Amount per FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW collection activity</td>
<td>Collection lorry</td>
<td>2.53 \cdot 10^{-6} \text{ parts/tonne}</td>
<td>8.78 \cdot 10^{-4} \text{ parts}</td>
</tr>
<tr>
<td></td>
<td>Diesel fuel</td>
<td>4.2 \text{ L/tonne}</td>
<td>1457 \text{ L}</td>
</tr>
<tr>
<td></td>
<td>Transport distance</td>
<td>5.6 \text{ km/tonne}</td>
<td>1943 \text{ tkm}</td>
</tr>
</tbody>
</table>

- The inventory of emissions from ecoinvent 3.3 was adapted according to the actual consumption rates in this case.
- Indirect emissions were calculated following the EMEP/EEA guidelines
Methodology

• The impact assessment was performed using the commercial software SimaPro version 8.2.0.
• The impact assessment method chosen was the ReCiPe Midpoint (Hierarchist) version 1.12.
Results

Climate change
- Carrier bag: 50%
- Household dustbin: 5%
- Street container: 10%
- Waste collection with lorry: 35%

Photochemical oxidant formation
- Carrier bag: 45%
- Household dustbin: 5%
- Street container: 10%
- Waste collection with lorry: 40%

Terrestrial acidification
- Carrier bag: 45%
- Household dustbin: 5%
- Street container: 10%
- Waste collection with lorry: 40%

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Results

Mainly due to disposal in landfill

Fossil depletion
Freshwater ecotoxicity
Freshwater eutrophication

- Carrier bag
- Household dustbin
- Street container
- Waste collection with lorry

NAXOS2018
Results

• Three examples of household waste carrier bags of common sizes were compared: 20L, 30L and 50L.

• Weight of each bag varied with size:
  – Bag 20L: 7.0 g
  – Bag 30L: 8.7 g
  – Bag 50L: 17.0 g
Results

Bag size comparison

- Climate change
- Fossil depletion
- Freshwater ecotoxicity
- Freshwater eutrophication
- Photochemical oxidant formation
- Terrestrial acidification

Bag sizes: 20L, 30L, 50L

NAXOS2018
Results

- Three alternative raw materials for household waste carrier bags were also compared:

<table>
<thead>
<tr>
<th>Type of bag</th>
<th>Material</th>
<th>Capacity (L)</th>
<th>Weight (g)</th>
<th>End of life</th>
<th>Biodegradability (in 100 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional HDPE bag</td>
<td>HDPE</td>
<td>30</td>
<td>8.7</td>
<td>23% recycling 77% landfill</td>
<td>~0%</td>
</tr>
<tr>
<td>100% recycled HDPE bag</td>
<td>HDPE (recycled)</td>
<td>30</td>
<td>8.7</td>
<td>23% recycling 77% landfill</td>
<td>~0%</td>
</tr>
<tr>
<td>Biodegradable bag</td>
<td>Starch-polyester bioplastic</td>
<td>25</td>
<td>10.9</td>
<td>100% landfill</td>
<td>27%</td>
</tr>
</tbody>
</table>
Results

Bag material comparison

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>Conventional HDPE bag</th>
<th>Biodegradable bag</th>
<th>100% recycled HDPE bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fossil depletion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Freshwater ecotoxicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshwater eutrophication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photochemical oxidant formation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrestrial acidification</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NAXOS2018
Results

• The fuel consumption rate provided by the municipality was compared with the reference given in ecoinvent 3.3 database to check the influence of this parameter:
Results

Fuel consumption data comparison

- Climate change
- Fossil depletion
- Freshwater ecotoxicity
- Freshwater eutrophication
- Photochemical oxidant formation
- Terrestrial acidification

Aveiro City Council vs ecoinvent 3.3
Conclusions

- The use of conventional HDPE plastic bags for household waste collection and transport might lead to relevant environmental impacts, they are even the highest contributor in some categories.
- Impacts from bags are mainly due to the consumption of non-renewable raw materials for production and to environmental consequences of their landfilling.
- Even though there are collection schemes which skip their use, there is not a clear alternative to replace plastic bags with the same hygienic advantages. Notwithstanding, enhancing their recycling seems a suitable way to reduce impacts.
Conclusions

• Along with plastic bags, diesel fuel consumption is the other major source of environmental concern in MSW collection.
• Fuel consumption is found to be highly related to the site-specific conditions of each location. Therefore, it is recommended to gather local based data when possible.
• Switching to cleaner fuels, or to electric driven vehicles, might be an alternative to reduce the environmental impact of vehicles. Nevertheless, the optimisation and reduction of excessive collection frequencies should be the first option to explore.
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