Environmental evaluation: Comparative study of bags

Verified by the critical review panel
Critical review panel

The Eco-Efficiency Analysis was critically reviewed by an independent external review panel consisting of the following organizations:

- DEKRA
  Alles im grünen Bereich.

- Öko-Institut e.V.
  Institut für angewandte Ökologie
  Institute for Applied Ecology

- Witzenhausen-Institut

- ETH
  Eidgenössische Technische Hochschule Zürich
  Swiss Federal Institute of Technology Zurich
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Introduction: Objectives and use of the study

• **Reason**
  – Transparency - the study is primarily intended to provide information to the public on the environmental performance over the life cycle of bags made of different materials

• **Purpose**
  – The aim of the analysis is to demonstrate the most eco-efficient life cycle for bags, the “2-in-1” concept: transportation of staple goods, reuse and disposal of organic waste, NOT the comparison of materials of bags
  – To exhibit the environmental benefits of promoting compostable bags for organic waste recycling as a pillar of the Roadmap to a Resource-Efficient Europe

• **Use**
  – Adequate communication tool for policy makers and NGOs
**Introduction: Methodology**

- The study is based on the Eco-Efficiency methodology developed by BASF to assess the life cycle of all materials and energy required to fulfill a defined customer benefit (functional unit).

- The environmental analysis follows the ISO standards 14040 and 14044 for life cycle assessment. The BASF Eco-Efficiency methodology goes beyond the standards by including life cycle costs and weighting to derive an environmental fingerprint as well as an overall environmental impact. It follows the ISO 14045.

- The methodology has been validated by the German TÜV in 2002 and by the US National Sanitation Foundation (NSF) in 2009.

*Note: This methodology was used by the "Öko-Institut" (Institute for Applied Ecology)" in Freiburg, Germany and in different Plastics Europe (formerly APME) studies. Öko-Institut uses a similar methodology with a different weighting system ("Ecograde"). TNO in the Netherlands uses the BASF standard method with a different weighting system. The Wuppertal Institute on the method: "Basically, the large number of indicators used in the eco-efficiency analysis of BASF make relatively reliable statements possible ...". The method was initially developed by BASF and Roland Berger Consulting, Munich.*
Study set-up: Customer benefit and alternatives

Customer benefit:
Transportation of 10kg staple goods from supermarket to home, reuse of bag and disposal of 2.5kg organic waste

Bag made of paper
Bag made of virgin PE
Bag made of PE (25% recycled)
Bag made of BASF ecovio® F film
Bag made of BASF ecovio® FS film

Note:
The customer benefit: “Transportation of 10kg staple goods from supermarket to home, reuse of bag and disposal of 2.5 kg organic kitchen waste” is considered during the whole life cycle.
Bags considered in this study are designed to carry max. weight of ca. 13kg and max. volume of ca. 23l.
Reuse is 1.5 times for paper bags and 2.5 times for plastic bags. Source: TNS Infratest: BASF Bio Bang Verhalten im Bereich „Bio-Müll“, Akzeptanz & Attraktivität biologisch abbauberer (Einkaufs-)Tüten/Verpackungen. 21.10.2010
Organic waste collected in bags weights 2.5kg. Source: Witzenhausen Institute. Main premises: total food waste collected in Germany in 2010 was 4.204,3 kt., 36.6 Million people have access and use properly organic waste management system, 2,2 people considered in a household, collection on weekly basis.
Study set-up: System boundaries example
Study set-up: Modelling the end-of-life (Organic Waste Flow) for the alternatives

National Model

Base Case

Assumptions:
Use of ecovio® bags increases organic waste collection on the national level to 70% only. Reference: The Berlin project, Kanthak & Soeling, Müll und Abfall, August 2012

Only 10% of German population uses compostable bags for organic waste collection. Reference: Witzenhausen Institut

Credits for energy recovery: Energy recovery data are reported separately in the Ecoinvent documentation for organic waste (5.1 MJ/kg). This number is derived from the wooden parts in organic waste. Calorific value of kitchen waste is lower than the value given for organic waste (3.6 MJ/kg). Energy recovery by incineration of organic waste equals therefore the energy needed to run the incineration process. Source: Witzenhausen Institut

Credits for composting: credits for using compost as substitute for fertilizer are assigned to composting process of organic waste. Credits are not assigned to composting of biodegradable bags, since the bags decompose into carbon dioxide and water.

Collection of food waste: the average increase of the collection rate due to ecovio® bag is 20% on the household level, having that 10% of the German population uses these bags leads to a 2% increase on the national level. This reflects real world conditions.
National model - base case / Environmental fingerprint

Results and Discussion

Methodology:
Values for environmental impact categories are normalized - the least favorable alternative is assigned a value of 1; the other alternatives are arranged on an axis ranging from 0 to 1. Since these are not absolute values, the relevance of the environmental impact differs among the categories. Aggregated and weighted data are presented in the environmental assessment portfolio.

Outcome:
Ecovio® bags have environmental advantages over PE bags in the categories resource consumption, energy consumption and emissions. Land use and accidents are directly related to renewable feedstock and farming - sustainable supply chain.

Decisive factors for each category:
- Energy: bag material production & cleaning the organic waste bin.
- Land use: occupation of land for materials, type of land.
- Resources: materials and cleaning the bin.
- Risk potential: work in the field for material production.
- Toxicity: pre-chains.
- Emissions: e.g. carbon footprint - dominated by the organic waste disposal, water consumption relevant for the result.
National model - base case & vision ecovio® / Environmental fingerprint

Results and Discussion

Key drivers for the environmental impact in all considered categories are: a) functionality of the material - composting or incineration at end-of-life, and b) reuse rate of the bags.

Food waste management drives the results of the study and emphasize the added value of compostable material in the application where it makes sense.

Vision ecovio® case compared to the Base case: Progress in categories resource consumption and emissions for ecovio® due to the benefits for transforming organic waste into compost instead of organic waste incineration. Occupational illnesses and accidents are statistically higher in composting plants than in incineration plants, but the absolute values are insignificant for the overall environmental performance. Other impact categories remain unchanged.

Citizens who collect organic waste in compostable ecovio® bags; 70 % of organic waste is composted, 30 % incinerated

All citizens who collect organic waste use compostable ecovio® bags; 100 % of organic waste is composted, 0 % incinerated
National model - base case & vision ecovio® / Environmental evaluation

Results and Discussion

Methodology:
Impact categories are weighted and aggregated to demonstrate the overall environmental performance.

Base case:
Evaluating the current situation, it was shown that even on this small purchase/usage scale ecovio® F bag is the most favorable alternative from a pure environmental perspective, followed by PE and ecovio® FS grade bag with higher renewable content; however all alternatives are considered to be comparable from an LCA perspective (methodological non-accuracy of 10-20%).

Vision ecovio® case:
Considering the fact that all Germany has to separate organic waste as of 2015 and thus looking into solutions for clean disposal and collecting as much organic waste as possible, compostable plastic bags should be considered as a strategic solution. The vision ecovio® case reflects the positive effects of using more “2-in-1” bags in order to achieve the ideal scenario of fulfilling the national target by showing better environmental performance compared to PE and paper bags.

Citizens who collect organic waste in compostable ecovio® bags; 70 % of organic waste is composted, 30 % incinerated

All citizens who collect organic waste use compostable ecovio® bags; 100 % of organic waste is composted, 0 % incinerated
Model household: Results and discussion

Retailers & End-users – Way forward

3 parameters were found to be crucial for improving the environmental performance of ecovio® bags:
EDUCATION, CONVENIENCE AND ACCEPTANCE OF ORGANIC WASTE COLLECTION.

Model description:
Model household considers the impact of all households purchasing ecovio® bags; include the purchase decision rate of biodegradable bags into this step.
Target audience for this model are retailers & end-users and the result could be a message on the bag, promoting the impact of the consumer, buying this bag and using it for organic waste collection.

Results:
The analysis shows that the increased use of ecovio® bags due to information and education, the increased collection rate due to the beneficial performance of the ecovio bag, as well as the increased composting rate due to the infrastructure and the public acceptance lead to significant environmental benefits for ecovio® bag compared to PE or paper bags.
The highest influence has the share of composting.
**Conclusion**

- **Summary**
  - Organic waste collection contributes to resource efficiency and the creation of a bioeconomy
  - Compostable bags help increase volumes in separate organic waste collection

- **Recommendation**
  - Exempt compostable bags from economic instruments and market restrictions
Life Cycle Assessment results
Cumulative energy demand

Weighting factor 12%
Cumulative energy demand: Comments

- The highest contribution to cumulated energy demand is linked to carrier bag material.
- Energy consumption of bag production is rather small.
- Contribution from transportation is negligible (under basic scenario assumptions).
- The production of a paper bag has the highest cumulative energy demand, due to material quantity and the less re-use phases compared to plastic bags. Paper bags are also heavier than plastic bags at comparable performance.
- Energy consumption linked to material is lowest in case of ecovio® F and ecovio® FS.
- Cleaning the waste bin is needed if people use a PE bag. This has an impact on the cumulative energy demand that is as important as the material production.
Resource consumption

Weighting factor 8%

[Bar chart showing resource consumption for different materials and processes]
Resource consumption: Comments

- Resource consumption patterns are similar to cumulative energy demand patterns; however, in case of resources the difference between fossil- and biobased material become evident. In fact, the Eco-Efficiency method assesses both energy from fossil sources as well as renewable energy forms. In case of resources, renewable resources are assumed to be always available, therefore they are not assessed.

- Both PE bags show the highest resource consumption.

- Resource consumption of bag production (processing) has the highest contribution

- Contribution from transportation is negligible (under basic scenario assumptions)

- Resource consumption linked to material is lowest in case of ecovio® FS

- The weight of paper bags is higher than that of ecovio® FS bags at comparable performance, so the resource consumption for producing the paper bag is higher.
Global warming potential

Weighting factor 10%
Global warming potential: Comments

- The highest contribution to the Global Warming Potential over life cycle is linked to the disposal of the kitchen waste.

- In case of bio-based materials (paper, PLA, …) CO₂ assimilation has been considered in the production phase (material), therefore biogenic CO₂ emissions during end-of-life (disposal phase) are also considered.

- Credits for substitution of fertilizers by composting are considered in the disposal phase.
**Acidification potential (AP)**

**Weighting factor 3%**
Acidification potential: Comments

- The amount of SOx and NOx emissions that are generated during disposal phase dominates over the corresponding emissions from all other life cycle steps.

- In case of paper bags a considerable contribution (more than 30%) to acidification potential is linked to SOx and NOx emissions generated by processing.
Photochemical ozone creation potential (POCP)

Weighting factor 2%

![Graph showing POCP values for different materials]
Photochemical ozone creation potential: Comments

• The impact for all the alternatives is nearly the same. The reason for this is that the amount of volatile organic compounds (VOC) emissions that are emitted into the lower atmosphere by disposal dominates over VOC emissions from other life cycle steps.
Ozone depletion potential (ODP)

Weighting factor 0.5%
Ozone depletion potential: Comments

• The highest impact is shown by ecovio® F and ecovio® FS, this is caused by the manufacturing of PLA (see Ref. 12 for more details) being a prechain of both types of ecovio®.

• Also PE and PE 25% rec. have a contribution to ozone depletion potential.

• NB: Due to the low absolute values of these emissions when compared to halogenated CFC emissions from all products at country level, the relevance of this impact potential is low (0.5%)
Water emissions

Weighting factor 13%
**Water emissions: Comments**

- Most water emissions occur during the disposal phase of the organic waste.
- Ecoflex® F and FS show lower water emissions because the cleaning of the waste bin for of PE and PE 25% rec. bags generates additional contribution to water emissions.
Solid wastes

Weighting factor 1%
**Solid wastes: Comments**

- Considering the credits for fertilizers by composting leads to a negative amount of solid wastes for the alternatives PE and ecovio® bags.

- In the production phase, the highest amounts of solid wastes are generated in the paper production. This is due to:
  - Rests and scrap
  - Kaolin clay milling
  - Residues in pulper

- Looking at the ecovio® F and ecovio® FS bags, the contribution linked to the production of PLA is higher than the contribution from the ecoflex® production. Between the contribution linked to the ecoflex® production in case of ecovio® F and ecovio® FS bags, the difference is due to the production of castor seeds.
Land use

Weighting factor 21%
**Land use: Comments**

- Land use is connected to building of streets, necessary for infrastructure for logistics and production.

- Land use is also connected to the use of land required for a product. Whereas this contribution is little for chemicals, in case of renewable materials the use of land plays a considerable role.

- Not only the area, also the occupation time of the land is considered (see Appendix B).

- The highest impact comes from the paper bag production which is based on trees. The data used in this study is a generic data from ecoinvent database “Kraft paper, unbleached, at plant/RER U”. In this dataset the time of land occupation for growing of trees is given with 150 years. This results in the rather high number for land use.

- Second highest impact can be observed from ecovio® FS bag production which is based on castor oil. The yield of castor seeds production is rather low compared to crops like corn and the high use of land for this production leads to rather high impact results in the LCA. Also the yield of oil extraction and of subsequent steps influence these results.

- Land use linked to corn production for PLA is higher than for chemicals, but small when compared to castor plant or trees.


**Toxicity potential**

Weighting factor 20%
Toxicity potential: Comments

• Assessment of toxicity potential is based on H-Phrases; not only the toxicity potential of a product is considered, but also of its pre-chain. This explains the high contribution from the production of PE and ecoflex®.

• High toxicity potential of PE (and PE 25% rec.) is linked to toxicity of the pre-chain of ethylene

• High toxicity potential of ecovio® is linked to toxicity of ecoflex® components and their pre-chain

• Contribution from paper, in comparison, is lower

• A remarkable contribution to the toxicity potential comes from the incineration of organic waste.
Risk potential

Weighting factor 9%

Diagram showing normalized illness accidents per category.
Risk potential: Comments

- The evaluation is based on the statistical data on occupational diseases and working accidents; specific data of the corresponding industry sectors are used.
- The amount of injuries and occupational diseases registered for the production of paper is high. Paper production is linked to forestry, which registers a high number of working accidents.
- ecovio® F and ecovio® FS show more occupational illnesses and accidents than PE, due to the longer production pathway. Also PLA is linked to occupational illnesses and accidents in agriculture.
- Processing plays a smaller role than materials.
- A credit is shown for composting (substitution of fertilizers).
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