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Reduce, Reuse, Recycle. What can LCA say about the 3R's and their environmental relevance?

Olivier Talon

UMONS Innovation Center

Life Cycle Assessment (LCA) in a nutshell

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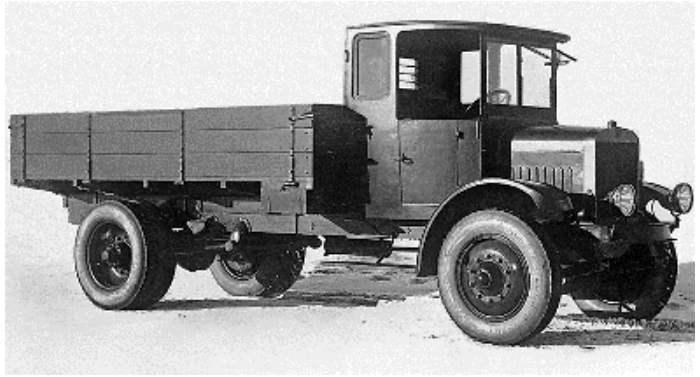
LCA identifies all the life cycle steps of a system

end of life

transport

product manufacturing

raw materials extraction



use phase

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LCA quantifies flows exchanged between the system and the environment

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LCA makes links between these flows and environmental indicators

methane

CO_2

HCl

glyphosate

land use

ozone depletion

acidification

eutrophication

climate change

human health

ecotoxicity

...

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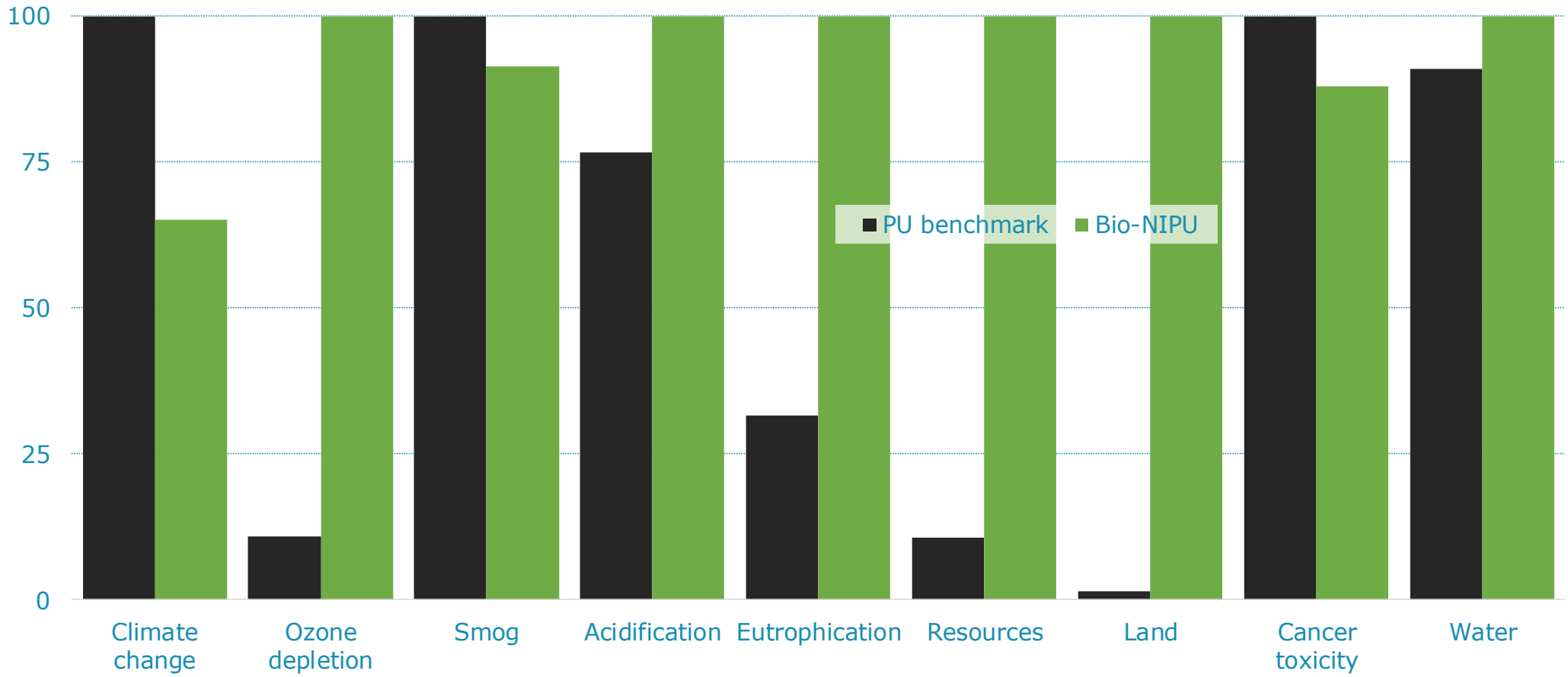
LCA translates these flows into environmental indicators



Results of the CO2Green project financed by Région Wallonne
Wallonie

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By allowing the comparison of the impacts of two systems, LCA makes it possible to evaluate the environmental relevance of a choice (between two products, between two ways of optimizing a process, etc.) by identifying potential impact shifts towards other life cycle steps or types of environmental damage.

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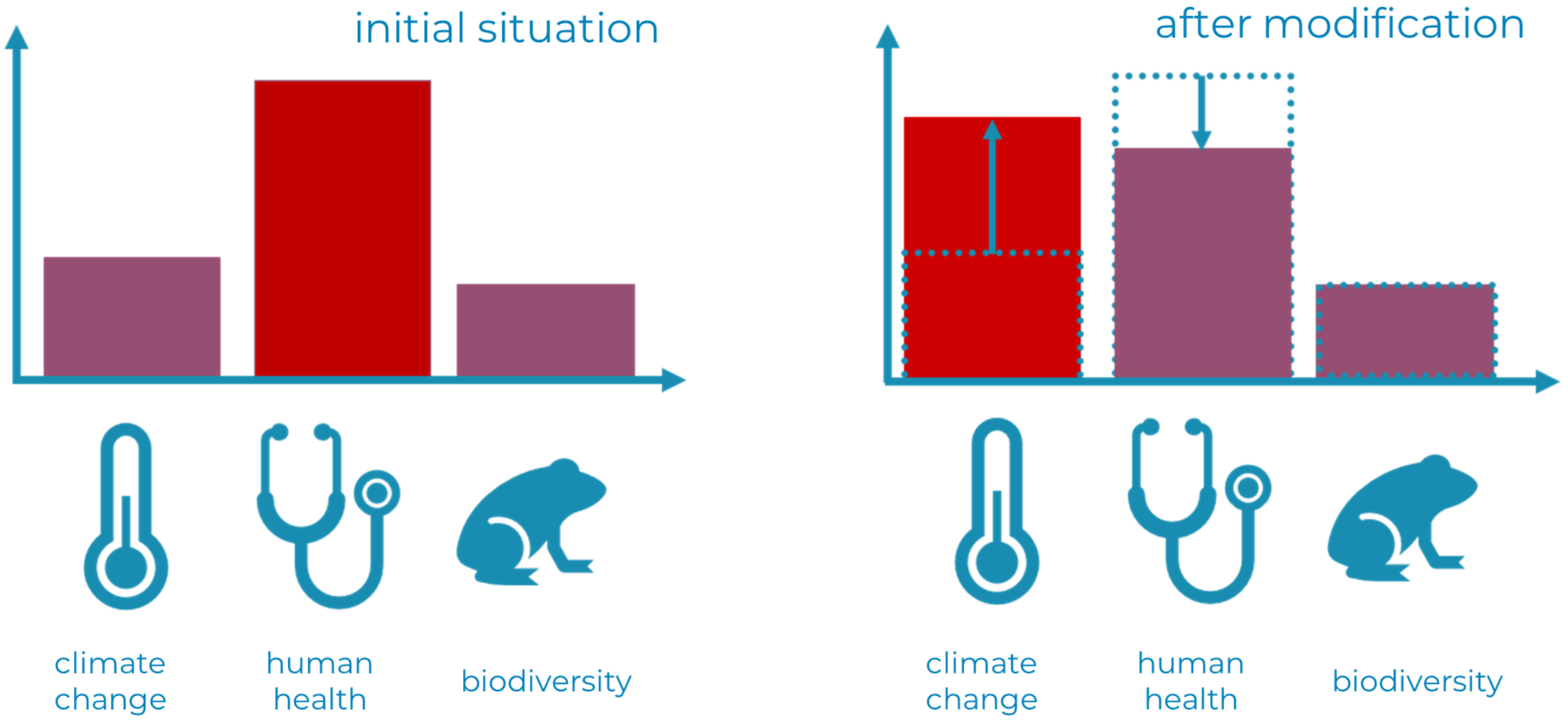
Impact shift towards another indicator



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Reduce

Reuse

Recycle

A preference scale for waste hierarchy

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How many Rs must a scale contain before you call it a scale?

Photo: Ramin Bahrani

Reduce

Reuse

Recycle

Rethink

Refuse

Resist

Repair

Return

Repeat

Reach out

Respect

Refurbish

Repurpose

Remember

Refill

Recover

Rot

Regift

Remove

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Different types of reduction

Reduce

Reduce weight

Reduce volume

Reduce number of parts

Design for reuse

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Different types of reuse

Reduce	Reuse
Reduce weight	Reuse waste / reuse packaging designed for multi-use?
Reduce volume	Refill by consumer
Reduce number of parts	Refill by producer
Design for reuse	At home / on the go

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Different types of recycling

Reduce	Reuse	Recycle
Reduce weight	Reuse waste / reuse packaging designed for multi-use?	Thermomechanical recycling
Reduce volume	Refill by consumer	Chemical recycling
Reduce number of parts	Refill by producer	Thermochemical recycling
Design for reuse	At home / on the go	Composting (?)

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Environmental relevance of the waste hierarchy for packaging

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Insights from literature

(figures are based on references, not directly copied from them)

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LCA vs. waste hierarchy – Biodegradable packaging case study

Reduce
Reuse
Recycle
Recover

Journal of Cleaner Production xxx (2014) 1–14

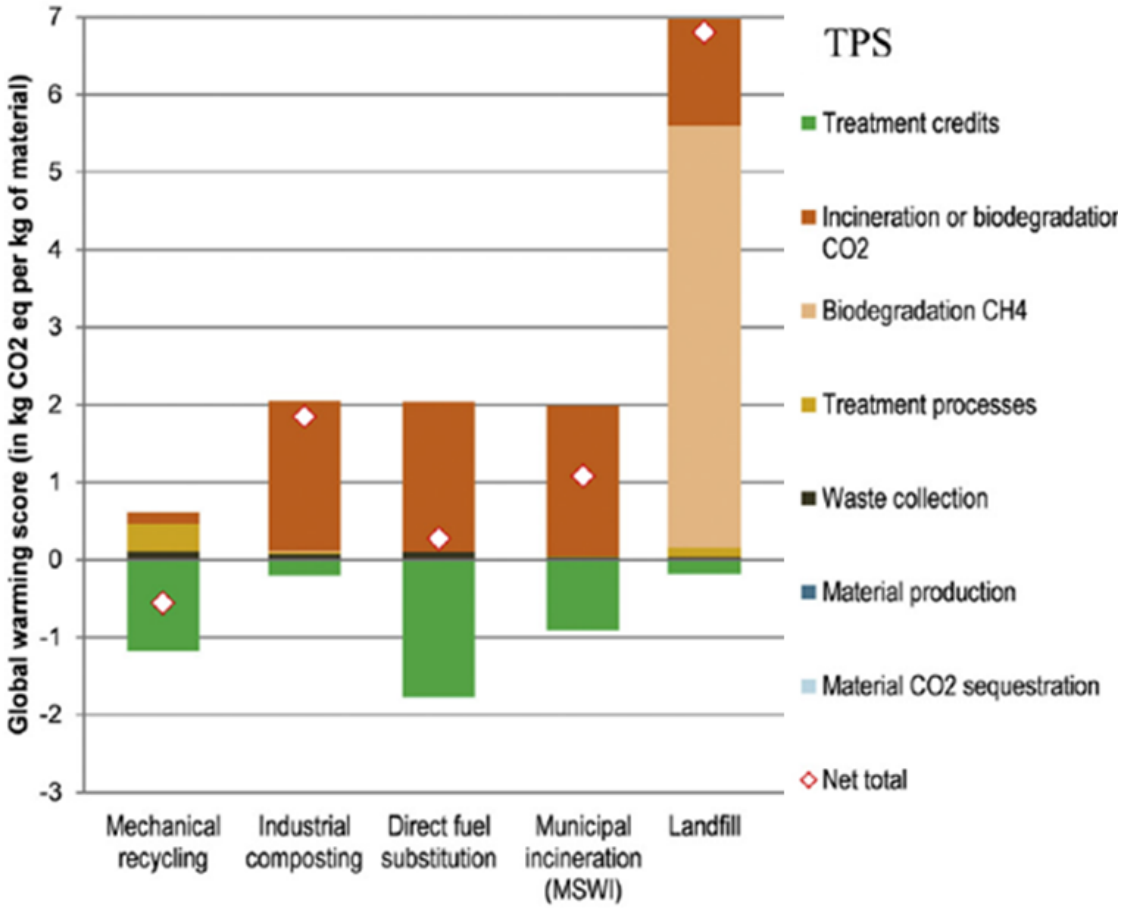
Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Life cycle assessment of end-of-life options for two biodegradable packaging materials: sound application of the European waste hierarchy

Vincent Rossi [a,*], Nina Cleeve-Edwards [b], Lars Lundquist [b], Urs Schenker [b], Carole Dubois [a], Sebastien Humbert [a], Olivier Jolliet [a]



Functional unit: EoL treatment of 1 kg dry packaging material as disposed by consumer.

Waste hierarchy makes sense for this case (TPS) - unless you consider composting as a recycling process.

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Design for reuse vs. design for recycling – Blush case study

Reduce
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Recycle
Recover

15 (2022) 200098

Contents lists available at ScienceDirect

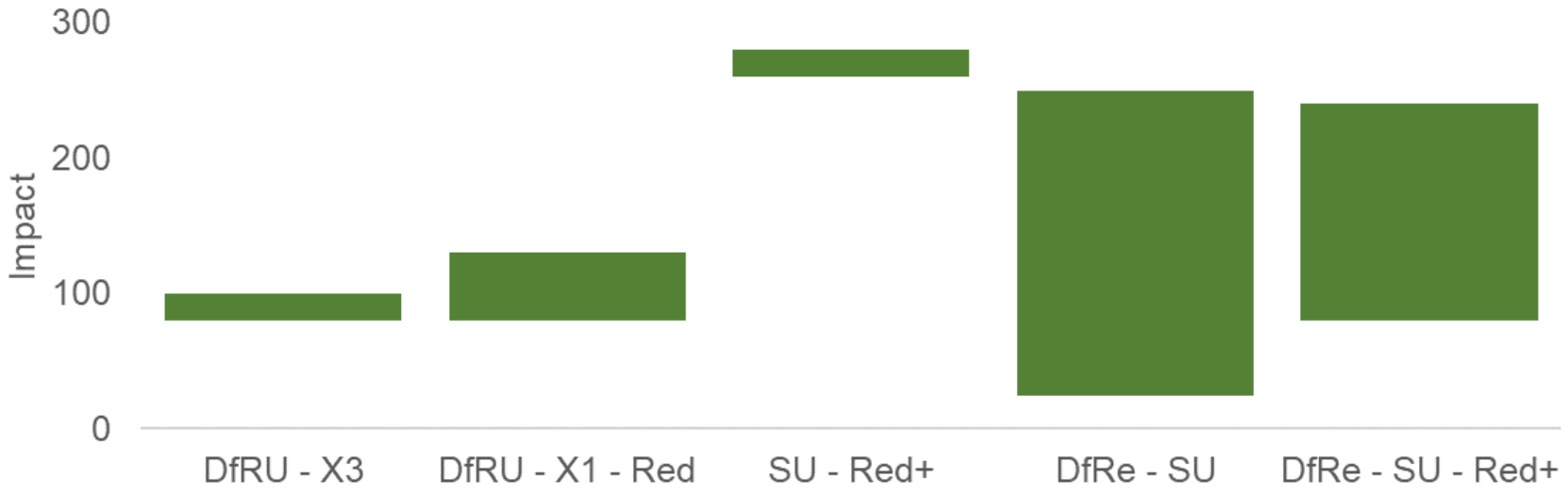
Resources, Conservation & Recycling Advances

journal homepage: www.sciencedirect.com/journal/Resources-Conservation-and-Recycling-Advances

Reusability and recyclability of plastic cosmetic packaging: A life cycle assessment

Isaac Jordan Gatt [a], Paul Refalo [a,*]

Fig. 1. Tivoli cosmetic blush compact.



Mass reduction does not result in impact decrease.

DfRe effect depends on effective recycling rate.

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Refillable bottles for water – waste reduction vs. climate impact

Reduce
Reuse
Recycle
Recover

Journal of Environmental Management 108 (2012) 73–83

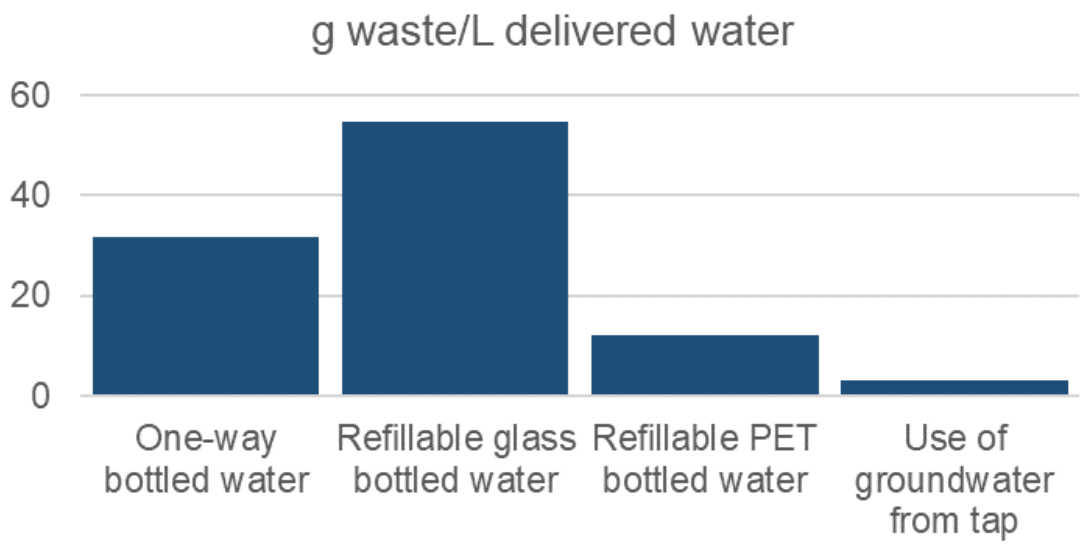
Contents lists available at SciVerse ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

LCA of waste prevention activities: A case study for drinking water in Italy

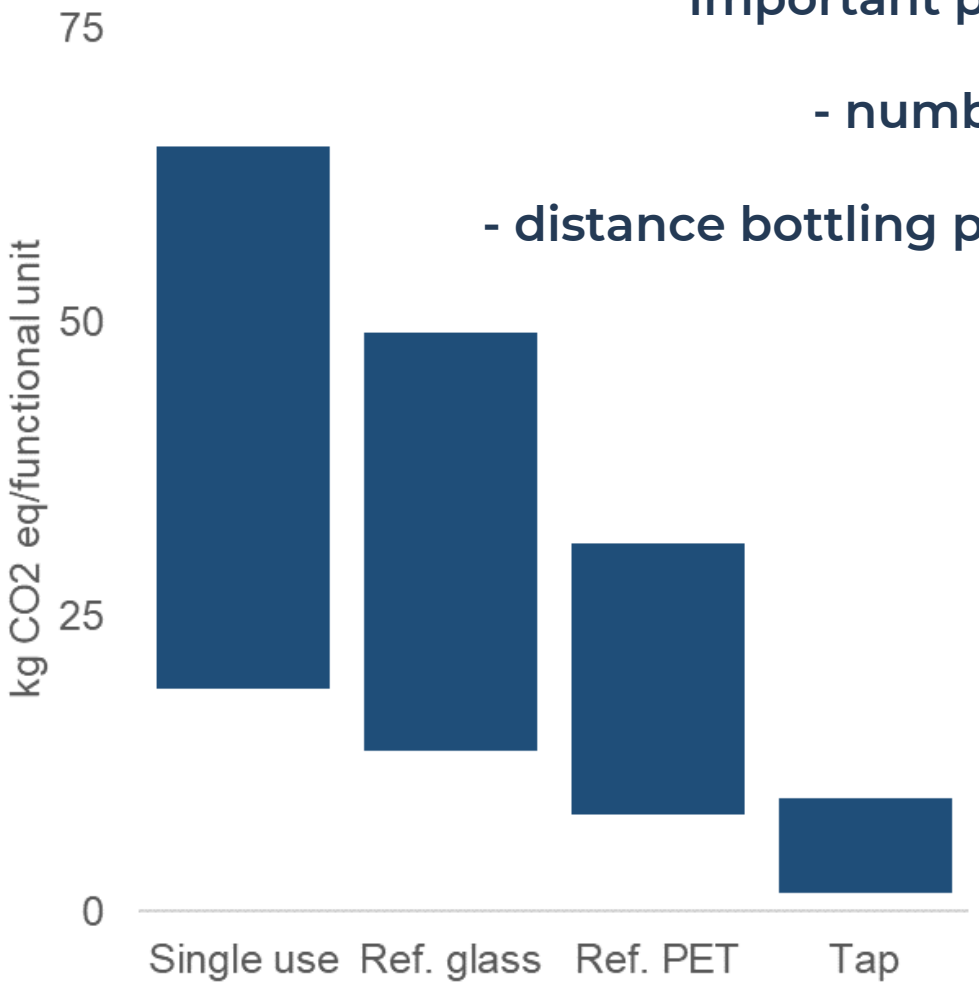
Simone Nessi*, Lucia Rigamonti, Mario Grosso



Important parameters:

- number of refills

- distance bottling plant / retail



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Reusable packaging for food delivery service

Reduce
Reuse
Recycle
Recover

Science of the Total Environment 794 (2021) 148570

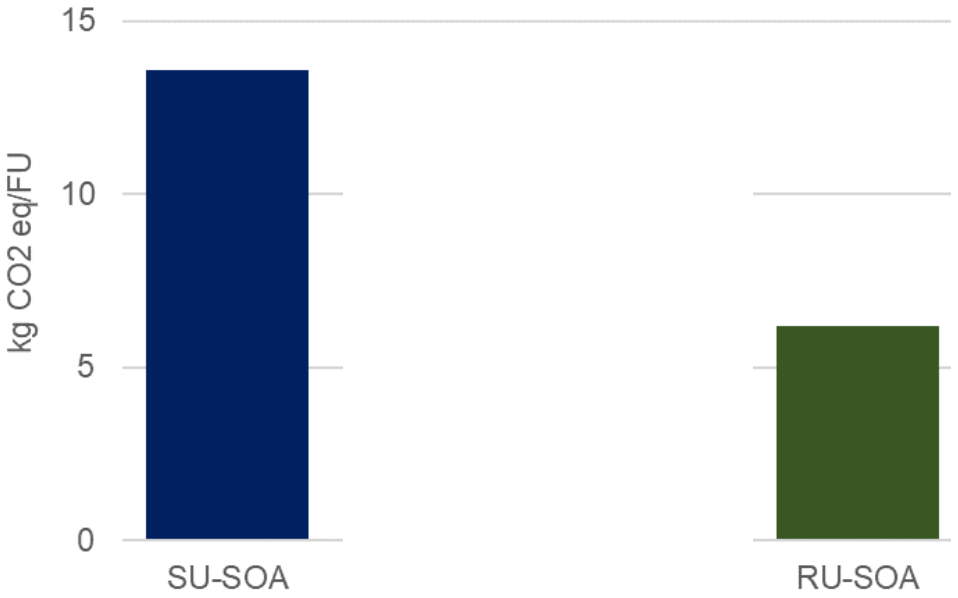
Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Potential climate benefits of reusable packaging in food delivery services. A Chinese case study

Laia Camps-Posino [a], Laura Batlle-Bayer [a], Alba Bala [a], Guobao Song [b], Huimin Qian [b], Rubén Aldaco [c], Ramón Xifré [a,d,e], Pere Fullana-i-Palmer [a,*]



Reuse scenario enables significant reduction of impacts.

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Reusable packaging for food delivery service

Reduce
Reuse
Recycle
Recover

Science of the Total Environment 794 (2021) 148570

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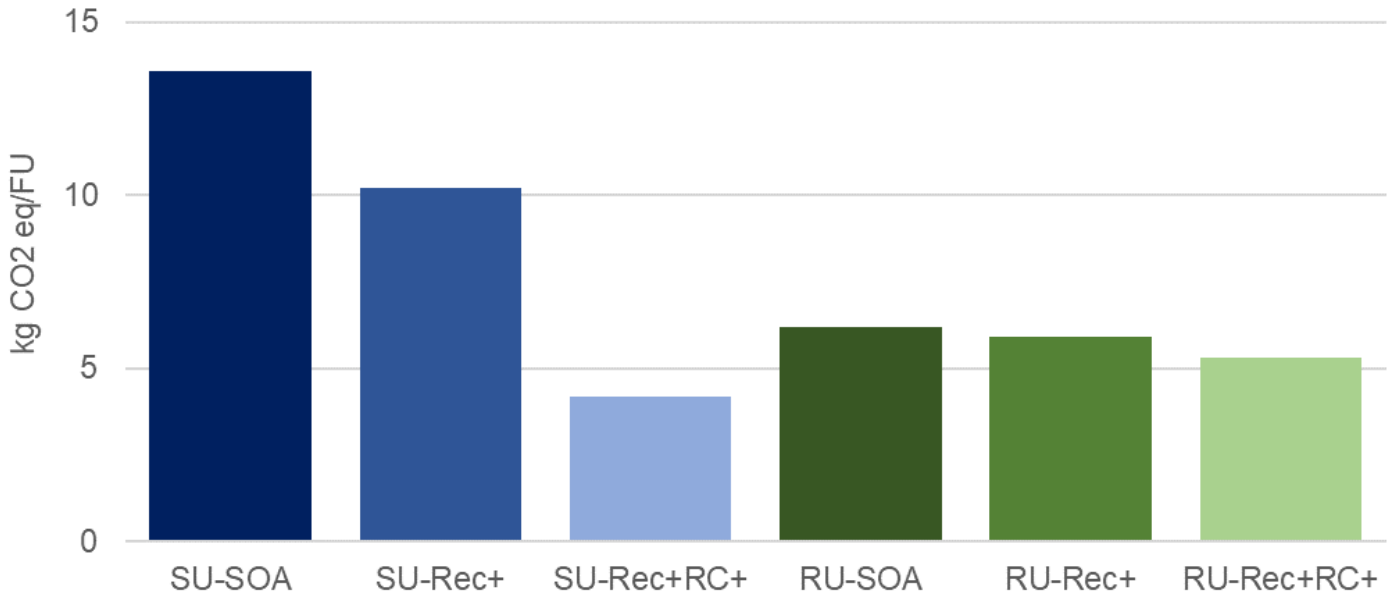

Reuse scenario enables significant reduction of impacts.

Impact of reuse dominated by washing steps.

Room for improvement (by enhancing recycling rate or recycled content) is higher for single use scenario.

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Break-even point

Reduce
Reuse
Recycle
Recover

Journal of Cleaner Production 211 (2019) 417–427

Contents lists available at ScienceDirect

Journal of Cleaner Production

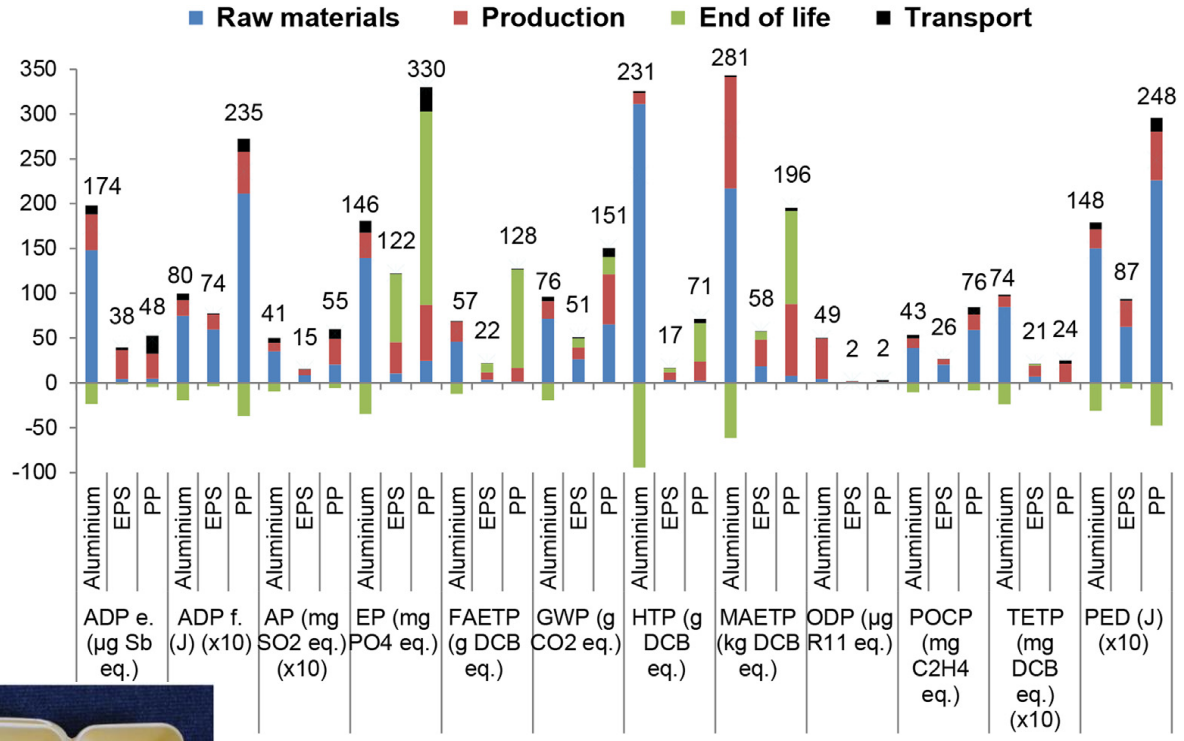
journal homepage: www.elsevier.com/locate/jclepro

Environmental impacts of takeaway food containers

Alejandro Gallego-Schmid [a, b, *], Joan Manuel F. Mendoza [a], Adisa Azapagic [a]

Table 3
Number of uses of polypropylene (PP) reusable containers needed to equal the impacts of single-use containers (aluminium and extruded polystyrene (EPS)).

Impact[a]	Reusable takeaway PP vs aluminium	Reusable takeaway PP vs EPS
ADP_e	1	32
ADP_f	4	4
AP	2	7
EP	3	4
FAETP	3	9
GWP	3	4
HTP	1	9
MAETP	1	6
ODP	1	3
POCP	2	4



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Waste hierarchy vs. impacts: energy recovery vs. landfill

Reduce
Reuse
Recycle
Recover

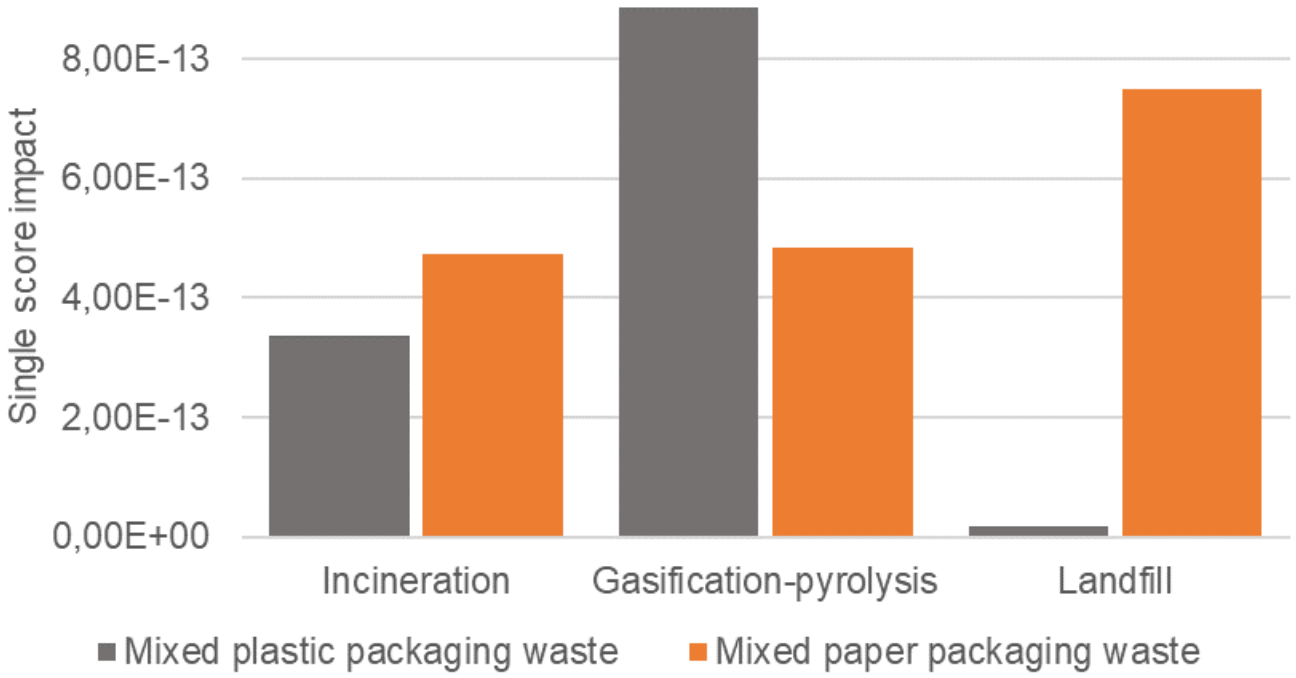
Journal of Material Cycles and Waste Management
https://doi.org/10.1007/s10163-019-00842-4

ORIGINAL ARTICLE

Check for updates

Life cycle assessment of paper and plastic packaging waste in landfill, incineration, and gasification-pyrolysis

A. Demetrious[1,2] · E. Crossin[3,4]



Waste hierarchy may not be always environmentally relevant.

Here, landfilling appears better than energy recovery for plastics.

Each case should be analysed beyond general a priori.

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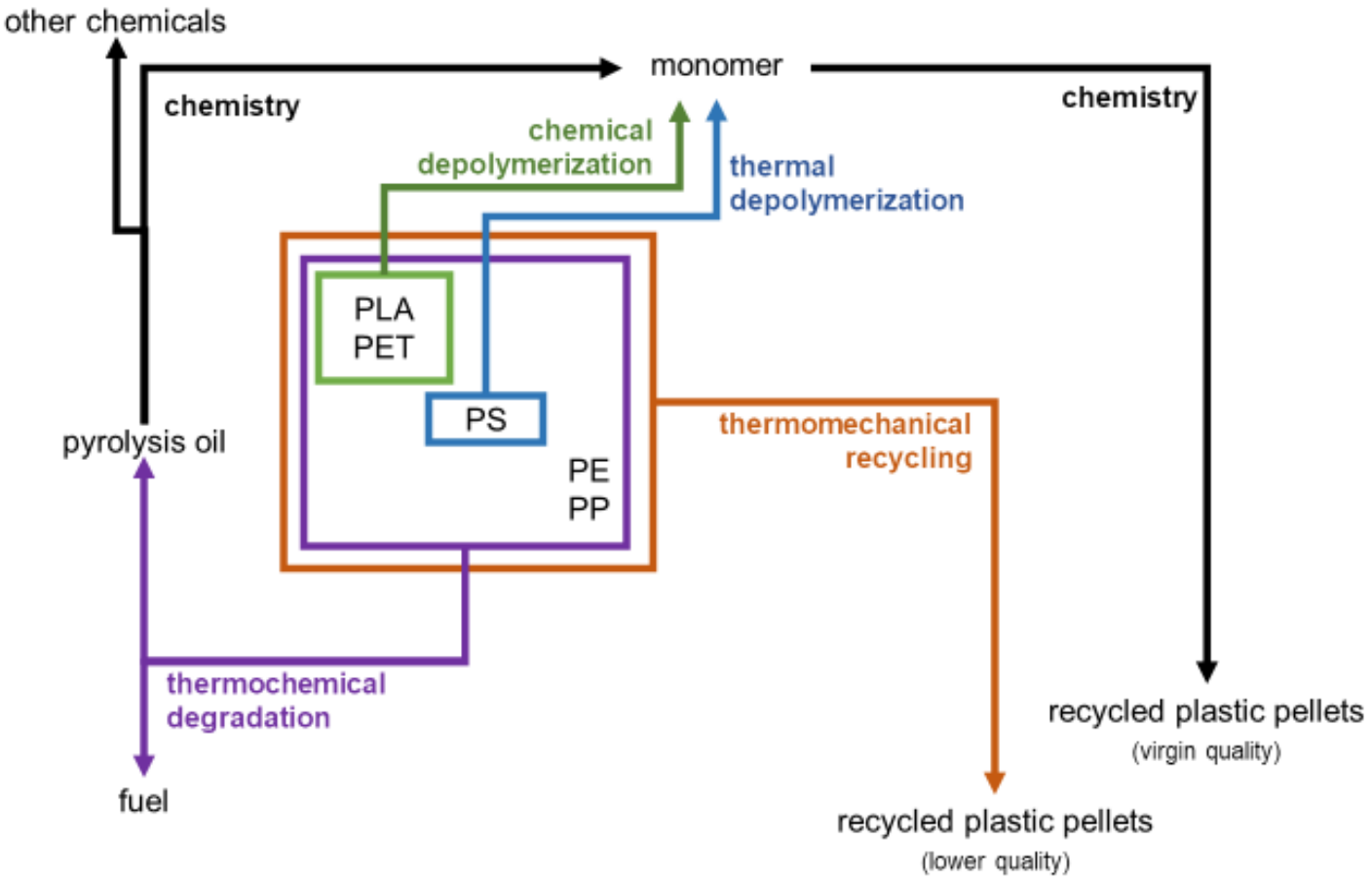
Recycling vs. recycling



different recycling loops

=

different processes

=

different impacts

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Recycling vs. recycling

Reduce
Reuse
Recycle
Recover

Waste Management 121 (2021) 331–342

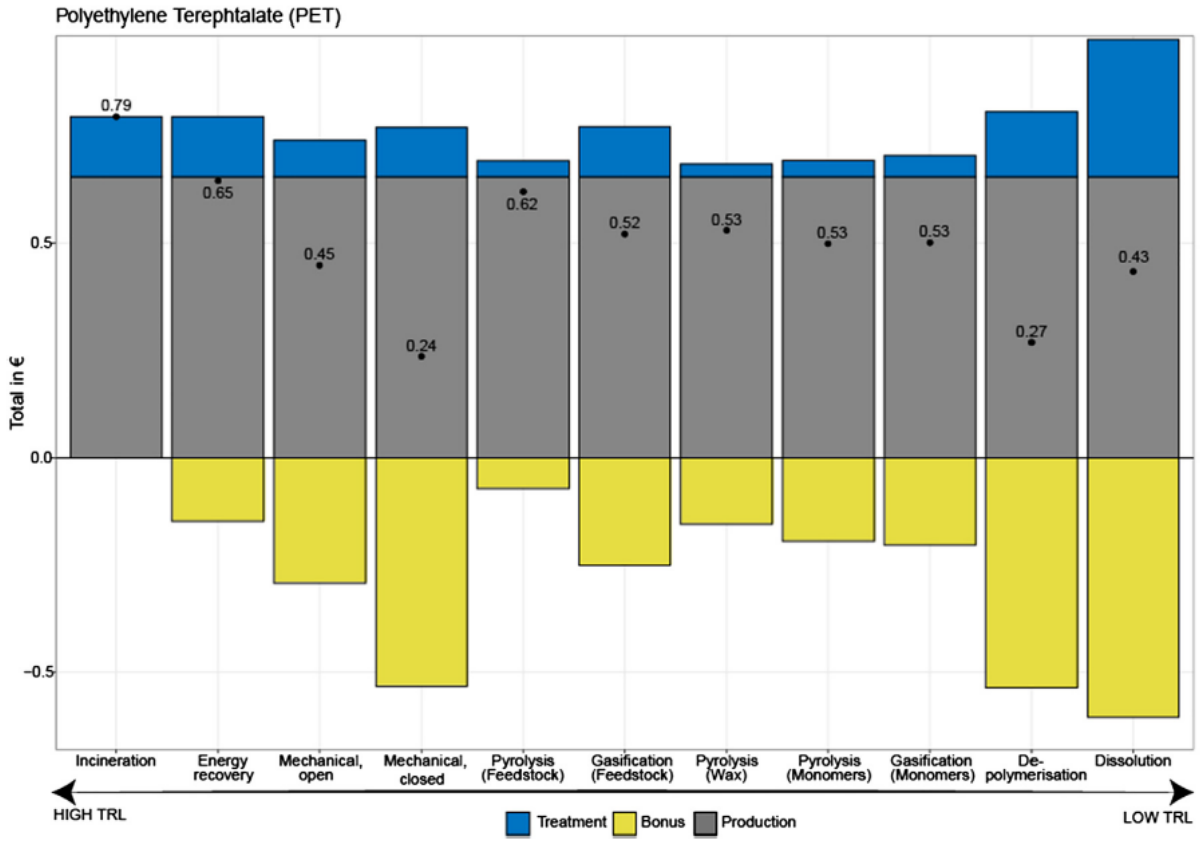
Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Plastic recycling in a circular economy; determining environmental performance through an LCA matrix model approach

A.E. Schwarz [a,*], T.N. Ligthart [a], D. Godoi Bizarro [a], P. De Wild [b], B. Vreugdenhil [b], T. van Harmelen [a]



All recycling processes do not have the same impacts, some may not be much better than energy recovery.

Hierarchy is case dependent, but a general trend can be “the longer the loop, the higher the impacts”.

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Conclusions

- The waste hierarchy seems mostly environmentally relevant, but there may be exceptions
- Reduction of waste by reuse strategy does not always mean reduction of environmental impacts, mostly because of cleaning steps
- Each case is specific, LCA can help identifying hotspots and avoiding wrong decisions
- Other R's (Rethink, Refuse…) may have a stronger impact than the best Reduce or Reuse scenarios…

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Recent open letter

LIFE CYCLE ASSESSMENT SCIENTISTS URGE EU POLICY MAKERS TO TREAT SOME PACKAGING ENVIRONMENTAL IMPACT ASSESSMENTS WITH CAUTION

We are particularly worried about some recently published reports on the benefits of single-use packaging which contain methodological flaws meaning that they do not account for the full complexity of environmental impacts. As MEPs enter final negotiations on the PPWR, and as the

We have seen LCA studies comparing single-use packaging and reuse packaging to demonstrate that single-use is invariably better. Yet while it is straightforward to compare two single-use products which go from cradle to grave in one go, it is more complex for products used multiple times, where it is the business model - not the product - which is evaluated. In such cases, rather than evaluating one scenario (e.g., 20 reuses or 50 km distance for the reuse phase), sensitivity analyses and scenario analyses must be used to determine the break-even point. This is the minimum number of times that a reusable product must be used to be environmentally better (if at all) than an equivalent number of uses of a single-use product. Only these recursive analyses can provide a systemic and comprehensive view. Studies which compare single-use products with reusable options and do not include sensitivity analyses or break-even points are simply inaccurate.

https://lnkd.in/eSh3fe5w

1. **Is a peer-reviewed, independent study conducted using the ISO 14040 and 14044 frameworks**. The study should be reviewed by an independent third party or by an independent chaired review panel.
2. **Respects steps laid out in ISO standards, starting with clear scope definition and comprehensive description of inventory data.** First, *the goal and scope definition* stage must precisely describe the product studied, the functional unit, the scope of the study, the assumptions made for each life cycle stage, and the methodology used to calculate impacts. Second, *the inventory* stage must describe and quantify the inputs and outputs involved in the life cycle of the system studied. Third, the LCA *impact* stage assesses the potential environmental impacts by converting the inventory data into specific impact indicators. It can involve different methods which must be specified. Fourth, *the interpretation* stage has as final aim the formulation of recommendations to improve the environmental performance of the system under study. We would like to emphasize that access to the goal and scope definition and the inventory data (stages 1 and 2) is a non-negotiable prerequisite to validity. This is because even a small variation in the methodological parameters or the inventory can significantly alter results.
3. **Assesses the highest possible number of environmental indicators.** The Product Environmental Footprint (PEF 3.1) method includes 16 mid-point impact categories (e.g. climate change, water resource depletion, land use transformation, human toxicity…). The ReCiPe LCA model includes 18 midpoint impact categories. Any exclusion of an indicator must be thoroughly justified.
4. **Includes the full life-cycle of the product reviewed**, from cradle to grave. Both upstream impacts (e.g. material production) and downstream impacts (e.g. recycling or incineration) must be assessed.
5. **Includes clear hypotheses and assumptions on breakage rate, return (trip) rate, weight and end of life strategies** (including recycling performance, quality of the recyclate, waste-to-energy, and repurpose) both for single-use and reusable packaging.
6. **If assumptions or lower quality data on parameters** have been used, **performs a sensitivity analysis** and discloses the source of such data**.** The conclusion of this sensitivity analysis should be included in the study, to ensure that the implications of using poor quality data are transparent.
7. **Considers different business model configurations for the use and end of life phases,** alongside clear sensitivity analyses.
8. **Integrates static comparisons with dynamic ones such as the evaluation of the environmental break-even points.**

Any report which assesses environmental impacts without transparency of data, a peer-review process or respect for established frameworks cannot be considered a good environmental impact assessment and so caution should be exercised when considering the results and recommendations.

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