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ENVIRONMENTAL PERFORMANCE OF SUPERMARKET BAGS IN THE BRAZILIAN CONTEXT: A screening comparison of virgin and recycled HDPE, LDPE, PP, and PET

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Abstract

The heavy reliance on virgin polymers and an estimated annual production of 72 billion supermarket bags in Brazil generate severe environmental burdens and complex waste management challenges, compounded by fragmented local legislation. With high-density polyethylene (HDPE) being the most common material currently used for supermarket bags, this study evaluated the life cycle of bags made from four major polymeric matrices: HDPE, low-density polyethylene (LDPE), polypropylene (PP), and polyethylene terephthalate (PET) in both virgin and recycled versions to identify lower-impact alternatives using a screening LCA.

Methodology

This study employed a screening life-cycle assessment (LCA) using the Eco-Audit tool from CES Selector (Granta EduPack), following ISO 14040 and ISO 14044 standards. Cradle-to-grave boundaries encompassed raw material extraction, extrusion, 200 km transport, and end-of-life routes. Twenty scenarios (Table 1) were modeled across single-use (27 micrometers) and reusable (200 micrometers) configurations, crossing four polymeric matrices (HDPE, LDPE, PP, and PET) in virgin and 100% recycled versions based on the 't-shirt' style bag structural model illustrated in Figure 1. The analysis assumed mechanical recycling with a 70% recovery rate versus sanitary landfill disposal, anchored to an annual household functional demand.

Figure 1 – "T-shirt" style plastic bags model

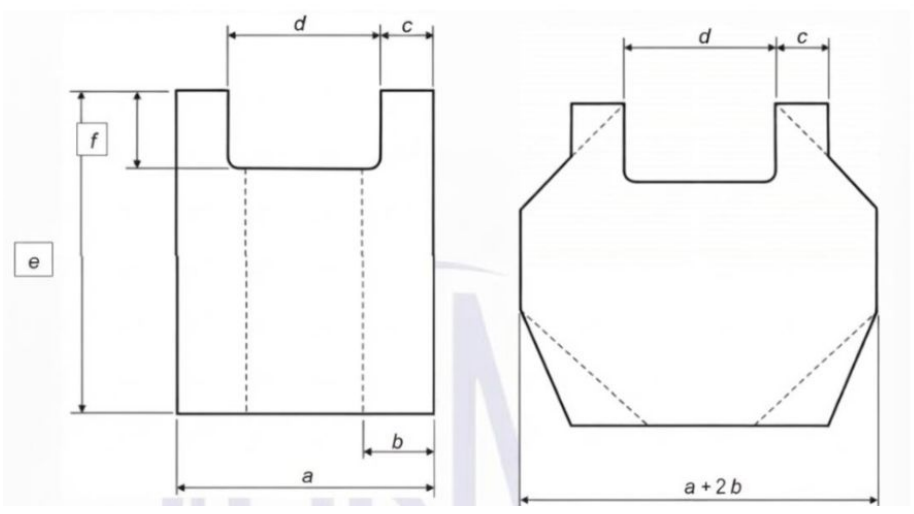


Table 1 – Overview of the 20 modeled scenarios.

Scenario	Material / Usage	Mass (kg)	Matrix Origin	End of Life
1–4	HDPE Single-use	0.0143	Virgin / Recycled	Landfill / Recycling
5–8	HDPE Reusable	0.0800	Virgin / Recycled	Landfill / Recycling
9–12	LDPE Single-use	0.0200	Virgin / Recycled	Landfill / Recycling
13–16	PP Reusable	0.0800	Virgin / Recycled	Landfill / Recycling
17–20	PET Reusable	0.1000	Virgin / Recycled	Landfill / Recycling

Results and Discussion

The results revealed that the material production step accounts for 88%-90% of primary energy in virgin options, the manufacturing and extrusion step rank second, while transport and end-of-life presented minimal influence.

The use of Virgin LDPE (Scenario 10) presented the highest impact (973.23 MJ and 33.49 kg CO_2 -eq) due its lower resistance to deformation and higher mass requirements.

Recycled HDPE sent to a landfill (Scenario 03) minimized impacts to 147.71 MJ and 8.72 kg CO_2-eq by avoiding primary crude oil extraction. Figures 2a and 3a show the contrast of the use of these materials when single-use configuration was available.

Reusable bags made of virgin PET presented values of 45.90 MJ and 2.15 kg CO_2-eq, whereas reusable bags made of recycled HDPE (Scenario 07) showed a drastic drop to 7.95 MJ and 0.469 kg CO_2-eq. Figures 2b and 3b compare these configurations.

Figure 2 - Energy consumption (MJ) highlighting the extremes among the 20 analyzed scenarios: a) single-use scenario: virgin LDPE and recycled HDPE sent to landfill. b) reuse scenario (1-year period): virgin PET and recycled HDPE.

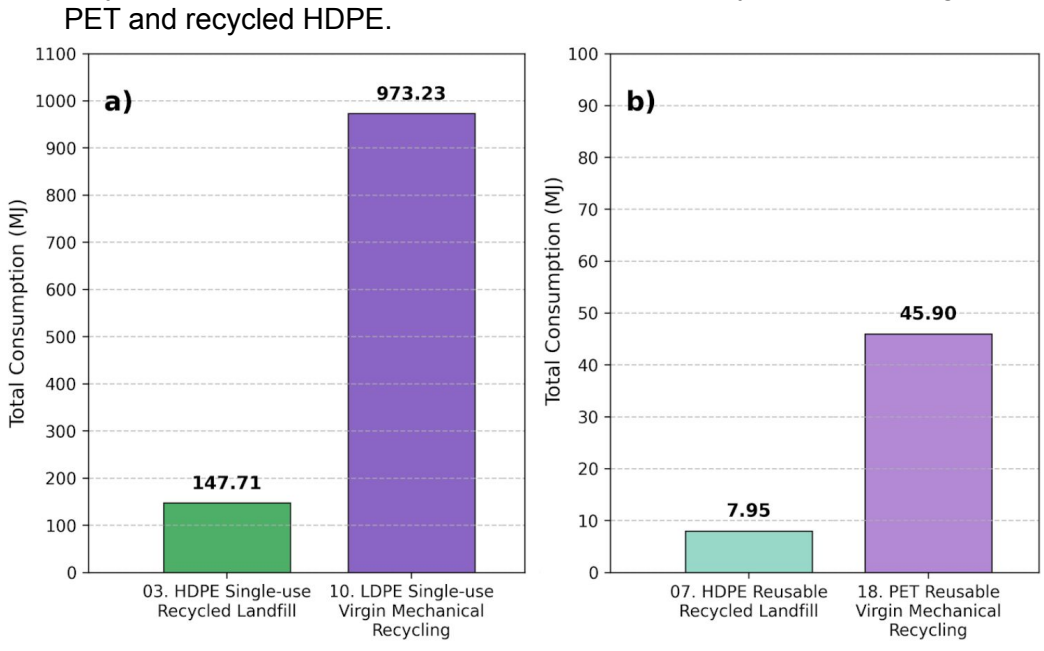
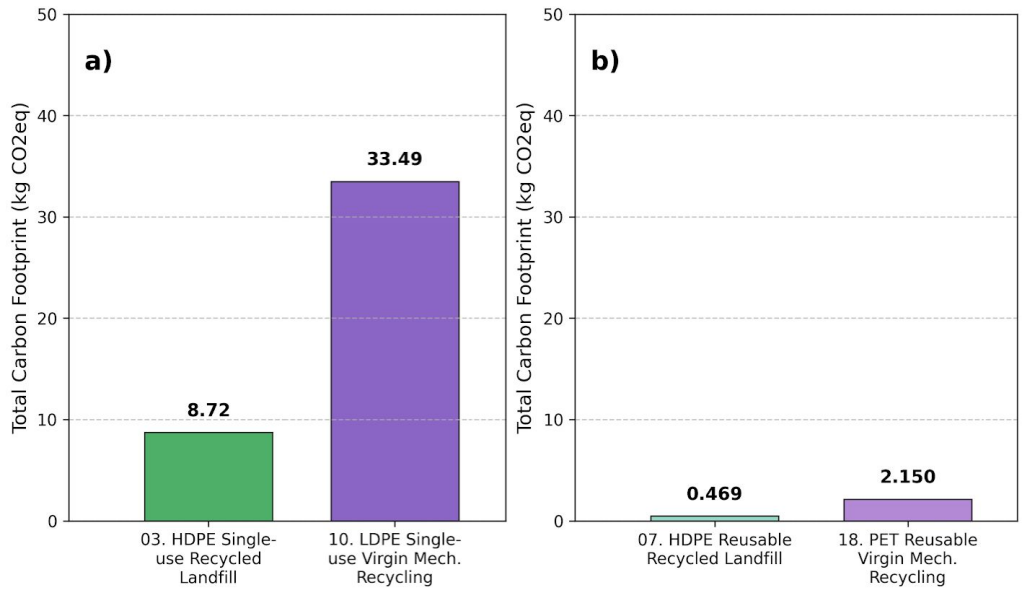


Figure 3 – Carbon footprint (kg CO_2eq) highlighting the extremes among the 20 analyzed scenarios: a) single-use scenario: virgin LDPE and recycled HDPE sent to landfill. b) reuse scenario (1-year period): virgin PET and recycled HDPE.



Conclusions

Designing bags explicitly for reuse is the most effective strategy to reduce environmental impact. Although reusable options require 5 to 6 times more mass during manufacturing for durability, their extended life cycle quickly offsets this initial cost. Effective decarbonization requires a dual technical strategy: prioritizing reusable design, combining it with recycled resins (rHDPE, rPP, and rPET), and ensuring sustained consumer usage.

References

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