CIRAIG™
International Reference Centre for the Life Cycle of Products, Processes and Services

Comparative LCA of single-use food containers including potential impacts from marine plastics

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Canadian Chemical Engineering Conference 2021

October 25, 2021

CentrEau
Centre québécois de recherche sur l'eau
Quebec Water Research Centre

ESG UQÀM

POLYTECHNIQUE MONTRÉAL

2015: 6,300 million metric tons cumulative plastic waste

2050: 26,000 million metric tons cumulative plastic waste

2-5% of plastic waste in coastal countries ends up in the ocean

Jambeck, J., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., … Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, *347*(6223), 768–771.

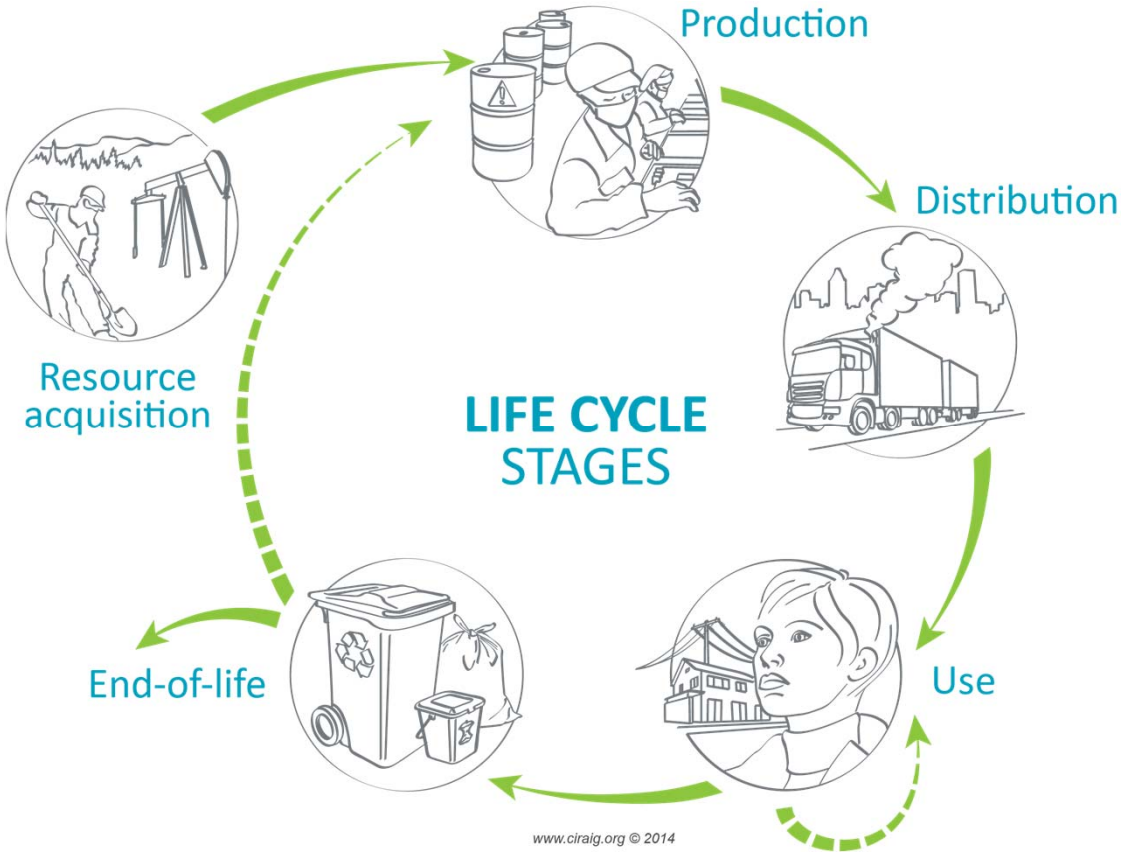
Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, *3*(7), 3–8.

2020: Canada announced upcoming ban of 6 types of single-use plastics

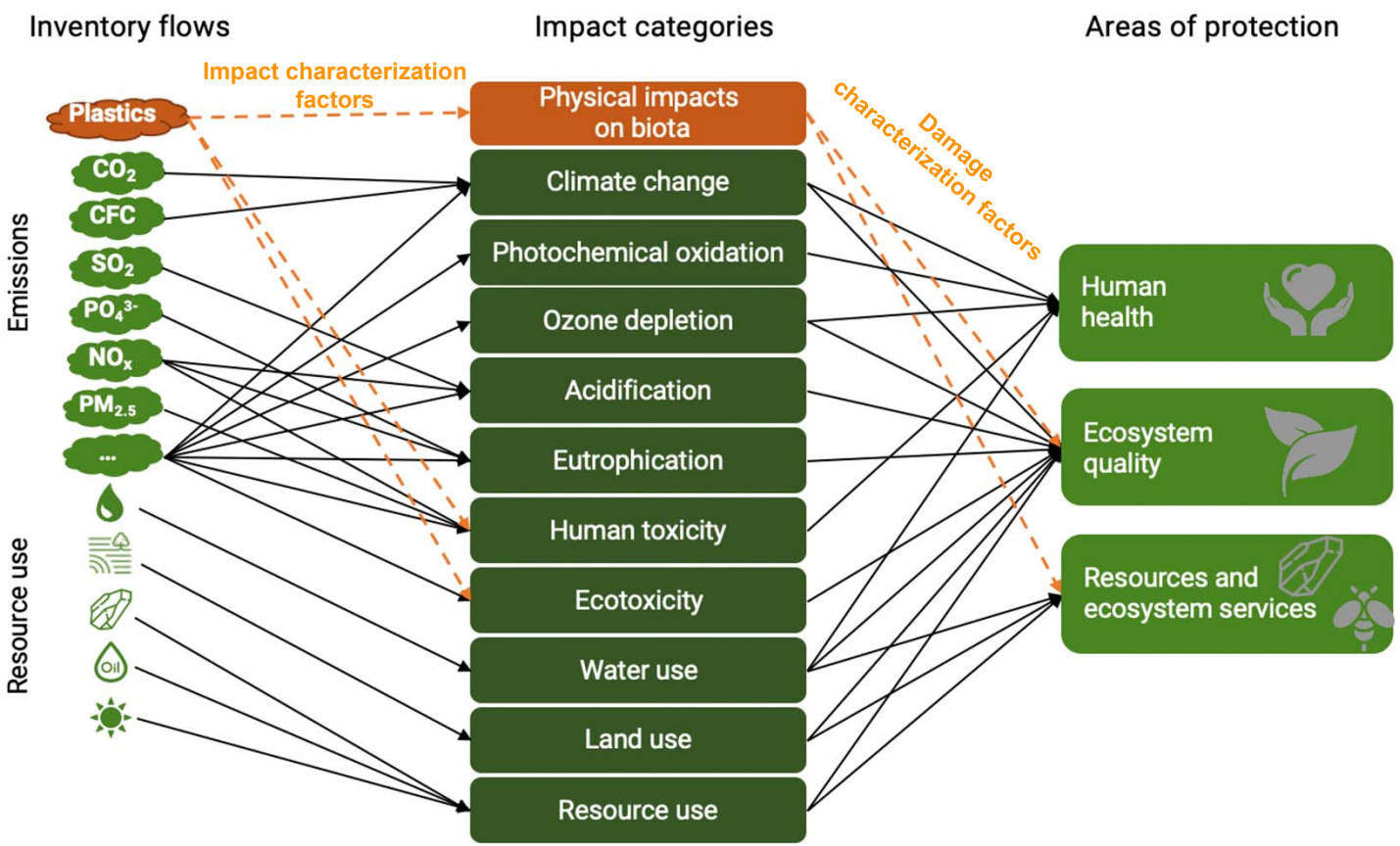
- Growing market for compostable or reusable alternatives

Are the alternatives less harmful to the environment?

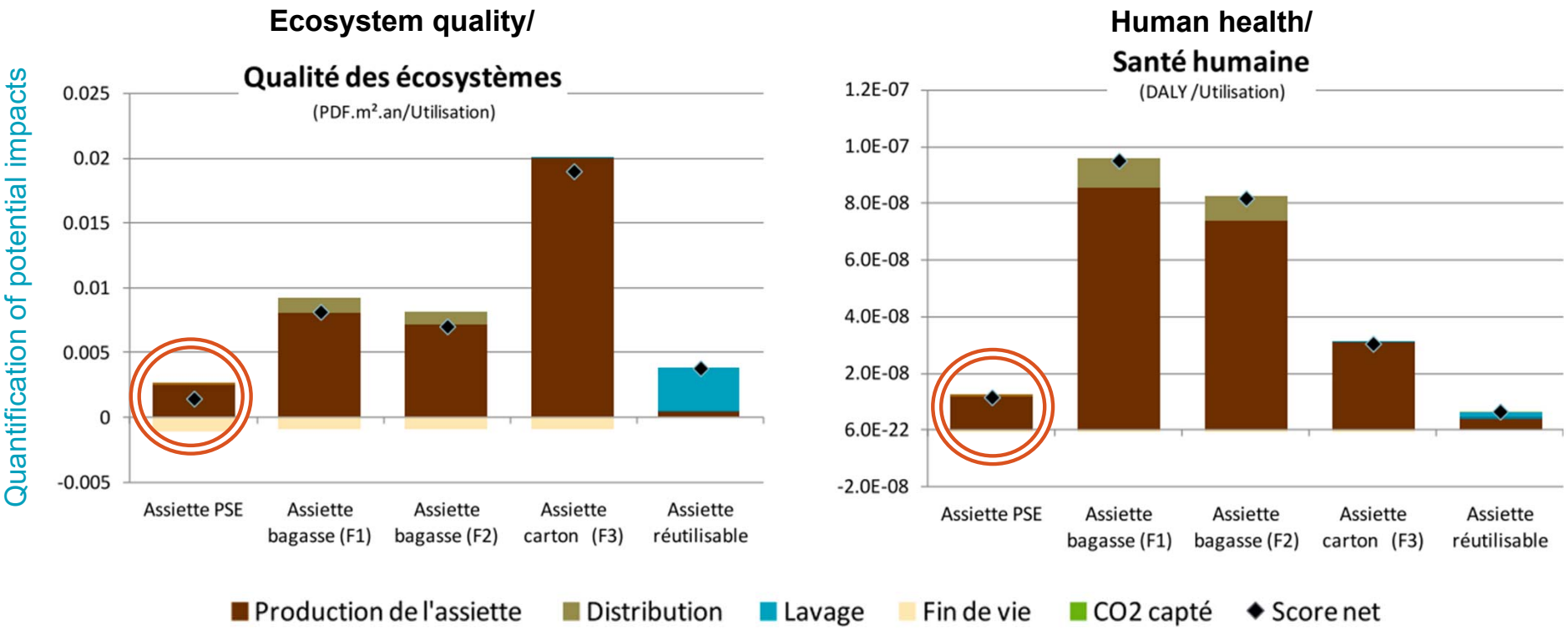
Stages in life cycle assessment (LCA)



Life cycle impact assessment



LCA case study of plastic, compostable and ceramic food plates



CIRAIG. (2017). Analyse du cycle de vie de différents types de vaisselle et de scénarios d'opération des aires de service alimentaire de Polytechnique Montréal. Montréal, Canada.

MarILCA (MARine Impacts in LCA)

- International scientific committee founded in 2018
- Coordinates harmonized research efforts among organizations across the globe
- Goal: Integrating impacts of marine litter, especially plastic, into LCA

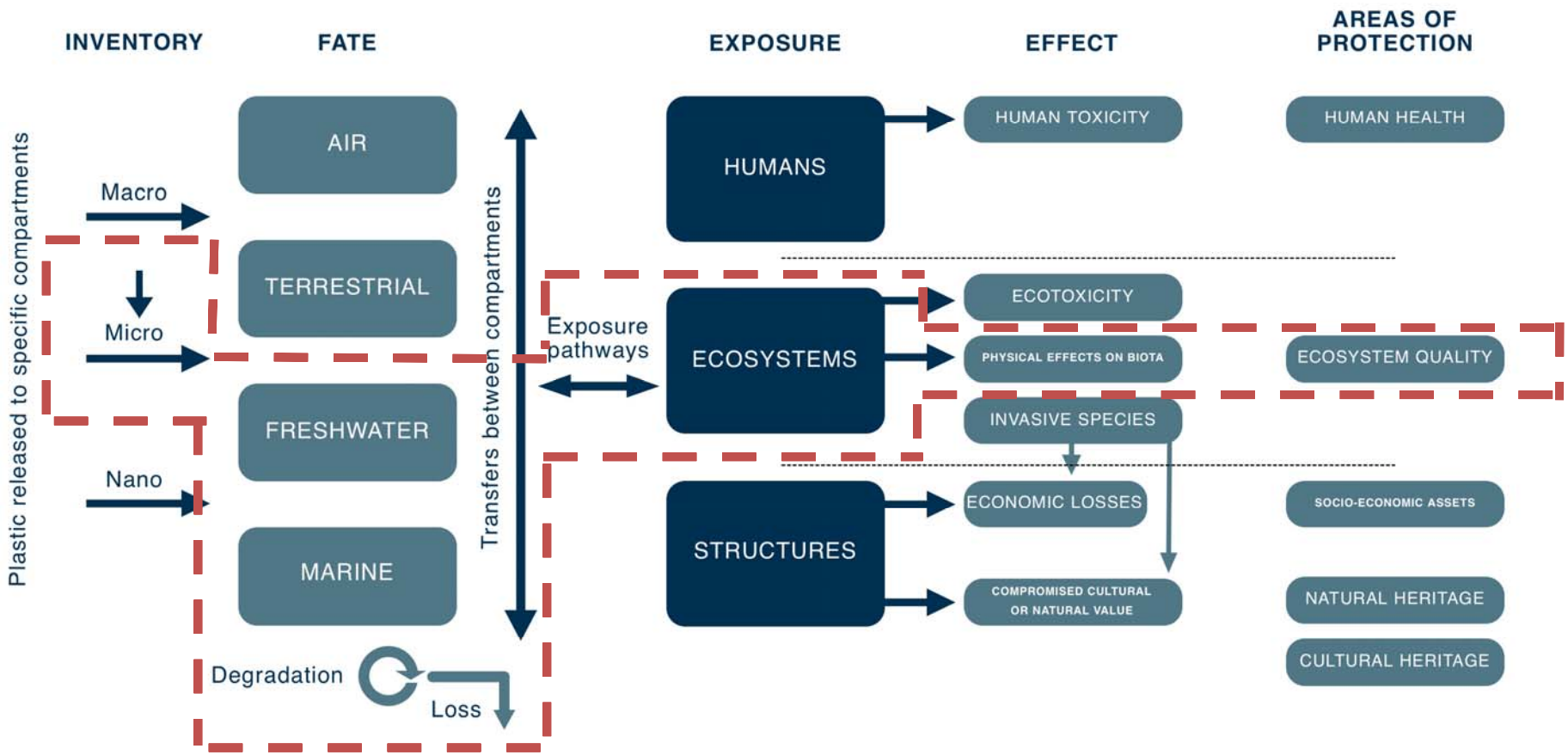
Life Cycle Initiative

hosted by

UN environment programme

marilca.org

MarILCA framework



LCA case study: Single-use food containers

Context: **Applying new MarILCA methodologies and identifying challenges, gaps and future research focus points**

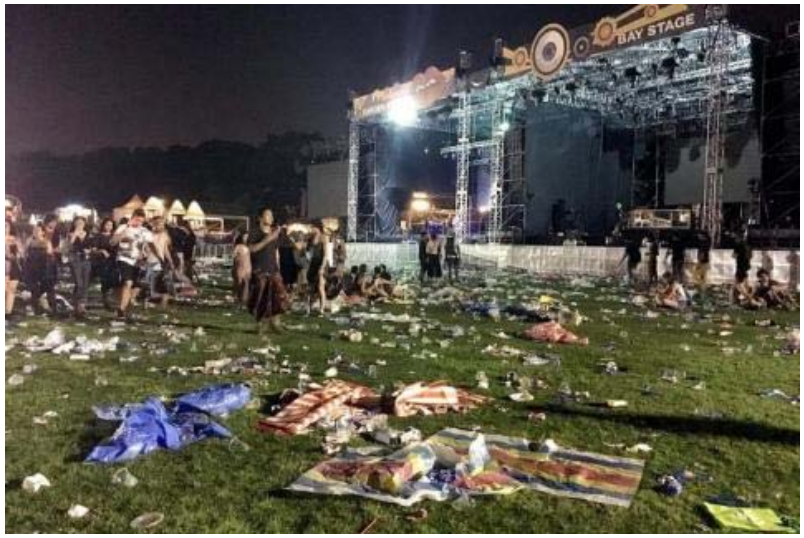
Functional unit: **"Using one container to carry a meal for one person at Places des Arts festival venue in Montréal"**

Single-use containers:

- Expanded polystyrene (Ontario)
- Bagasse (China)
- Wood pulp (Québec)

Reusable plate:

- Ceramic (China)



Methodology: Preliminary characterization factors (CFs)

*Microplastic emission * CF = Damage on ecosystems quality*

[kg plastic] [PDF*m^2*year]

*CF = Fate factor * Exposure factor *Effect factor*

Distribution and longevity of microplastics

Ingestion of microplastics

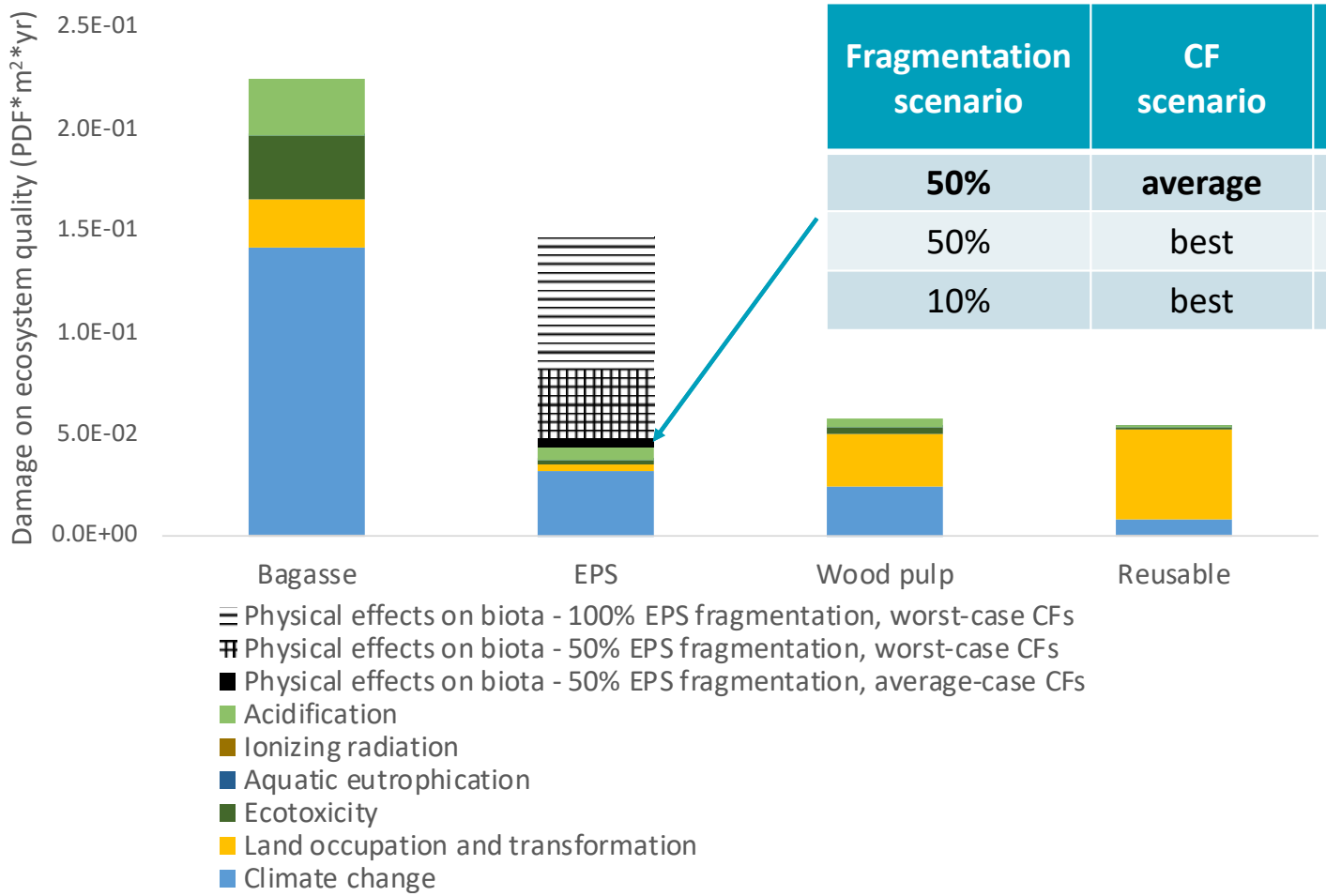
Animal health issues, reproductive impairment

This work

Lavoie et al. (2021) ✓

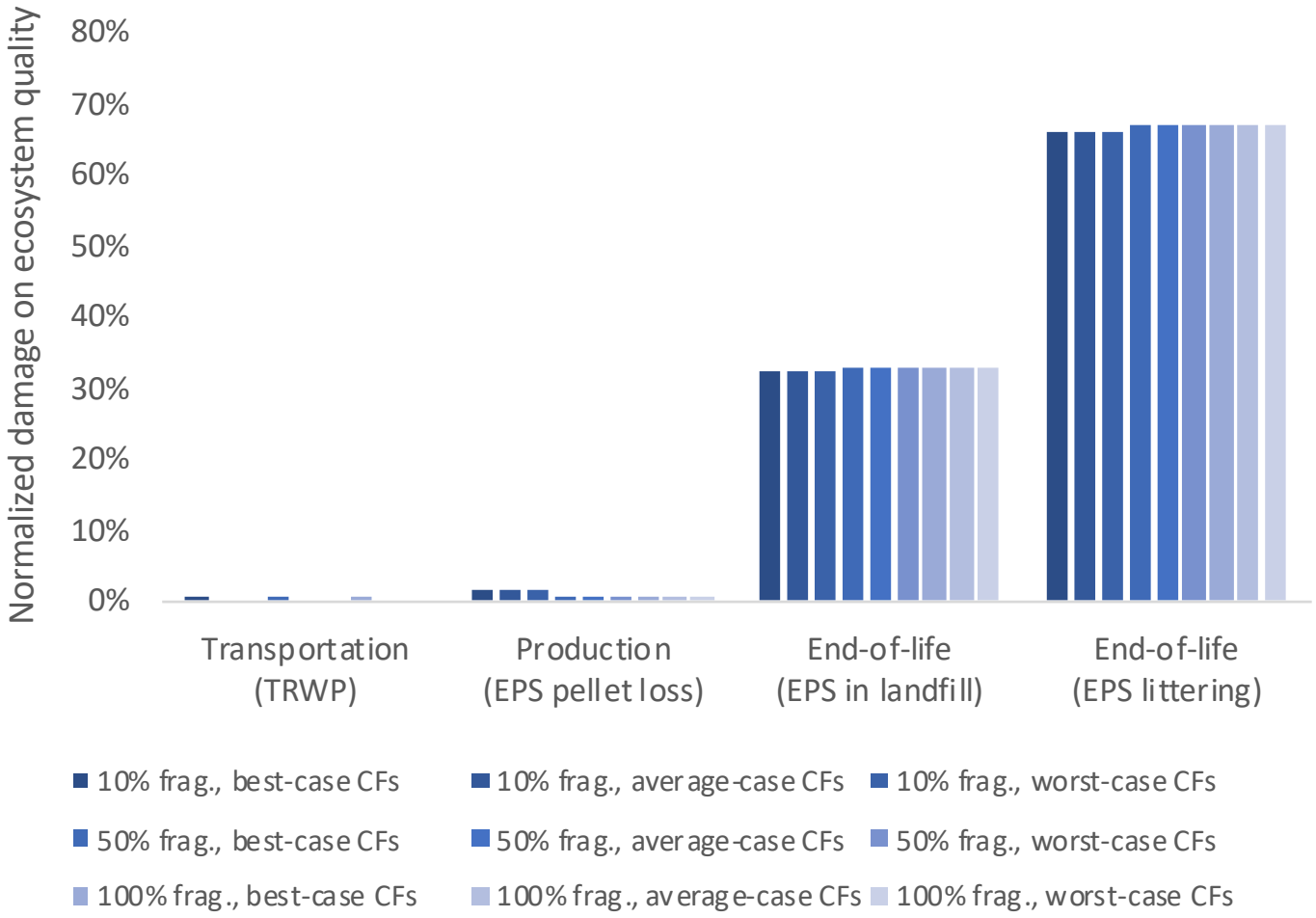
Lavoie, J., Boulay, A., & Bulle, C. (2021). Aquatic micro- and nano-plastics in life cycle assessment: Development of an effect factor for the quantification of their physical impact on biota. *Journal of Industrial Ecology*, (2015), 1–13.

Results: Ecosystem quality

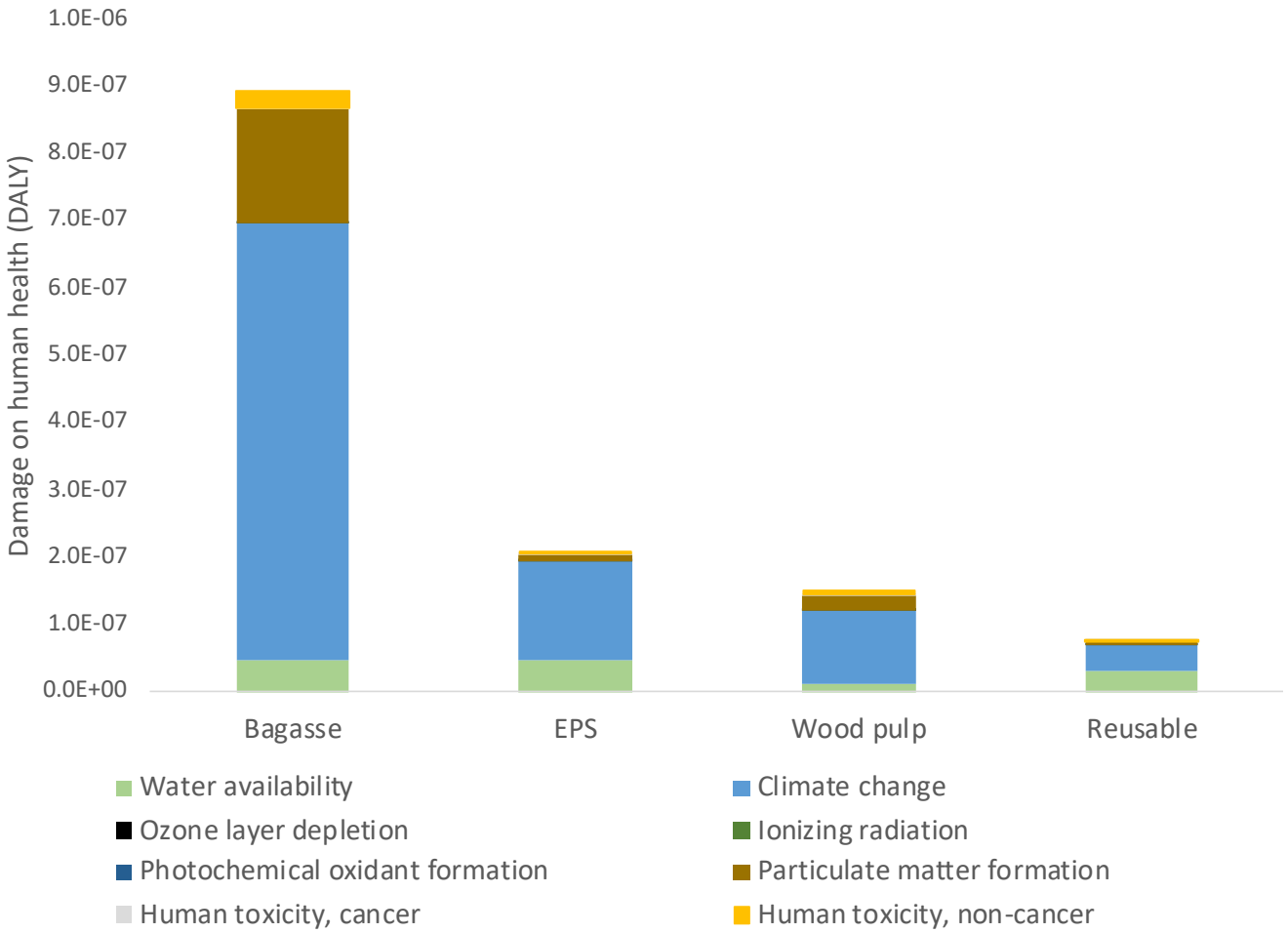


Fragmentation scenario	CF scenario	Physical effects on biota (PDF*m²*year)
50%	**average**	**5.86E-03**
50%	best	3.23E-05
10%	best	6.54E-06

Physical effects on biota by life cycle stage (EPS container)



Results: Human health



Conclusions:

- Bagasse containers show the highest damage on both human health and ecosystem quality.
  - **A compostable container is not necessarily the most environmentally-friendly option.**

- For the EPS container, littering has the largest impact within *physical effects on biota.*
  - **Reducing littering would significantly reduce the impacts of EPS containers.**

- Reusable, wood pulp and EPS (average plastic impacts scenario) containers show similar damage on ecosystem quality. However, this would change in the worst-case scenario for plastic impacts.
  - **Detailed modelling the fate and impacts of microplastics is needed to reduce uncertainty.**

Thank you!

Methodology: Inventory and impact assessment

Life cycle inventory:

- Ecoinvent 3
- Previous CIRAIG study (2017)
- Directly from suppliers
- Plastic Leak Project **-> expanded polystyrene (EPS) waste and tire and road wear particles (TRWP)**

Life cycle impact assessment:

- Modified version of ImpactWorld+ (including new plastic characterization factors)

Peano, L., Kounina, A., Magaud, V., Chalumeau, S., Zgola, M., & Boucher, J. (2020). Plastic Leak Project - Methodological Guidelines. *Quantis and EA*, *v1.3*

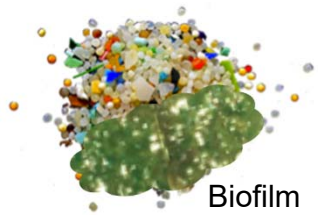
CIRAIG. (2017). Analyse du cycle de vie de différents types de vaisselle et de scénarios d'opération des aires de service alimentaire de Polytechnique Montréal. Montréal, Canada.

Methodology: Preliminary fate modelling

Fragmentation

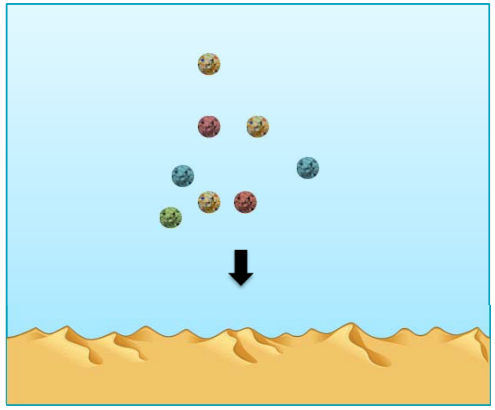
100%, 50%, 10%

Degradation



0, 0.001, 1 µm/year

Sedimentation



0%, 10%, 50% in 100 years

Integrated in CFs

Scenarios: worst, average, best

Research at CIRAIG

Ongoing:

- Detailed modelling of the fate of microplastics in different **marine environmental sub-compartments**
- Detailed modelling of plastic **fragmentation and degradation**

Future:

- Detailed modelling of the fate of microplastics **in and across all environmental** compartments
- Development of preliminary characterization factors for modelling **human health** impacts of plastics