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Conception of novel biobased and biodegradable packaging polymers

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Introduction

Almost 40 % of the global annual polymer production is used for packaging of consumer goods. Packaging is an essential partner for protection and selling of goods. The drawback of the massive use of synthetic materials in short-lived applications, such as packaging, is their accumulation in natural habitats due to their very slow degradation kinetics. Biodegradability of polymer resins is one feature to consider for decreasing persistent pollution. It is particularly interesting in the case of multilayer materials and polymer blends where recycling is technologically not feasible.

Objective – biodegradable packaging

The objective of the project Creabiom was to develop biobased and biodegradable additives for PLA using by-products of the food industry. An exhaustive screening work showed that by-products of the vegetable oil refinery, and in particular deodorizer distillates, had a potential for becoming polymer additives.

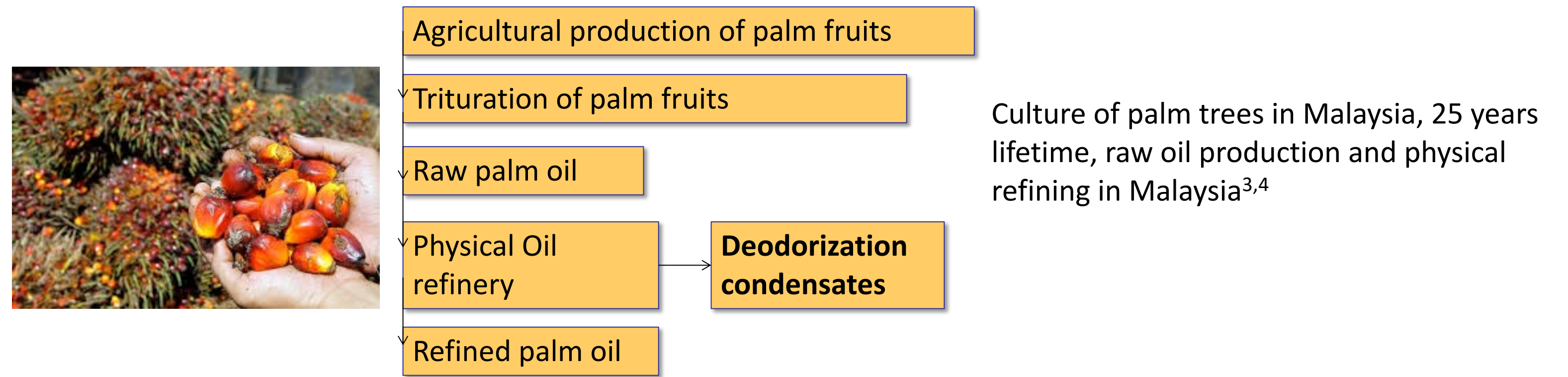
LCA of biobased and petrochemical additives

Scope: cradle to gate

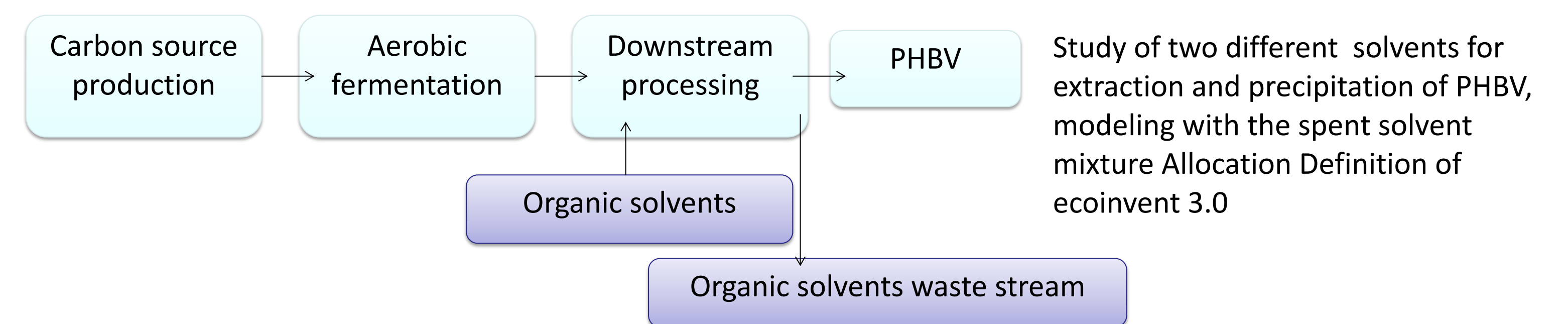
Functional unit:

- Plasticizing equivalent to 1 kg palm oil deodorization condensates
- 1 kg of polymer

Inventory palm oil deodorization condensates



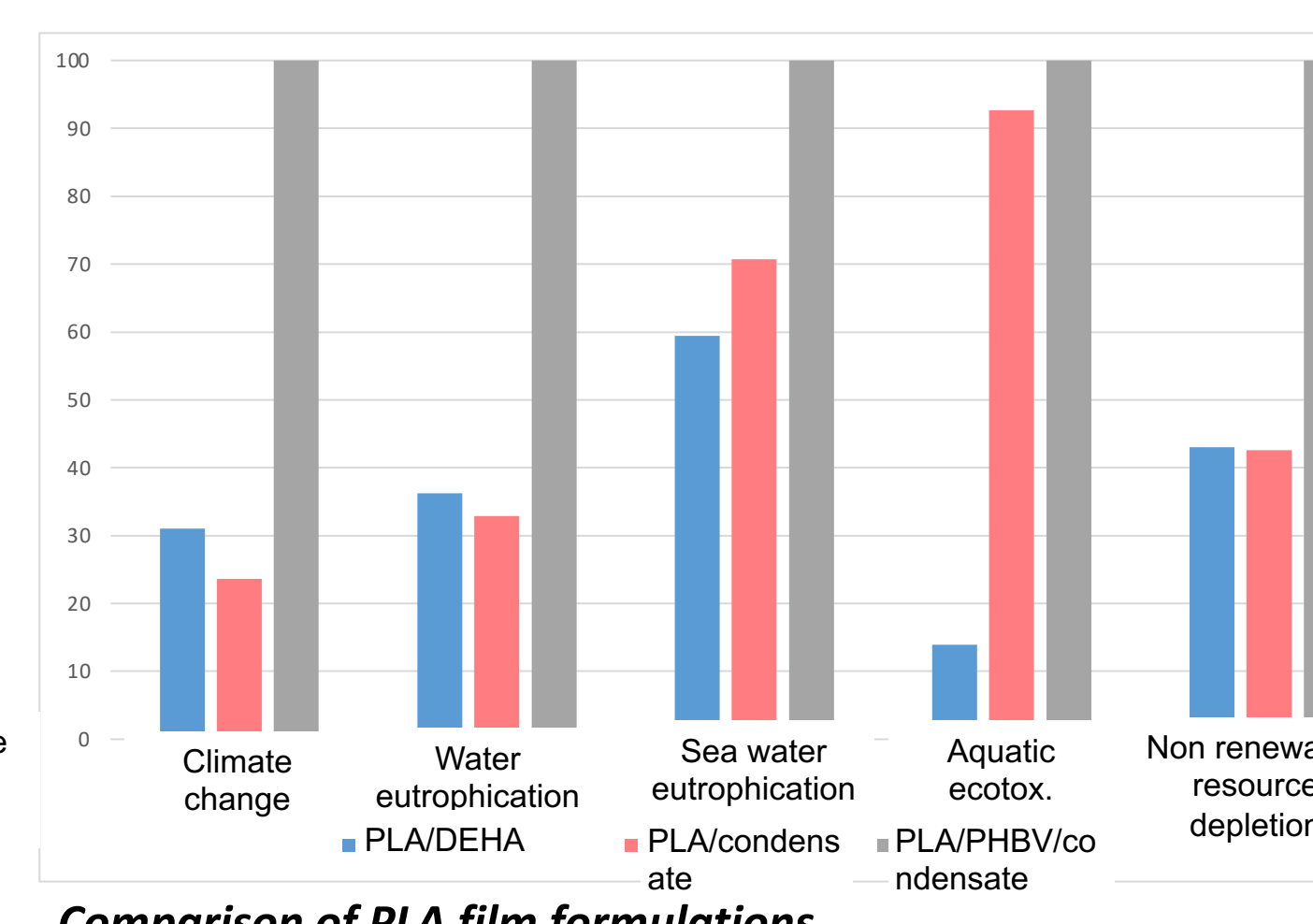
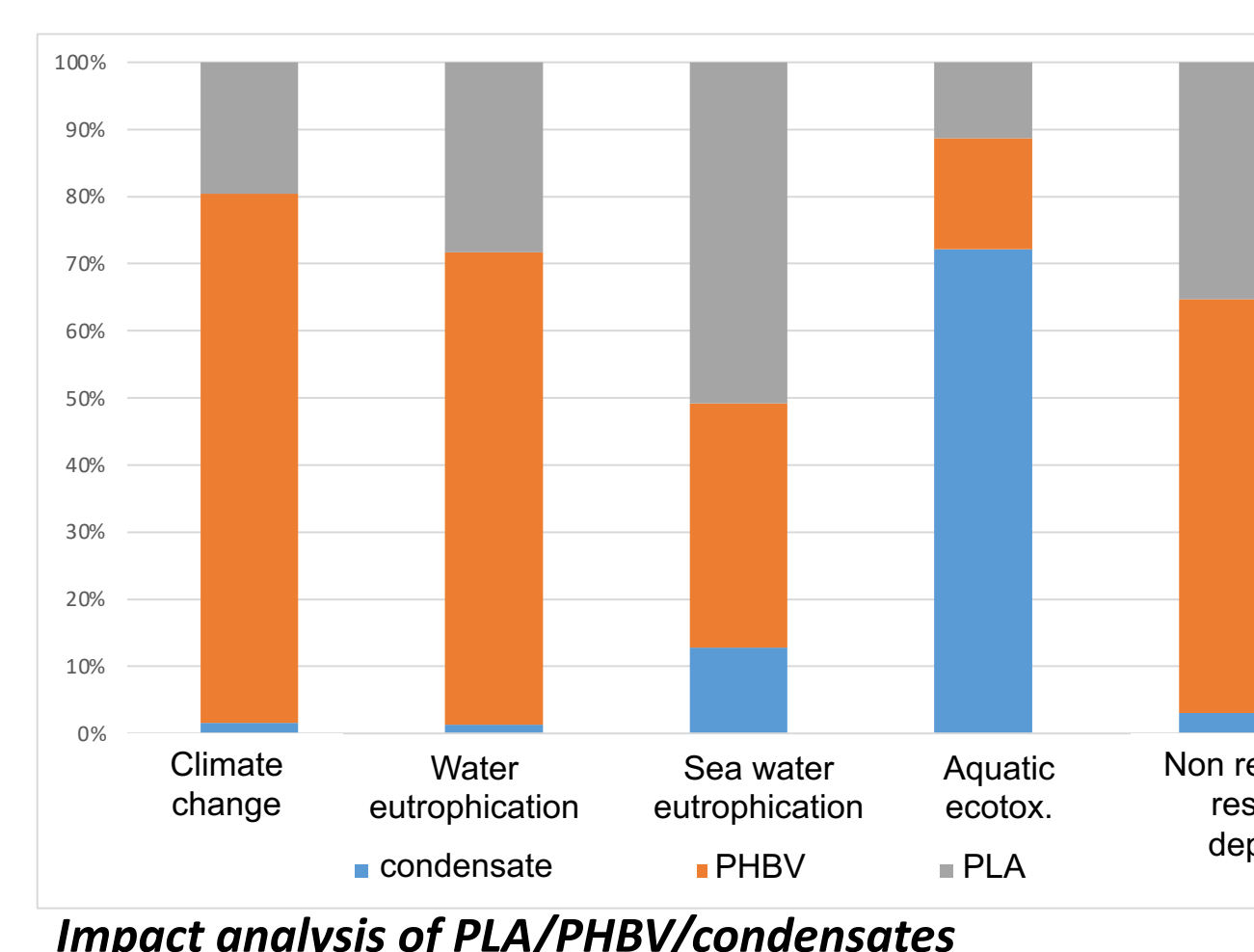
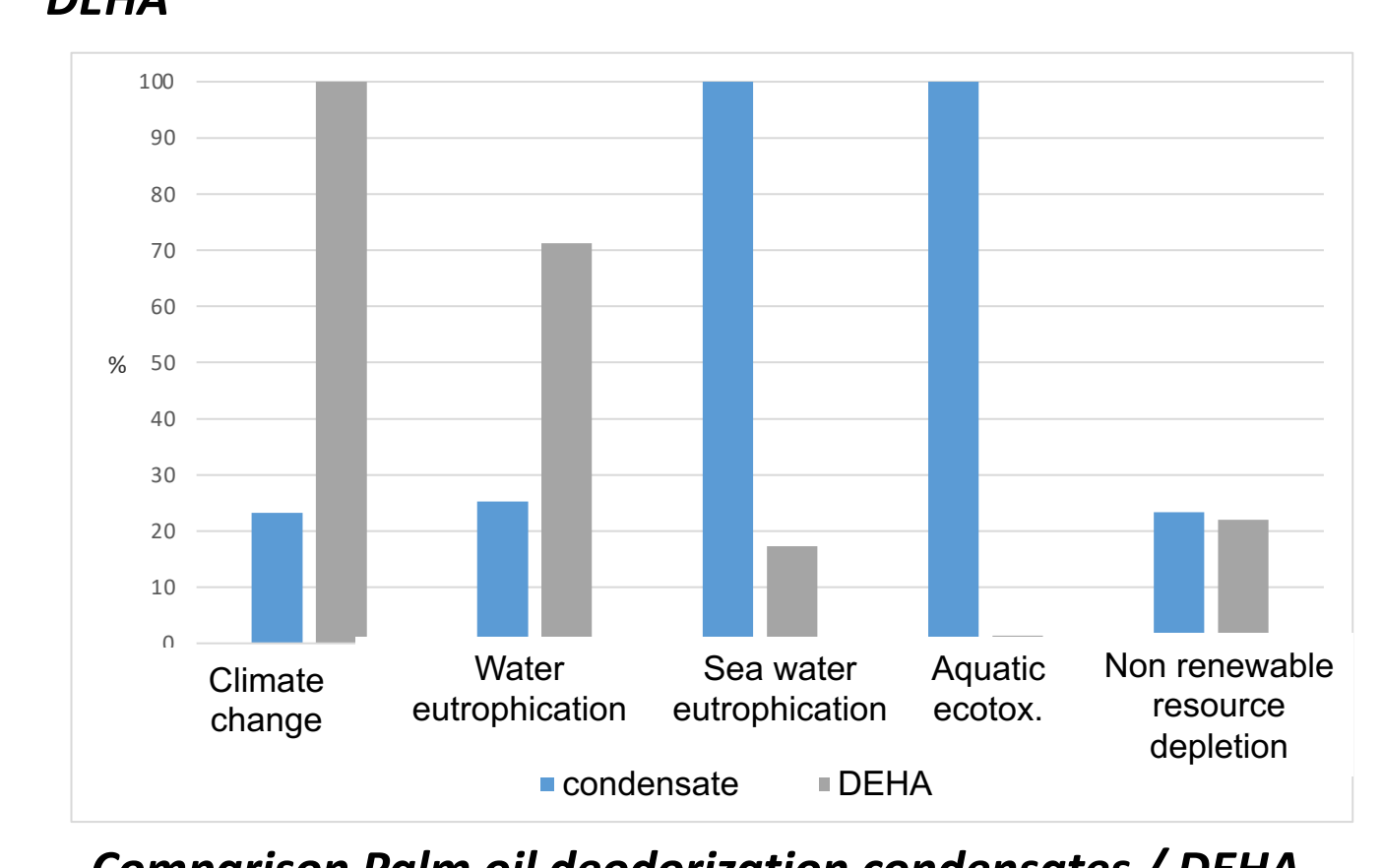
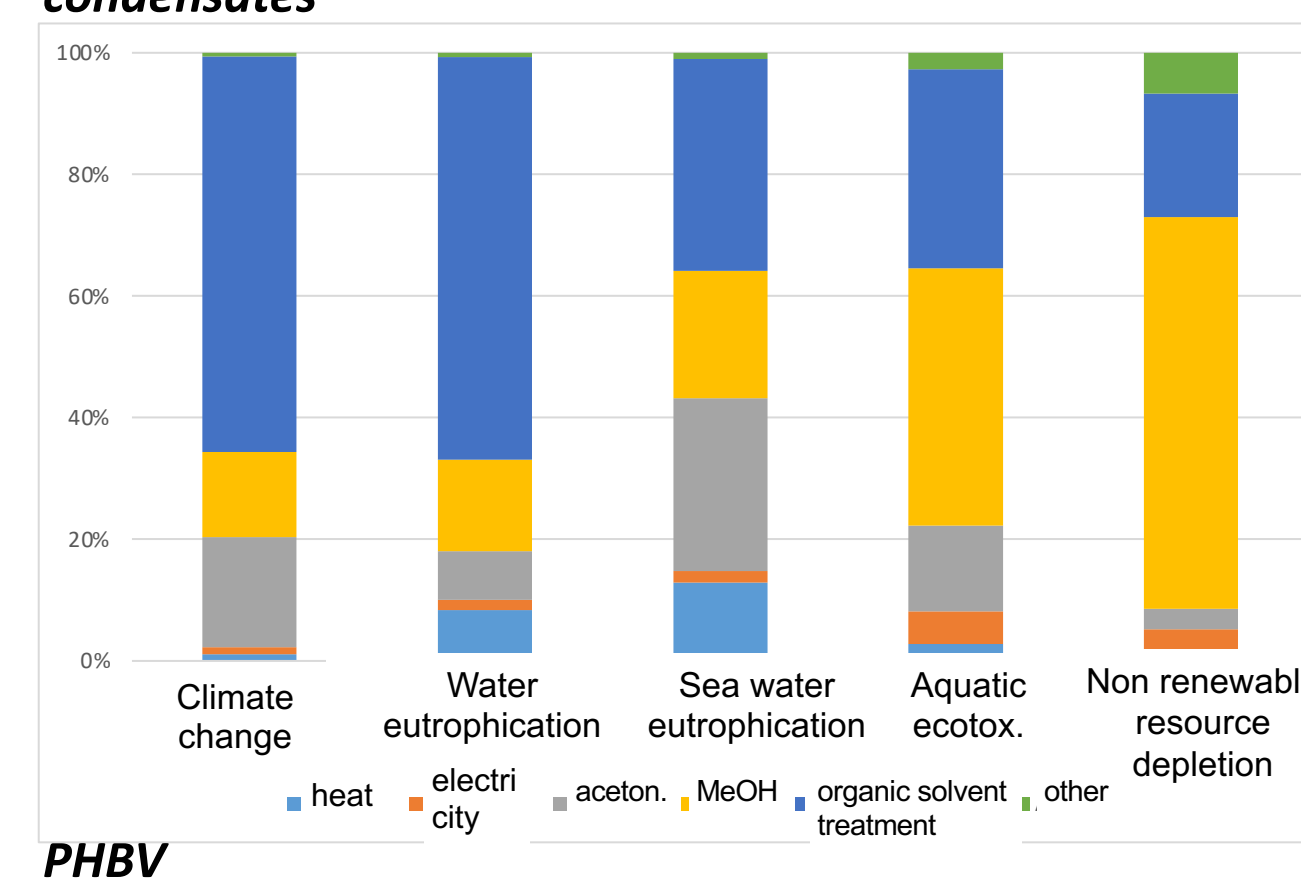
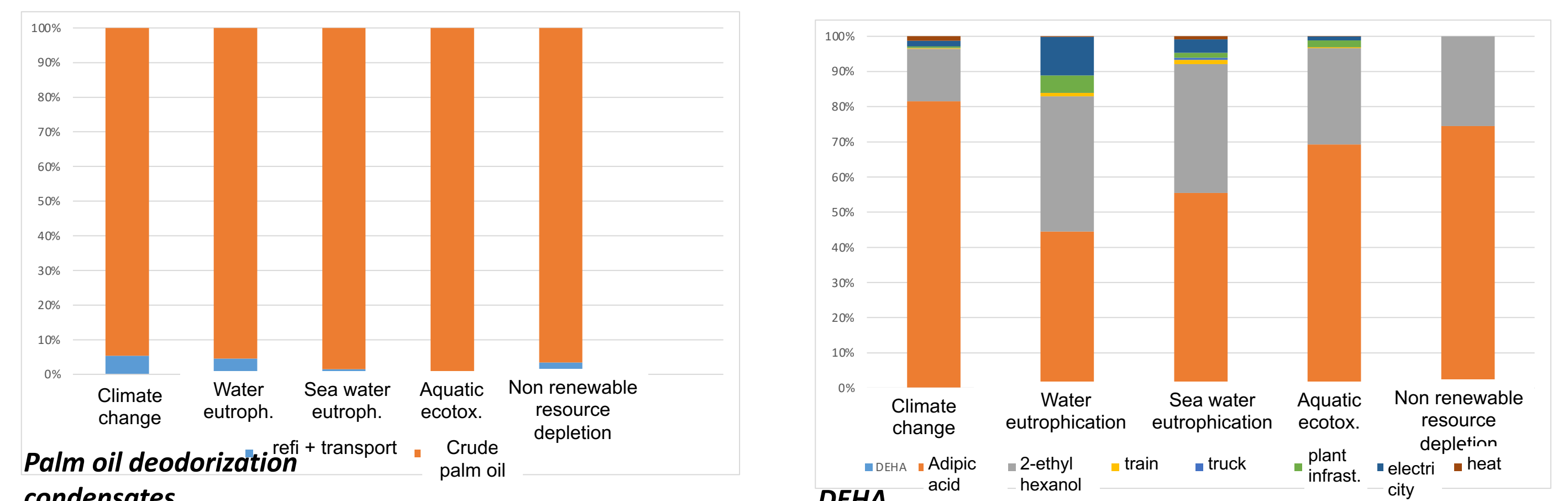
Inventory of poly(3-hydroxybutyrate-co-valerate), PHBV



Inventory of bis(2-ethylhexyl) adipate (DEHA) production CAS 103-23-1 and poly(lactide), PLA

- DEHA: Adipic acid, n-butanol, citric acid, aldol process from propylene for the production of 2-ethylhexanol after ecoinvent 3.0 esterification of adipic acid after ecoinvent 2.0 for unknown chemical processes and 100 % yield
- PLA: Use of data published by NatureWorks⁵

Environmental Impact Analysis



We showed that deodorizer distillates of palm oil were particularly efficient toughening agents for polylactide and that the use of poly(hydroxybutyrate-co-valerate), a bacterial polyester, increased the thermal stability during storage. The compounded PLA had the following characteristics^{1,2}:

- Increased ductility from initially 5 to 130 % elongation at break
- Glass transition temperature higher than RT (40 ° C)
- Biodegradable after EN 13432
- Compliance with the regulation EU 10/2011 for Food Contact Materials

LCA objectives

- Comparison of environmental impact of deodorizer distillates to a commercial plasticizer of PLA (ISO 14040:2006)
- Comparison of the environmental impact of the biobased compound to the petrochemical one

LCA impact categories

- Climate change – kg eq. CO₂ (Method IPCC, 2007, 100 a, v1.02)
- Water eutrophication – kg eq. P and kg eq. N (Method ReCiPe 2008)
- Sea water eutrophication – kg eq. P and kg eq. N (ReCiPe 2008)
- Aquatic ecotoxicity – CTUe -(Method USEtox)
- Non renewable resources depletion – kg eq. Sb (abiotic depletion, CML baseline 2000, v2.05)

Software: SimaPro (2014), use of ecoinvent 3.0 (2013)

References

1. Ruellan et al, Express Polymer Letters, 2015, 9, 1087
2. Ruellan et al, Polymer International, 2016
3. Schmidt et al, J of Land Use Science, 2009, 4, 35
4. Tan et al, J of Oil Palm Research, 2010, 22, 913
5. Suwanmanee et al, Int. Journal of Life Cycle Analysis, 2013, 18, 401

Conclusion

A biodegradable polylactide film with enhanced ductility was developed using palm oil refinery by-products. The material was formulated with PHBV to enhance thermal stability. The analysis of the developed materials showed that no difference between biobased and petrochemical plasticizers was found. However, the use of PHBV for technological reasons impacted negatively the environmental footprint. The reason was the need for organic solvents in the downstream processing of PHBV. LCA shows thus to the need for optimizing and codesigning production biorefinery processes.