Decreased ecotoxicity impacts of sun care products with laccase-based solutions

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Goal and context of the study

This study is part of the Horizon project OXIPRO which develops more environment-friendly solutions for consumer products using novel oxidoreductase processes.

Sun care products used for UV protection include several chemicals which can have detrimental impacts on the aquatic ecosystems when ending up in natural waters in the use stage. This case study focuses on the innovative use of biocatalytic synthesis to produce melanin-like polymers as UV filters in sunscreens, aiming for minimize the ecotoxic impacts in comparison to traditional products.

Methodology

Using LCA and EF3.1 methodologies and the SULCA-tool, an OXIPRO sunscreen with a melanin-like polymer UV-filter was compared to a traditional sunscreen (Figure 1). Since toxicity impacts depend on the receiving water body, both fresh water and sea water as ending points were considered.

The functional unit of the study is the production and use of 1 kg of sunscreen including its packaging.

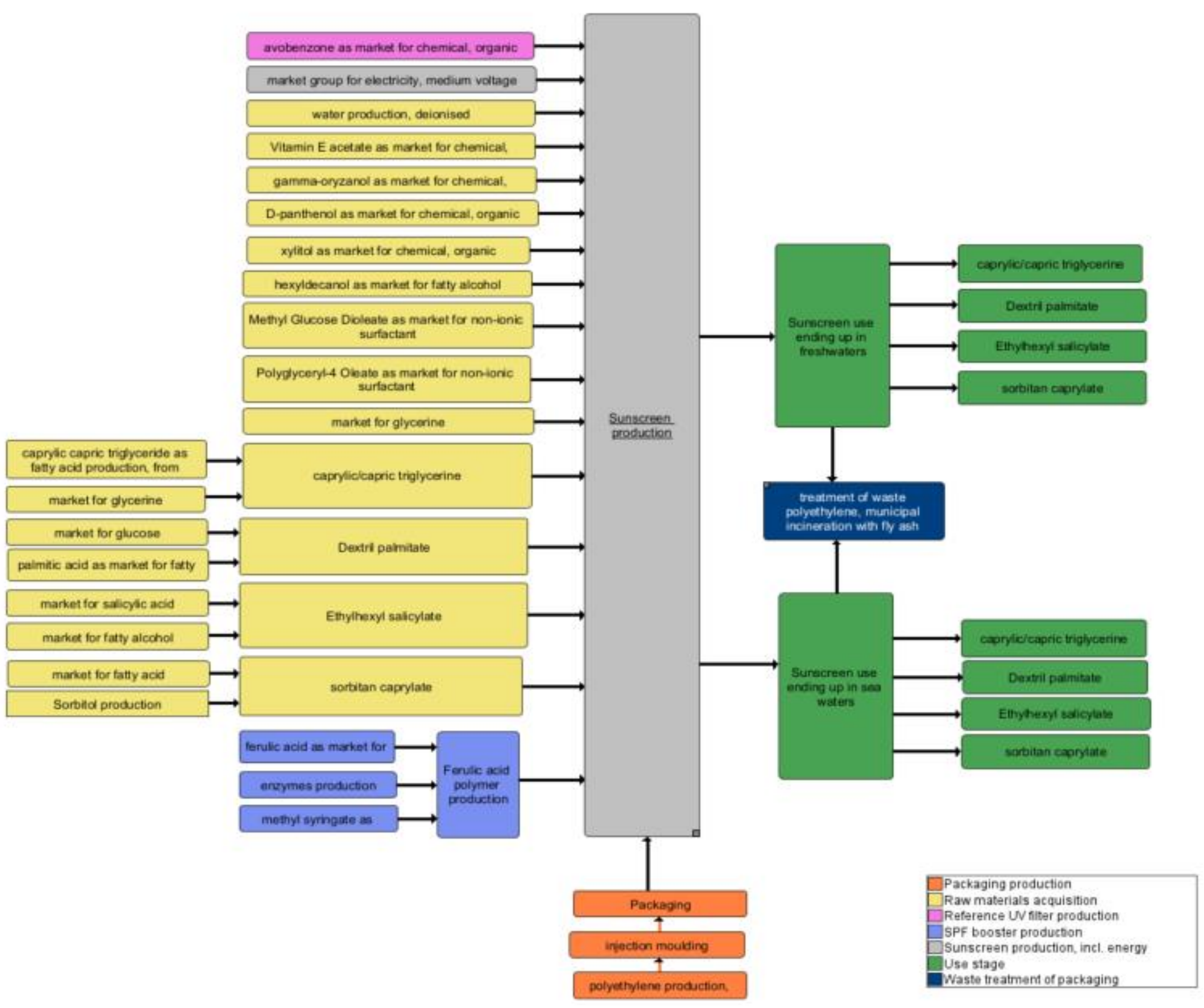
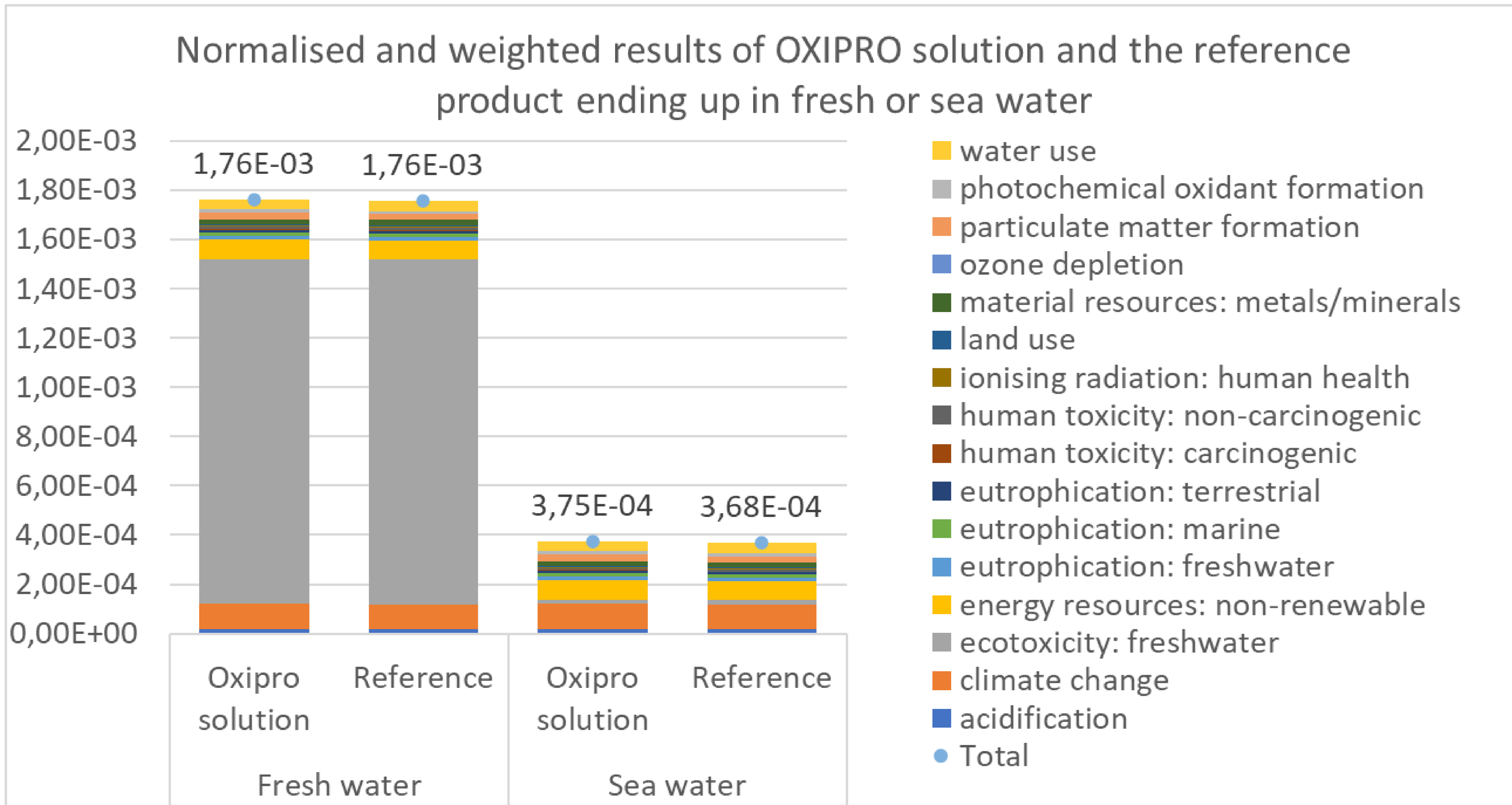


Figure 1: Flowchart of sunscreen life cycle with a cradle to grave system boundary

Results of LCA

Most of the environmental impacts of sunscreens origin from raw material acquisition. The use stage only contributes to the toxicity categories. However, the main contributor to toxicity is not the traditional UV filter but other ingredients present in both sunscreens.



Toxicity of chemicals

The toxicity of chemical ingredients varies a lot, thus the beneficial impact of the OXIPRO solutions may be relatively higher if compared to other reference UV filters than those used in this study.

Traditional UV Filters	Human toxicity, non-carcinogenic, CTUh/kg		Ecotoxicity, freshwater, CTUe /kg		Dosage Reference
	To sea water	To fresh water	To sea water	To fresh water	
Avobenzone	3.28E-08	2.20E-07	3.71E-02	8.57E+01	up to 3 %
Dioxybenzone	1.31E-08	7.35E-07	3.12E+00	1.13E+04	up to 3 %
Ensulizole8	1.31E-11	4.85E-08	1.84E-11	4.57E+02	up to 4 %
Homosalate	1.70E-07	2.23E-06	4.86E+01	2.54E+05	up to 15 %
Octinoxate10	3.41E-09	5.34E-08	6.00E-04	1.65E+01	up to 7.5 %
Octisalate11	4.02E-09	7.99E-08	3.01E+00	3.09E+04	up to 5 %
Octocrylene	1.99E-08	1.63E-07	1.08E-05	3.30E+01	up to 10 %
Oxybenzone	0.00E+00	0.00E+00	6.41E-03	3.94E+04	up to 6 %
Sulisobenzone	2.05E-10	1.04E-06	3.61E-08	2.55E+04	up to 10 %
TiO2	2.51E-08	7.90E-08	7.20E-03	1.15E+01	up to 25 %
Zinc oxide	1.87E-11	3.22E-08	9.03E-08	6.39E+03	up to 25 %

Conclusions

- *Public robust data of specific chemicals and enzymes production are needed, today only average values for production are available*
- *The enzyme-derived polymers generated in OXIPRO could not fully eliminate toxicity challenges relating to sunscreens*
- *Toxicity impacts are complex on different organisms and research is still much needed*

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