Improving the robustness of freshwater ecotoxicity impact assessment of cosmetic products in LCA:

Summary and illustration of the work conducted by the EcoBeautyScore Consortium

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Limitations of USEtox© model adapted by the European Commission for evaluating freshwater ecotoxicity impacts

The Product Environmental Footprint (PEF) method prescribes the **USEtox© 2.1 model** adapted by the European Commission (EC) to assess **freshwater ecotoxicity impact** (fw ecotox) of consumer products. This impact category usually is a major environmental hotspot in cosmetic products' footprints, mainly via **ingredients end-of-life** (>80% of total fw ecotox impact). Two main limitations associated to the fw ecotox characterization factors (CF) in the PEF EF3.1 reference package were identified:

Poor coverage of EBS priority ingredients[1] by EF3.1 CF: ~ **30% only** (201 out of 671 priority ingredients across 4 product segments).

EF3.1 CF needing adaptations: update of input data based on existing data and revision of inconsistent values required for prioritized ingredients.

[1] List of substances determined as part of the Consortium work reflecting the most used ingredients in Body Wash, Hair Wash, Hair Treat and Face Moisturizing products.

Actions were carried out by the Consortium to tackle these limitations of EF3.1 fw ecotox CF for cosmetics.

EcoBeautyScore (EBS) Consortium objective

The EcoBeautyScore (EBS) Consortium aims at **developing a common environmental impact scoring system for cosmetic products**. Its main purpose is to enable consumers to make more informed purchasing decisions based on a standardized environmental impact assessment of products. Its main objectives include creating a common method for environmental impact assessment and establishing methodological principles for scoring products based on a rating scale, *e.g.* A-E. The scope of the Consortium covers all cosmetic products and has 70+ members, aiming for inclusivity regardless of size or resources.

EBS simplified method based on the Most Sensitive Species (MSS) to calculate Effect Factors (EF)

1. EF is the most impacting factor of the CF equation

$$CF_{fw,x}^{*} = FF_x \times XF_x \times EF_x$$

* [PAF.m³.d.kg⁻¹]

For EF3.1 CF of interest:

- Fate Factors (FF) range between ≈ 2 and ≈ 90 [d]
- Exposure Factors (XF) comprised within 0 and 1 [-]
- Effect Factors (EF) variation by 5 orders of magnitude (max ≈ 9E+04 [PAF.m³.kg⁻¹]

A Collection of existing ecotoxicity data from European Chemicals Agency (ECHA) and members' databases for priority ingredients to focus on EF update.

B EF data curation using a simplified method for EF recalculation.

C Update of CF equation with (i) recalculated EF, (ii) use of existing values, semi-specific or generic proxies for FF × XF.

2. Simplified methodology for calculating EF: MSS-HC5 approach

Cover the **3 standard trophic levels** (*Algae A, Daphnia D* and *Fish F*), prioritize **chronic (chr) over acute (ac) data,** use **most sensitive species'** $EC_{10,chr}$ *(or NOEC)* **as a proxy value for** HC_5

$$EF_{EBS} = 1000 \times (0.05 / HC5_{EC10,chr})$$

- **Convert acute into chronic-eq data:** if no chr data available, use lowest $EC_{50,ac}$ value for calculation of the lowest $EC_{10,chr}$ reference value using an ac-to-chr factor (100 for metals and organometallics; 10 for other substances, including organics).
- **Use of safety factors (SF)** when not all trophic levels covered for a conservative approach:
  - *If no chr data available:* apply SF = 1 for all 3 trophic levels, SF = 5 for 2 trophic levels only and SF = 10 for 1 trophic level only.
  - *If chr data available on top of ac data for 3 trophic levels:* Use SF = 1 if MSS trophic level also has chr data, else SF function of trophic levels covered by chr data.

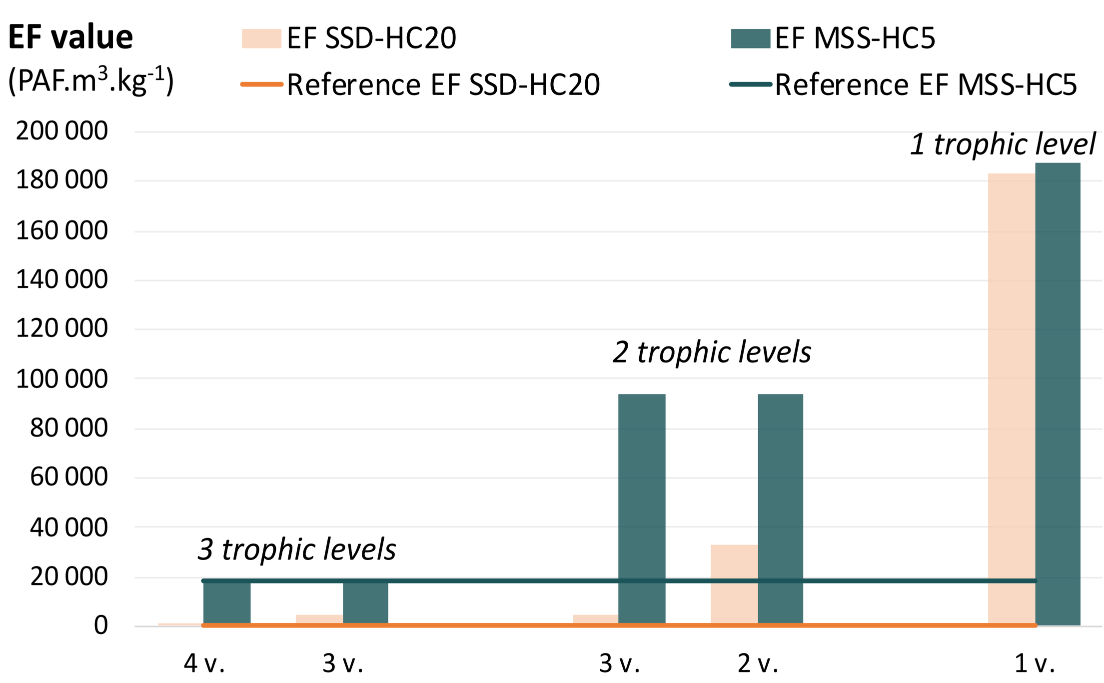
CF improvement as a result of EF based on MSS-HC5 approach – 2 examples for cosmetic ingredients

UV filter CAS 6197-30-4	CF [CTUe]	EF [PAF.m³.kg⁻¹]	FF x XF [d]
EF 3.1	3.3E+01	≈ 5 EF value derived from single chr value (Algae) - *Source: EC Ecotox Explorer*	≈ 7
EBS	1.24E+05	**1.8E+04** (i) ac and chr data available for 3 trophic levels, SF = 1; (ii) MSS-HC_5 = 0.00266 mg/L (Daphnia – NOEC) - *Source: REACH dossier (EC 228-250-8)*	≈ 7

Fatty alcohol CAS 36653-82-4	CF [CTUe]	EF [PAF.m³.kg⁻¹]	FF x XF [d]
EF 3.1	1.6E+05	5.0E+04 Reliable data for 3 trophic levels: non-toxic substance at the limit of solubility, chr and ac EC50 and EC10 all > 0.024 mg/L - *Source: REACH dossier (EC 253-149-0)*	≈ 3
EBS	8.0E+02	**2.5E+02** (i) ac data available for 2 trophic levels, SF = 5; (ii) no observed effect up to limit of water solubility - 100 mg/L considered as the ref value for $EC_{50,ac}$ for the 2 trophic levels (highest tested concentration in ecotoxicity tests), ac-to-chr factor = 10	≈ 3

EF sensitivity depends on number of available data across all trophic levels: MSS-HC5 approach is less variable than SSD-HC20

Case study 1: UV filter (CAS 6197-30-4) – 5 data points (2# A / 1# D / 2# F)



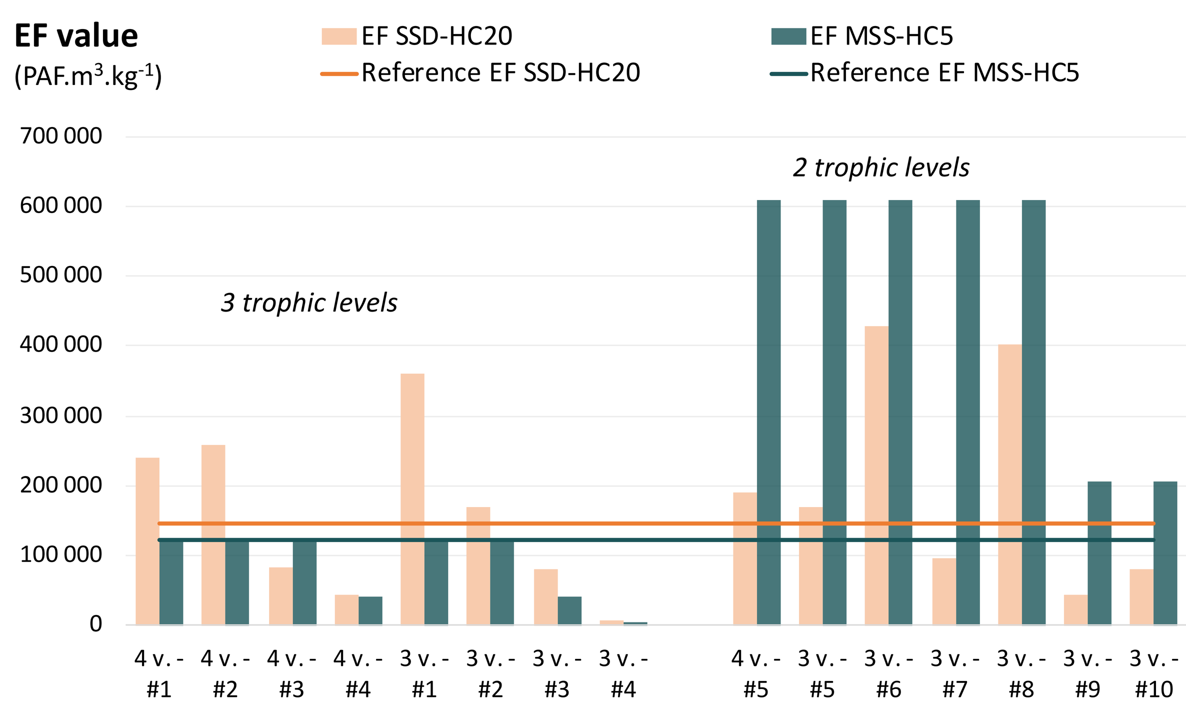
- Unreliable (non-sigmoid) SSD (species vs log $EC_{10,chr}$) curve
- Reference value for *Daphnia* (MSS), no observed ecotoxicity for *Algae* and *Fish* up to the limit of water solubility
- SSD-HC_{20} EF sharp decrease the more available data across trophic levels, while MSS-HC_5 EF better reflects ecotoxicity for MSS

v = ecotoxicity value

Ref. EF SSD-HC_{20} = 3.15E+02 PAF.m³.kg⁻¹

Ref. EF MSS-HC_5 = 1.88E+05 PAF.m³.kg⁻¹

Case study 2: Anti-dandruff (CAS 13463-41-7) – 5 data points (2# A / 1# D / 2# F)



Reliable (sigmoid) SSD (species vs log $EC_{10,chr}$) curve

Algae min data as reference ecotoxicity value (MSS)

SSD-HC_{20} EF more sensitive to variations in data availability than MSS-HC_5 EF

When data for 3 trophic levels, MSS-HC_5 EF varies only if the MSS is not part of the subset

v = ecotoxicity value

Ref. EF SSD-HC_{20} = 1.45E+05 PAF.m³.kg⁻¹

Ref. EF MSS-HC_5 = 1.22E+05 PAF.m³.kg⁻¹

Benefits of the MSS-HC5 approach

- **Alignment with regulatory methods** from EU Environmental Risk Assessment (ERA), driven by the principle of ecosystem preservation.
- **Equally or more robust approach than SSD-HC_{20}** : MSS-HC_5 not dependent on SSD curve ability to properly translate the concentration (log_{10}) $EC_{10,chr}$ x species $EC10_{chr}$ relationship.
- **Pragmatic approach:** Scalable MSS-HC_5 approach suitable for extensive computation of EF values (up to ~ 30,000 relevant cosmetic ingredients), based on available reference ecotoxicity values (*e.g.* for ERA, ecolabel).
- **Easier maintenance:** Simple screening for a possible change in reference value ($EC_{50,ac}$ or $EC_{10,chr}$) and No. of standard trophic levels to derive HC_5.

Conclusions and recommendations

Developed MSS-HC_5 approach to **strengthen the assessment** of the freshwater ecotoxicity impact of cosmetic ingredients at **end-of-life stage**.

Doubled coverage of EBS priority ingredients with ingredient-specific fw ecotox CF based on MSS-HC_5 method (**~60%** vs ~30% in EF3.1) for an improved product differentiation.

MSS-HC_5 method **relevant for other industries** using a large number of chemical substances and willing to improve how freshwater ecotoxicity impacts are assessed in LCA.

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