Product Environmental Footprint Supporting Study in the EF Shadow Pilot Phase: Shampoo for Delicate Hair

Product Environmental Footprint
Supporting Study
Shampoo for Delicate Hair

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1 Summary

This supporting study is part of Cosmetics Europe's PEF Project which follows closely the PEF guidelines of the European Commission, whose goals are:

- to test the draft "Study into the development of Product Environmental Footprint Category Rules for shampoo" (hereafter referred to as PEFCR);
- to validate the outcomes of the screening study.

The functional unit considered is as follows:

A hair wash carried out in Europe (EU 28 MS), on average length hair

The reference flow considered, i.e., the amount of product needed to provide the defined function, is 10.46 grams of shampoo.

The system boundaries of the study encompass the life cycle of the use of shampoo, from the materials extraction to the end-of-life of the shampoo and its packaging. Pierre Fabre provided primary data concerning the shampoo formulation (ingredients), the packaging quantity and type, manufacturing energy consumption, water use and waste generated. The transportation distance of the bottle was also provided. The remainder of the data was based on secondary data from the PEFCR. Since the use stage is highly dependent on consumer habits, which can vary significantly depending on the consumer, and for which little data are available, the modelling of this life cycle stage is considered to have a high level of uncertainty.

Figure 1 presents the overall results contribution for the shampoo life cycle. The use stage dominates or has a significant contribution for all indicators except freshwater ecotoxicity, which is dominated by product end-of-life. The production of the shampoo ingredients, as well as distribution stages both have non negligible contributions for several indicators. Shampoo manufacturing has a large contribution for the ionizing radiation indicators. This is because the shampoo is manufactured in France, where over 75% of the grid mix is from nuclear energy. Packaging production and end-of-life, relative to the other life cycle stages, do not have a large contribution to the overall results.

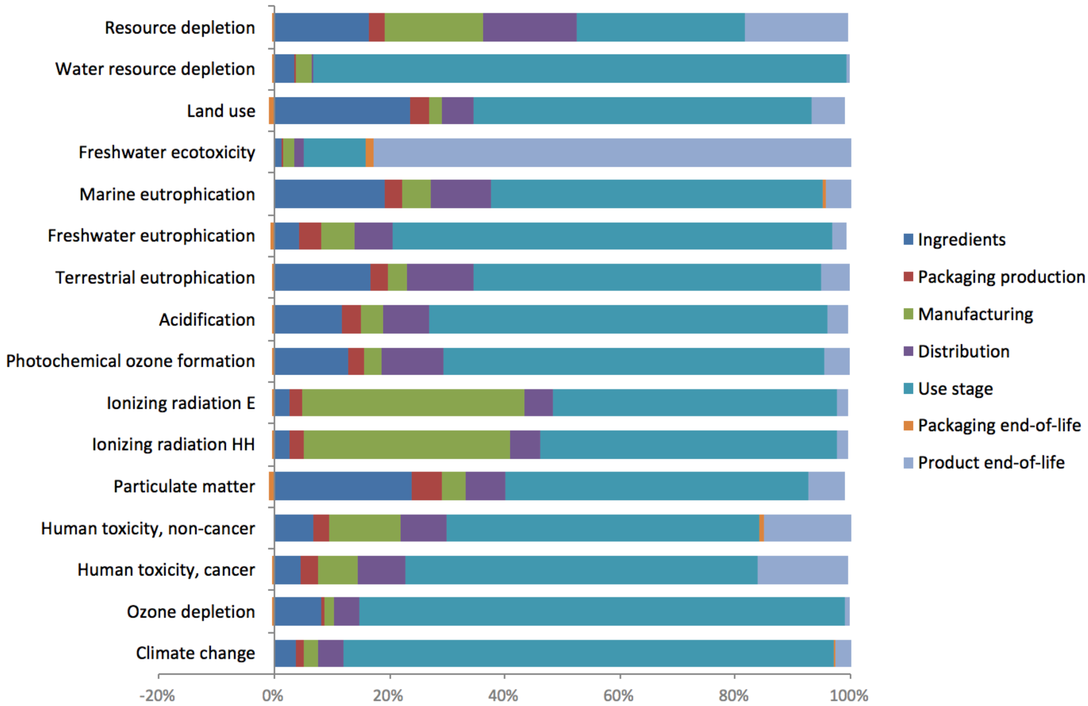

Figure 1. Overall results for one shampoo use per life cycle stage

The indicators evaluated as relevant for a shampoo are:

- Climate change
- Water resource depletion
- Mineral and fossil resource depletion
- Freshwater ecotoxicity (subject to the availability of appropriate methodology and data)

This selection was performed based on two normalisation approaches. The process and results to identify the most relevant EF impact categories are presented in Annex II: Normalisation.

The supporting study conclusions are consistent with those obtained from the representative product screening study.

2 General

The characteristics of the product under study are:

Product description: Shampoo for delicate hair (400 ml) **Product classification:** C 20.42.16.30 “Shampoos” **Company:** Pierre Fabre **Company location:** France **Date of publication of the supporting study:** April 2016 **Geographic validity:** Manufactured in France, distributed and used in Europe **Reference study:** Study into the development of Product Environmental Footprint Category Rules (PEFCR) for shampoo, Final draft, April 2016 **Critical review:** this report has not undergone a critical review process	

The current document endeavours to be compliant with the requirements of the ‘Product Environmental Footprint (PEF) Guide’ (Annex II to Recommendation (2013/179/EU), the “Guidance for the implementation of the EU PEF during the EF Pilot Phase” (version no. 5.0.) and the “Study into the development of Product Environmental Footprint Category Rules (PEFCR) for shampoo”, Final draft, April 2016. The latter document will be referred to throughout this report as PEFCR.

3 Goal of the study

This supporting study is part of Cosmetics Europe’s PEF Project which follows closely the PEF guidelines of the European Commission, whose goals are:

- to test the draft “Study into the development of Product Environmental Footprint Category Rules for shampoo” (hereafter referred to as PEFCR);
- to validate the outcomes of the screening study (such as the selection of relevant impact categories, life cycle stages, processes and elementary flows)

4 Scope of the study

4.1 Functional unit and reference flow

The functional unit considered is as follows:

A hair wash carried out in Europe (EU 28 MS), on average length hair

The reference flow considered, i.e., the amount of product needed to provide the defined function, is 10.46 grams of shampoo.

4.2 System boundaries

Figure 2 illustrates all life cycle stages included in the study as well as a description of the main activities considered in each life cycle stage. Pierre Fabre provided primary data concerning the shampoo formulation (ingredients), the packaging quantity and type, manufacturing energy consumption, water use and waste generated. The transportation distance of the bottle was also provided. The remainder of the data was based on secondary data from the PEFCR.

Life cycle stage	Description of activities included for each life cycle stage
1 Ingredients production	• Extraction of resources • Pre-processing of all material inputs to the studied product • Transportation from pre-processing facilities to the production facility
2 Packaging production	• Production of raw materials for packaging (plastics, cardboard, etc.) • Packaging manufacturing processes (blow molding, extrusion) • Transportation of packaging to shampoo manufacturing facility
3 Manufacturing	• Energy and water use for shampoo manufacturing • Packaging of the shampoo • Treatment of waste and wastewater • Manufacturing plant infrastructure
4 Product distribution and storage	• Energy inputs for warehouse lighting and heating • Distribution center infrastructure • Transportation from manufacturing plant to point of sale, to consumer's home
5 Use stage	• Energy use during shower • Water use during shower
6 Packaging end-of-life	• Transportation of packaging to treatment facilities • Recycling, incineration, landfilling of packaging
7 Product end-of-life	• Wastewater treatment (including infrastructure and sludge treatment) • Product end-of-life (aquatic environment)

Figure 2. System boundary diagram with the main activities included per life cycle stage

4.3 Supplementary analysis

No supplementary analyses were performed.

5 Life cycle inventory analysis

5.1 Data collection and quality assessment

Pierre Fabre provided primary data for the shampoo formulation (ingredients), packaging quantity and type, as well as manufacturing energy consumption, water use and waste generated. The transportation distance of the bottle was also provided. The remainder of the data were based on secondary data from the PEFCR. This includes data for transportation and distribution, use stage energy consumption and water use, packaging and product end-of-life. The main modelling limitations lie within the use stage. Since the use stage is highly dependent on consumer habits, which can vary significantly depending on the consumer, and for which little data are available, the modelling of this life cycle stage is considered to have a high level of uncertainty.

For confidentiality reasons, no life cycle inventory quantities are communicated in this chapter.

Table 1 lists the shampoo ingredients, the associated dataset used for the modelling and the data quality ranking. All datasets are based on ecoinvent version 2.2.

Table 1. Shampoo ingredients, modelling dataset and data quality ranking (DQR)

Pierre Fabre name	Modelling dataset (ecoinvent v2.2)	DQR[1]
Dexpanthenol (75%)	Chemicals organic, at plant/GLO	5
Sodium laureth sulfate (70%)	Fatty alcohol sulfate, mix, at plant/RER (w/o heavy metals)	2
Lauryl betaine (30%)	Chemicals organic, at plant/GLO	5
Coco glucoside/water	Crude coconut oil, at plant/PH (w/o heavy metals)	3
Coco glucoside /glycol oleate	Crude coconut oil, at plant/PH (w/o heavy metals)	3
Glycerin (99.5%)	Glycerine, from palm oil, at esterification plant/MY (w/o heavy metals)	2
Guar hydroxypropyl/hydrox	Chemicals organic, at plant/GLO	5
Sodium benzoate	Sodium borates, at plant/US	2
Citric acid	Acetic acid, 98% in H2O, at plant/RER	2
Chloride sodium sulfate	Sodium sulphate, powder, production mix, at plant/RER	3
Fragrance	Chemicals organic, at plant/GLO	5
Purified water	Tap water, at user/RER	3

[1] DQR: Data quality ranking, 1 = Excellent, 2 = Very good, 3 = Good, 4 = Fair, 5 = Poor

Table 2 lists the packaging types, the associated dataset used for the modelling as well as the data quality ranking. All datasets are based on ecoinvent version 2.2.

Table 2. Packaging types, modelling dataset and data quality ranking (DQR)

Pierre Fabre name	Modelling dataset (ecoinvent v2.2)	DQR[1]
Primary packaging		
Shampoo bottle	50% Polyethylene terephthalate, granulate, bottle grade, at plant/RER Blow moulding/RER U	3
	50% recycled PET (Franklin et al. 2010)	3
Shampoo bottle cap	Polypropylene, granulate, at plant/RER U Blow moulding/RER U	3
Shampoo labels and stickers	Polyethylene, LDPE, granulate, at plant/RER Extrusion, plastic film/RER	3
Secondary packaging		
Corrugated board	Corrugated board, fresh fibre, single wall, at plant/RER	3
Tertiary packaging		
Pallet	EUR-flat pallet/RER	3
PP foil	Polypropylene, granulate, at plant/RER Extrusion, plastic film/RER	3
Packaging transport		
Truck transport	Transport, lorry 16-32t, EURO5/RER	3

Table 3 lists dataset used for the manufacturing modelling as well as the data quality ranking. All datasets are based on ecoinvent version 2.2. All manufacturing data were provided by Pierre Fabre except for the infrastructure, for which the value is based on the PEFCR assumptions.

Table 3. Manufacturing modelling dataset and data quality ranking (DQR)

Pierre Fabre name	Modelling dataset (ecoinvent v2.2)	DQR[1]
Electricity consumption	Electricity, low voltage, at grid/FR	3
Natural gas consumption	Natural gas, burned in industrial furnace >100kW/RER	3
Light fuel oil	Light fuel oil, burned in industrial furnace 1MW, non-modulating/RER	3
Water use	Tap water, at user/RER U - adapted flows Pfister, France	3
Infrastructure (manufacturing plant)	Chemical plant, organics/RER/I	2
Wastewater treatment	Treatment, sewage, to wastewater treatment, class 3/CH	3

For the distribution and use stage, generic data from the PEFCR was used (refer to the PEFCR for the modelling details). For the packaging end-of-life stage, the 50:50 formula was used, as well as the default end-of-life treatment assumptions (see PEFCR).

Table 4 lists the ingredients' end-of-life modelling. Wastewater treatment connectivity and efficiency data are based on the PEFCR, where the default values are 85% and 90%, respectively. The substances for which wastewater treatment efficiencies differ from that of the default value are alpha-hexyl cinnamaldehyde (99.9%), dihydromyrcenol (99.9%) and hexyl salicylate (99.8%).

Table 4. Ingredients end-of-life modelling

Name	ecoinvent v2.2 elementary flow[1]
Dexpanthenol (75%)	dexpanthenol
Sodium laureth sulfate (70%)	sodium laureth sulfate
Lauryl betaine (30%)	C12/15 Alkyl dimethylbetaine
Coco glucoside/water	Alcohols, coco, ethoxylated, C12-14EO20
Coco glucoside /glycol oleate	Alcohols, coco, ethoxylated, C12-14EO20
Glycerin (99.5%)	Glycerol
Guar hydroxypropyl/hydrox	hydroxypropyl guar hydroxypropyltrimonium chloride
Sodium benzoate	Sodium benzoate
Citric acid	Citric acid
Chloride sodium sulfate	Sodium chloride
Fragrance[2]	alpha-hexyl cinnamaldehyde
	dihydromyrcenol
	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-
	hexyl salicylate
	patchouli oil
Purified water[3]	not modelled

[1] Some substances not existing in ecoinvent v2.2 were added/custom modelled
[2] 20% alpha-hexyl cinnamaldehyde, 50% dihydromyrcenol (modelled as dihydromyrcene), 10% Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-, 15% hexyl salicylate, 5% patchouli oil
[3] not modelled, no end-of-life impacts

5.2 Data gaps

Please refer to the PEFCR for recommendations on filling data gaps.

5.3 Supplementary analysis

Please refer to the PEFCR for default assumptions and data sources.

6 Impact assessment results

6.1 *PEF results*

Figure 3 presents the overall results contribution for the shampoo life cycle. The use stage dominates or has a significant contribution for all indicators except freshwater ecotoxicity, which is dominated by product end-of-life. The production of the shampoo ingredients, as well as distribution stages both have non negligible contributions for several indicators. Shampoo manufacturing has a large contribution for the ionizing radiation indicators. This is because the shampoo is manufactured in France, where over 75% of the grid mix is from nuclear energy. Packaging production and end-of-life, relative to the other life cycle stages, do not have a large contribution to the overall results.

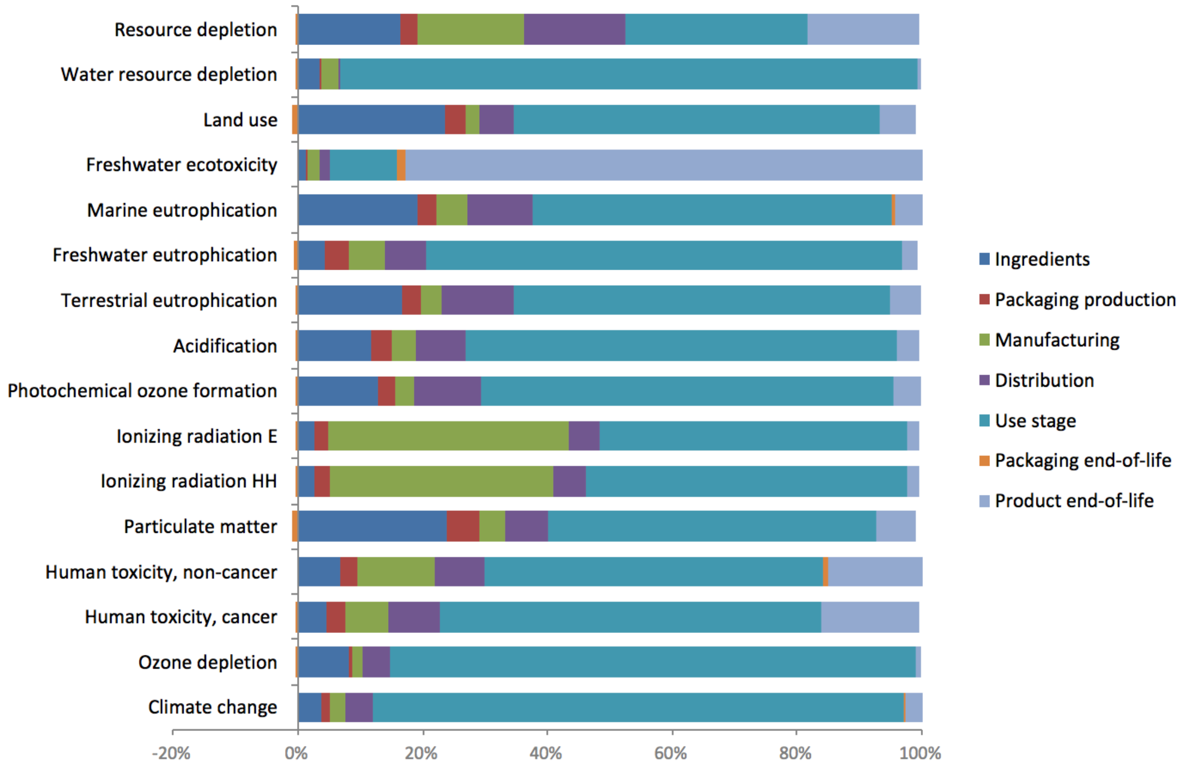

Figure 3. Overall results for one shampoo use per life cycle stage

The indicators evaluated as relevant for a shampoo are:

- Climate change
- Water resource depletion
- Mineral and fossil resource depletion
- Freshwater ecotoxicity (subject to the availability of appropriate methodology and data)

This selection was performed based on two normalisation approaches. The process and results to identify the most relevant EF impact categories are presented in Annex II: Normalisation.

The supporting study conclusions are consistent with those obtained from the representative product screening study.

Detailed results for the use stage are shown in Figure 4. For water resource depletion, tap water use in the shower is the main contributor. For all other indicators, the electricity and/or natural gas consumption, used to heat the shower water, are the main contributors. Note that the European (UCTE) grid mix was used as we assume product use on the European market.

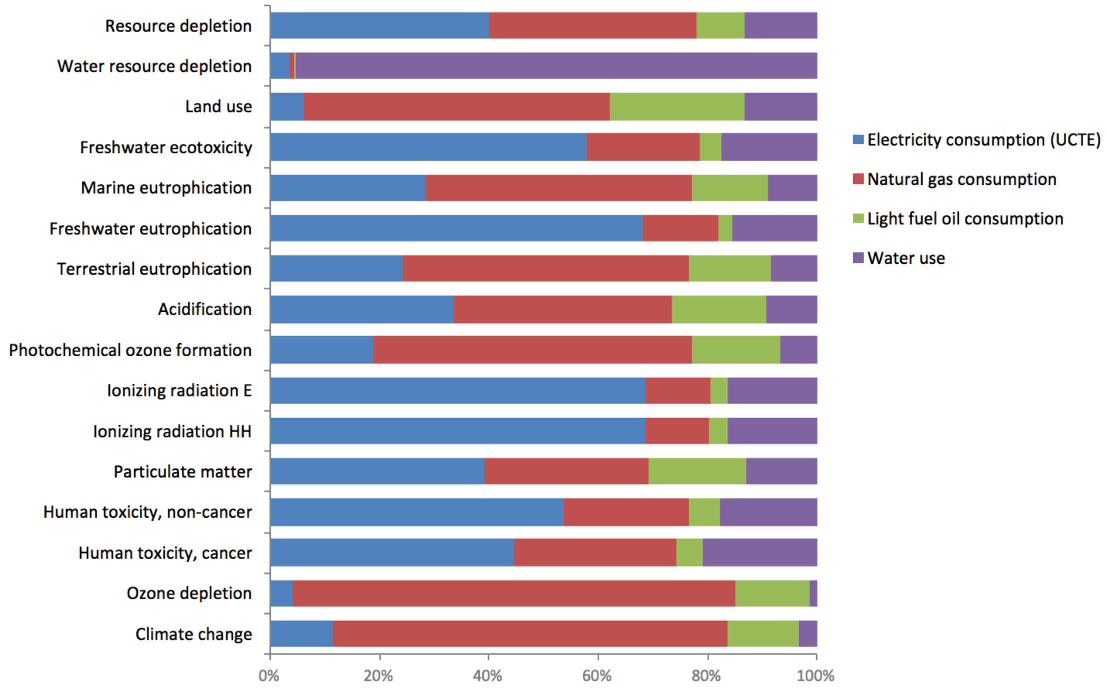

Figure 4. Detailed results for shampoo use stage

Detailed results for the product end-of-life are shown in Figure 5. Wastewater treatment dominates all indicators except for freshwater ecotoxicity, for which ingredients end-of-life is the main contributor. Processes responsible for the wastewater treatment impacts are mainly infrastructure-related such as the sewer grid and the wastewater treatment plant. Sludge treatment is found to be negligible compared to wastewater treatment impacts.

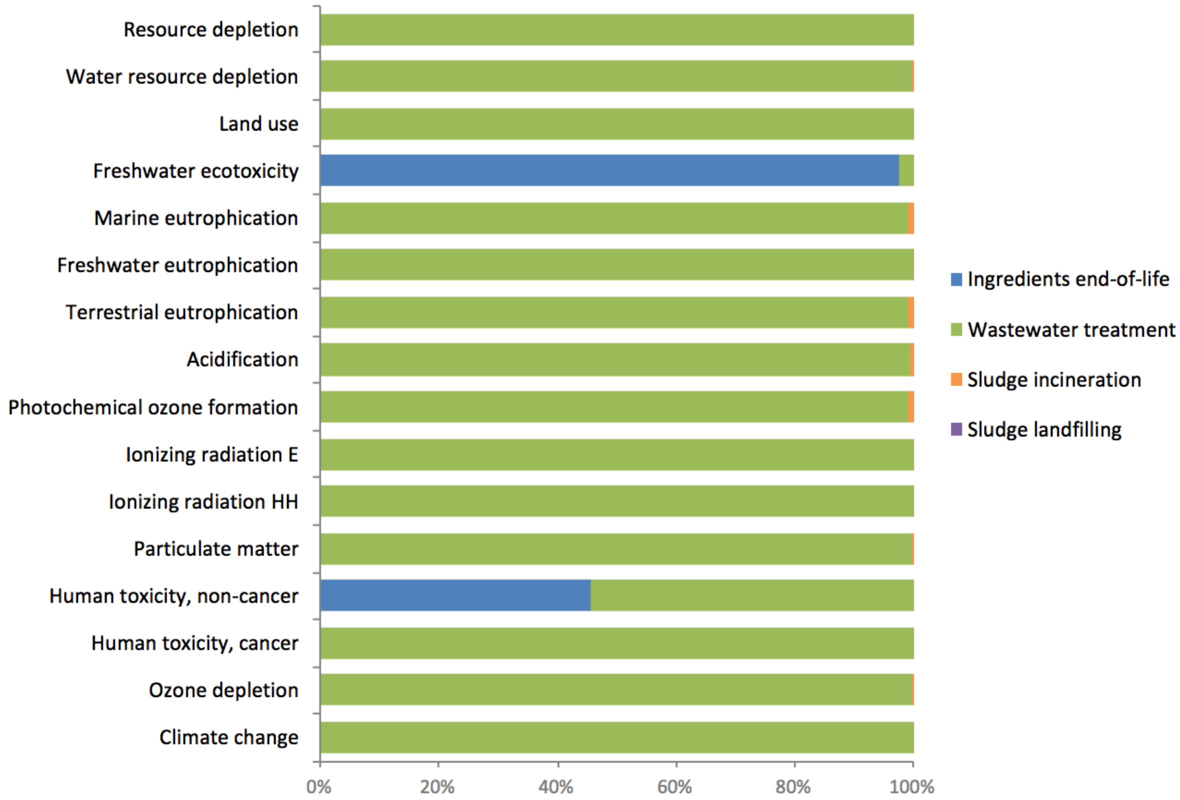

Figure 5. Detailed results for product end-of-life stage

Table 5 presents the ingredients emitted to nature and their associated freshwater ecotoxicity impacts and contribution. Sodium laureth sulfate is the main contributor, accounting for 85% of freshwater ecotoxicity impacts. The coco glucoside/water and coco glucoside/glycol oleate are the next most contributing ingredients, each representing 7% of impacts. These two ingredients are modelled as Alcohols, coco, ethoxylated, C12-14EO20.

Table 5. Summary of freshwater ecotoxicity impacts contribution of shampoo ingredients emitted to nature

General information	Freshwater ecotoxicity	
Pierre Fabre name	**CF (CTUe/kg)**	**Ecotoxicity contribution (%)**
Dexpanthenol (75%)	33.0	0.1%
Sodium laureth sulfate (70%)	12081	85%
Lauryl betaine (30%)	274.53	1%
Coco glucoside/water	2720.8	7%
Coco glucoside /glycol oleate	2720.8	7%
Glycerin (99.5%)	0.213	0.003%
Guar hydroxypropyl/hydrox	35.2	0.01%
Sodium benzoate	146	0.08%
Citric acid	22.0	0.002%
Chloride sodium sulfate	3.87	0.0005%
alpha-hexyl cinnamaldehyde[1]	110	0.01%
dihydromyrcenol[1]	135	0.03%
Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-[1]	4'200	0.32%
hexyl salicylate[1]	6'090	0.44%
patchouli oil[1]	158	0.01%
Purified water	0	0%
Characterization factor (CF) data source:		
USEtox default	Cosmede database	

[1] Fragrance: 20% alpha-hexyl cinnamaldehyde, 50% dihydromyrcenol (modelled as dihydromyrcene), 10% beta-pinene, 15% hexyl salicylate, 5% patchouli oil

Table 6 presents the ingredients emitted to nature and their associated human toxicity, non-cancer impacts and contribution. This is specific to the product end-of-life stage, which accounts for approximately 15% of the overall shampoo life cycle for this indicator. Since no characterization factors are available for the ingredients, the characterization factor for dimethicone was used as a proxy, as recommended in the PEFCR. Note that the characterization factors and proxies are considered to have a very high uncertainty and low robustness. Sodium laureth sulfate and glycerin are the main contributors, accounting for 41% and 23%, respectively, of human toxicity, non-cancer effects for this life cycle stage. This is expected as all characterization factors have the same value (2.36E-6 CTUh/kg) for all ingredients (except for water, which has a CF of 0) and these two substances are present in the largest.

For the impact category human toxicity, cancer effects, no characterization factors are available for the shampoo ingredients therefore these impacts are not taken into account in the study. This is a limitation of USEtox model applied to shampoo ingredients.

Human health, cancer and non-cancer effects are not considered to be relevant indicators (see Annex II: Normalisation for more information).

Table 6. Summary of human toxicity, non-cancer effects contribution of shampoo ingredients emitted to nature

Pierre Fabre name	Human toxicity, non-cancer, impact contribution
Dexpanthenol (75%)	6%
Sodium laureth sulfate (70%)	23%
Lauryl betaine (30%)	8%
Coco glucoside/water	8%
Coco glucoside /glycol oleate	8%
Glycerin (99.5%)	41%
Guar hydroxypropyl/hydrox	1%
Sodium benzoate	2%
Citric acid	0.3%
Chloride sodium sulfate	0.4%
Fragrance	
alpha-hexyl cinnamaldehyde	0.3%
Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-	0.8%
dihydromyrcene	0.2%
hexyl salicylate	0.2%
patchouli oil	0.1%

[1] Characterization factor, used dimethicone as proxy

6.2 Supplementary analysis

No supplementary analyses were performed.

7 Interpreting PEF results

7.1 PEF results

The results of the Pierre Fabre supporting study product are in line with those obtained from the representative product screening study. The same relevant impact categories, life cycle stages and processes were identified. The main contributing substance at product end-of-life is sodium laureth sulfate for both products (Pierre Fabre and representative product).

The main areas of uncertainty in the study lie in the impact assessment methods. The impact categories for which the methods are currently not sufficiently reliable are human toxicity, cancer effects, human toxicity, non-cancer effects, freshwater ecotoxicity, water depletion, resource depletion, ionizing radiation and land use. The use stage modelling is also a large source of uncertainty. Since the use stage is highly dependent on consumer habits, which can vary significantly depending on the consumer, and for which little data are available, the modelling of this life cycle stage is considered to have a high level of uncertainty.

7.2 Benchmark

Figure 6 shows a comparison of the Pierre Fabre shampoo and the screening study representative product. Potential impacts of the Pierre Fabre shampoo are in the same order of magnitude (less than 10% difference) as that of the representative product for all indicators except for the two ionizing radiation indicators and freshwater ecotoxicity. The Pierre Fabre shampoo has higher ionizing radiation impacts due to the manufacturing electricity consumption. The modelled grid mix for the Pierre Fabre shampoo manufacturing is France, which has over 75% nuclear energy, while the modelled grid mix for the representative product is UCTE (32% nuclear energy). The ionizing radiation impacts are mainly from the uranium milling tailings.

Freshwater ecotoxicity impacts of the Pierre Fabre shampoo are approximate half of those of the representative product. This is related to the product end-of-life impacts on freshwater ecotoxicity when the shampoo ingredients are emitted to nature. The main freshwater ecotoxicity contributor for both the Pierre Fabre and the representative shampoo is sodium laureth sulphate (SLS). However, the Pierre Fabre shampoo has smaller potential impacts due to the smaller quantity of SLS per functional unit compared to the representative shampoo

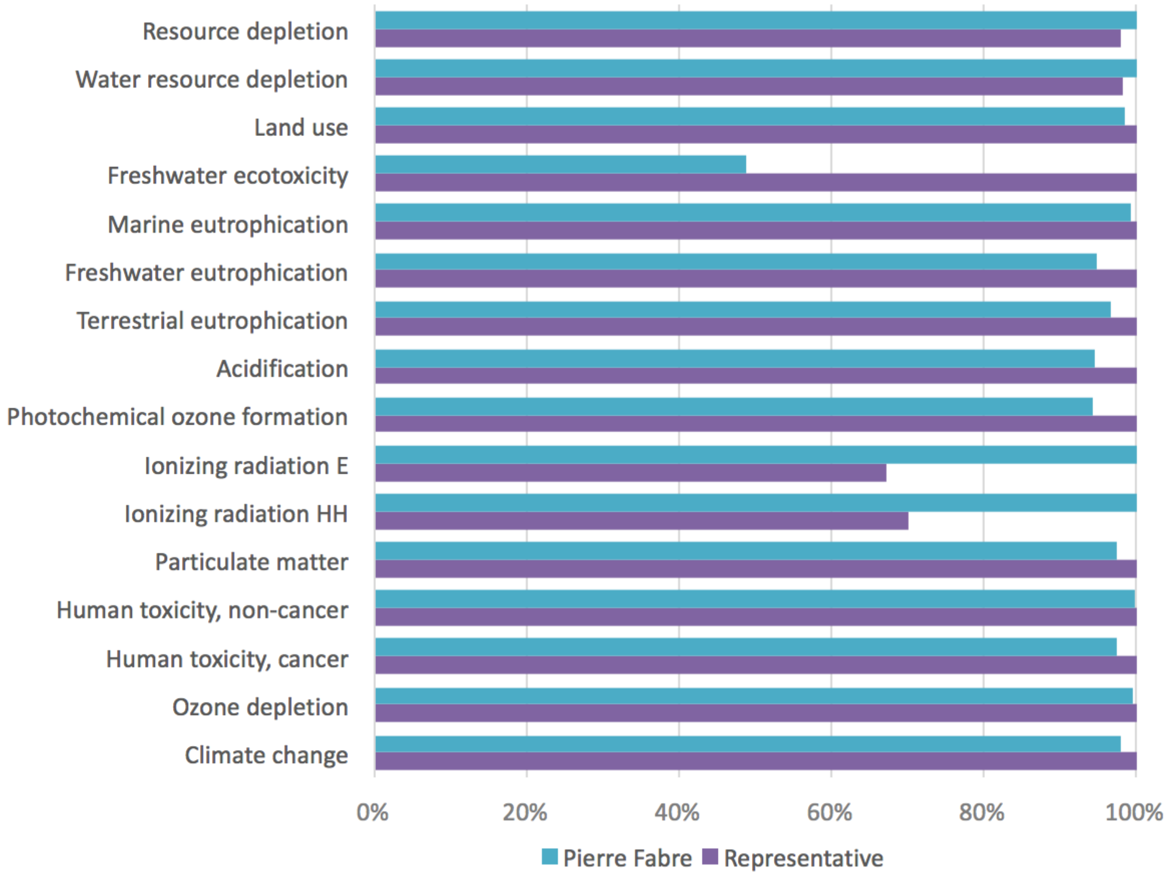

Figure 6. Benchmark comparison of Pierre Fabre shampoo vs representative product

7.3 *Performance classes*

No performance classes are currently proposed based on the PEFCR.

8 Annex I: Bibliographic references

Author	Reference
AFNOR (2011)	AFNOR (2011-2012). BP X30-323-5 12/2011, General principles for an environmental communication on mass market product - Part 5: Methodology for the environmental impacts assessment of shampoos. → *New version will be published in 2014*
Arif	S. Arif, Technical Bulletin: hair shampoos, the science & art of formulation, Pilot Chemical; www.pilotchemical.com
de Schryver (2009)	De Schryver, A. M., Brakkee, K. W., Goedkoop, M. J., & Huijbregts, M. a. J. (2009). Characterization Factors for Global Warming in Life Cycle Assessment Based on Damages to Humans and Ecosystems. Environmental Science & Technology, 43(6), 1689–1695. doi:10.1021/es800456m
ecoinvent v2.2	Frischknecht R., Jungbluth N., Althaus H.-J., Doka G., Dones R., Heck T., Hellweg S., Hischier R., Nemecek T., Rebitzer G. and Spielmann M., 2005, The ecoinvent database: Overview and methodological framework, International Journal of Life Cycle Assessment 10, 3–9.
Environmental Footprinting with USEtox	http://usetox.tools4env.com/substances, consulted 18.09.2014
European Commission (2006)	European Commission (2006). Integrated Pollution Prevention and Control, Reference Document on the Best Available Techniques for Waste Incineration. http://eippcb.jrc.ec.europa.eu/reference/BREF/wi_bref_0806.pdf
European Commission (2007)	Establishing the ecological criteria for the award of the Community eco-label to soaps, shampoos and hair conditioners. 2007/506/EC. OJ L 186, 18.7.2007, p.36
European Commission (2013)	Commission decision of 19 December 2013 amending the Decision 2007/506/EC in order to prolong the validity of the ecological criteria for the award of the EU Ecolabel to soaps, shampoos and hair conditioners
European Commission et al. (2012)	European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS) and LEITAT (2012). Revision of the European Ecolabel Criteria for Soaps, Shampoos and Hair Conditioners: preliminary results from the technical analysis. August 2012. 28-30.
European Commission et al. (2012a)	European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS) and LEITAT (2012). Revision of the European Ecolabel Criteria for Soaps, Shampoos and Hair Conditioners: background report including revised draft criteria proposal. August 2012. 81.
European Commission (2013)	European Commission (2013). 2013/179/EU: Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations. Annex II: Product Environmental Footprint (PEF) Guide. Official Journal of the European Union, L 124, Volume 56, May 4th, 2013. http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2013:124:SOM:EN:HTML
European Commission (2013a)	European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS) (2013a). JRC Scientific and Policy Reports. Best Environmental Management Practice in the Retail Trade Sector. European Union, 2013.
European Commission (2014)	European Commission (2014). Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) Pilot Phase. Version 3.4. January 15th, 2014.
European Commission (2015a)	European Commission (2015), Humbert, S., Guignard, C. PEF / OEF : Default data to be used to model distribution, storage and use stage. Version a, January 13th, 2015

Author	Reference
European Commission (2015b)	European Commission, Joint Research Centre (JRC), Saouter, E., Sala, S., Pant, R. USEtox: Potential issues and work proposal, TAB meeting (presentation), 29 September 2015
Eurostat (2011)	Environment and Energy, Waste statistics, Waste streams, Municipal waste generation and treatment, by type of treatment method, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database,
Franklin (2010)	Franklin Associates, a Division of ERG, April 7, 2010, Life cycle inventory of 100% postconsumer HDPE and PET recycled resin from postconsumer containers and packaging, Final report.
Frischknecht et al. (2005)	Frischknecht R., Jungbluth N., Althaus H.-J., Doka G., Dones R., Heck T., Hellweg S., Hischier R., Nemecek T., Rebitzer G. and Spielmann M., 2005, The ecoinvent database: Overview and methodological framework, International Journal of Life Cycle Assessment 10, 3–9.
Goedkoop et al. (2001)	Goedkoop, M., Spriensma, R. (2001). The Eco-indicator 99: A damage oriented method for Life Cycle Impact Assessment. Methodology Annex. Amersfoort, The Netherlands.
Hall et al. (2011)	Hall, B., Steiling, W., Safford, B., Coroama, M., Tozer, S., Firmani, C., McNamara, C., Gibney, M. (2011). European consumer exposure to cosmetic products, a framework for conducting population exposure assessments Part 2. Food and Chemical Toxicology, 49(2), 408–422. doi:10.1016/j.fct.2010.11.016
Henkel (2008)	Case study shampoo documentation, Case study undertaken within the PCF pilot project Germany. 2008
Hera (2004)	Human & Environmental Risk Assessment on ingredients of European household cleaning products, Alcohol Ethoxysulphates (AES) Environmental Risk Assessment. 2004 http://www.heraproject.com/files/1-E-04-HERA%20AES%20ENV%20%20web%20wd.pdf (consulted 18.07.2014)
Humbert (2009)	Humbert S (2009). Geographically differentiated life-cycle impact assessment of human health. Doctoral dissertation, University of California, Berkeley, USA.
Humbert et al. (2009)	Humbert, S., Loerincik, Y., Rossi, V., Margni, M., & Jolliet, O. (2009). Life cycle assessment of spray dried soluble coffee and comparison with alternatives (drip filter and capsule espresso). Journal of Cleaner Production, 17(15), 1351–1358. doi:10.1016/j.jclepro.2009.04.011
Humbert et al. (2011)	Humbert, S., Marshall, J. D., Shaked, S., Spadaro, J. V, Nishioka, Y., Preiss, P., … Jolliet, O. (2011). Intake fraction for particulate matter: recommendations for life cycle impact assessment. Environmental Science & Technology, 45(11), 4808–16.
Humbert et al. (2012)	Humbert, S., de Schryver, A., Margni, M., & Jolliet, O. (2012). IMPACT 2002+: User Guide - Draft version Q2.2 (version adapted by Quantis)
International Energy Agency (IEA) (2011)	Electricity and heat data, 2011, EU-27, http://www.iea.org/statistics/statisticssearch/
Jolliet et al. (2003)	Jolliet, O., Margni, M., Charles, R., Humbert, S., Payet, J., Rebitzer, G., & Rosenbaum, R. (2003). IMPACT 2002+: A new life cycle impact assessment methodology. The International Journal of Life Cycle Assessment, 8(6), 324–330.
Klaschka et al. (2013)	Klaschka, Ursula, et al. "Occurrences and potential risks of 16 fragrances in five German sewage treatment plants and their receiving waters." Environmental Science and Pollution Research 20.4 (2013): 2456-2471.
Making Cosmetics Inc.	Making Cosmetics Inc., How to make shampoos, www.makingcosmetics.com
Mottram et al. (2000)	F.J. Mottram, C.E. Lees (2000). Hair Shampoos. 2000. 289-306.
Pfister et al.	Pfister, S., Koehler, A., & Hellweg, S. (2009). Assessing the environmental impacts of

Author	Reference
(2009)	freshwater consumption in LCA. Environmental Science & Technology, 43(11), 4098–4104. doi:10.1021/es802423e
Research Institute for Fragrance Materials (2013)	Life Cycle Assessment of Selected Fragrance Materials, Final report, PE International and Five Winds Strategic Consulting
Sala et al. (2012)	Sala S, Wolf M, Pant R. (2012). Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods. Database and Supporting Information. EUR 25167 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2012. JRC6825
Simonich et al. (2002)	Simonich,S, Federle, TW, Eckhoff, WS, Rottiers, A, Webb,S, Sabaliunas,D, de Wolf§, W. Removal of Fragrance Materials during U.S. and European Wastewater Treatment. *Environmental Science & Technology* 2002 *36* (13), 2839-2847
OECD (2011)	Wastewater treatment, % population connected, http://stats.oecd.org

9 Annex II: Normalisation

Based on the screening study results, Table 21 shows results obtained with the EU 27 normalisation factors and Table 22 illustrates results with the Quantis proposed conversion factors. The European Commission normalisation factors are applied at the midpoint level while the Quantis proposed conversion factors are applied at the endpoint level, which allows one to identify the relative contribution of midpoint indicators to the endpoints' results (areas of protection). These factors are taken from various LCA methodologies and publications.

Based on an analysis of both normalization methods, the impact categories evaluated as relevant for a shampoo are:

- Climate change
- Water resource depletion
- Mineral and fossil resource depletion
- Freshwater ecotoxicity (subject to the availability of appropriate methodology and data)

When considering the European Commission (EC) and Quantis proposed methods, the impact category Human toxicity, cancer effects, is also identified as being relevant, however, the main contribution for this impact category is from energy use during the use stage and this indicator is thus correlated with the Climate change indicator. When considering all the Human Health related indicators, global damage to this area of protection[1] linked to the use of shampoo appears to be negligible. Based on the previous analysis and considering that the positive impacts linked to personal hygiene cannot be adequately assessed in LCA, it is proposed not to consider Human Health in the final list of impact categories.

The safety of personal care products such as shampoos is guaranteed by toxicity risk assessment and thus differs from potential indirect impacts on human health (particulate matter impacts, toxicity of substances bioaccumulated in food, etc.). The environmental (LCA) evaluation of a shampoo attempts to provide information on what we could refer to as "Public health effects", meaning these impacts more globally highlight "indirect" effects on the population over the life cycle of a shampoo.

[1] Climate change (HH), Ozone depletion, Human toxicity, cancer and non-cancer effects, Particulate matter, Ionizing radiation, Photochemical ozone formation, Water resource depletion