

## Supplementary material

### S1 Life cycle inventory of the investigated shampoo

This supplementary material contains the life cycle inventory of the investigated shampoo, as well as the modelling using ecoinvent-v3.5 background datasets. Throughout the study, the system model *allocation, recycled content cut-off* was used within the ecoinvent database.

#### 1. Energy mixes for electricity and heating

With respect to electricity, two types of products were used in the study: The Swiss market mix for manufacturing and the Zurich electricity mix for distribution and use phase. The Swiss market mix was modelled directly with the corresponding ecoinvent dataset *Electricity, low voltage {CH}| market for*. The electricity mix of Zurich is given in Table S1. The dataset *Electricity, low voltage, production, hydro power mix, Switzerland* describes low voltage electricity only based on hydropower and was derived from the ecoinvent dataset for electricity from hydropower at medium voltage.

**Table S1: Life cycle inventory for the eco-friendly electricity product provided by the energy supplier in Zurich, Switzerland**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Electricity, low voltage, Zurich, Switzerland</b>	<b>1</b>	<b>kWh</b>	
<b>Input, energy</b>			
Electricity, low voltage, production, hydro power mix, Switzerland	0.857	kWh	
Electricity, low voltage {CH}  market for	0.143	kWh	

Heating of water was needed for the use phase as well as for rinsing shampoo containers to be refilled within the packaging scenarios 2, 3 and 4. The heating energy was modelled according to the energy mix of Zurich, as shown in Table S2. The Swiss energy mix for heating, which was used within a sensitivity study, was modelled adapting the shares from the different energy sources. The electricity in the Swiss heating energy mix was modelled using the Swiss market mix instead of the Zurich mix.

**Table S2: Life cycle inventory for heating energy used for provision of warm water in Zurich, Switzerland**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Heat, for warm water heating, Zurich, Switzerland</b>	<b>1</b>	<b>MJ</b>	
<b>Input, energy</b>			
Heat, central or small-scale, natural gas {CH}  heat production, natural gas, at boiler condensing modulating <100kW	0.499	MJ	share of gas heating
Heat, central or small-scale, other than natural gas {CH}  heat production, light fuel oil, at boiler 10kW, non-modulating	0.272	MJ	share of oil heating
Heat, district or industrial, other than natural gas {CH}  heat, from municipal waste incineration to generic market for heat district or industrial, other than natural gas	0.158	MJ	share of district heating
Heat, borehole heat pump {CH}  heat production, borehole heat exchanger, brine-water heat pump 10kW	0.0598	MJ	share from heat pumps
Heat, central or small-scale, other than natural gas {CH}  heat production, softwood chips from forest, at furnace 50kW	0.0095	MJ	share from wood heating
Heat, central or small-scale, other than natural gas {CH}  operation, solar collector system, Cu flat plate collector, multiple dwelling, for hot water	0.048	MJ	share from solar thermal power
Electricity, low voltage, Zurich, Switzerland	0.248	MJ	share from electricity

#### 2. Provision of packaging material

The life cycle inventory of four different packaging scenarios are listed in Tables S3 to S6.

The dataset *Corrugated board box {RER}| production, 95% recycled* which was used for all cardboard materials was derived based on the dataset *Corrugated board box {RER}| production*, taking into account a share of recycled material

of 95%.

The three refill solutions (scenario 2, 3, 4) included the water and energy demand to rinse a shampoo container prior to refill. It was assumed that each container would be rinsed twice with 50°C hot water, heated up from 15°C. Using the specific heat capacity of 4.185 J/kgK for water, this led to an energy demand of 0.144 MJ per liter water.

**Table S3: Life cycle inventory for packaging material used in scenario 1 where shampoo is sold in 500ml glass bottles**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Scenario 1: Provision of 500 ml glass bottles with pump dispenser</b>	<b>0.5</b>	<b>kg</b>	<b>data referring to 0.5 kg shampoo</b>
Primary packaging: glass bottle			
Packaging glass, brown {DE}  production	266	g	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	90.4	kgkm	Transportation to shampoo manufactory
Primary packaging: carton box			
Corrugated board box {RER}  production, 95% recycled	28.5	g	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1.51	kgkm	Transportation to shampoo manufactory
Primary packaging: pump dispenser			
Polypropylene, granulate {RoW}  production	10.18	g	main parts of dispenser
Polyethylene, low density, granulate {RoW}  production	0.66	g	dip tube
Extrusion, plastic pipes {RoW}  extrusion, plastic pipes	10.84	g	manufacturing of PP/PE parts
Packaging glass, white {RoW}  production	0.16	g	glass ball
Steel, chromium steel 18/8 {GLO}  market for	0.78	g	spring
Transport, freight, sea, transoceanic ship {GLO}  market for	254	kgkm	Transportation from China to Europe
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	28.1	kgkm	Transportation to shampoo manufactory
Secondary packaging			
Corrugated board box {RER}  production, 95% recycled	48.2	g	289 g box for 6 glass bottles
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	3.61	kgkm	Transportation to shampoo manufactory

The tinplate canister used in scenario 2 was assumed to consist of stainless steel which is plated with tin. The tin content was assumed to be 0.02% (Carbotech, 2015). The share of recycled material was set to 75%. With respect to steel, this was accounted for using the datasets *Steel, low-alloyed, hot rolled {GLO}| market for* for primary material and *Iron scrap, sorted, pressed {GLO}| market for* for secondary material. With respect to tin, only primary material was modelled, assuming the recycling of tinplate included the recovery of tin which could then be reused for tinplating. However, only 75% of tin within tinplate material can be recovered within recycling processes according. This was taken into account using the following formula for the amount of tin as primary material:

$$\text{tincontent (primary material)} = 0.02\% * (0.25 + 0.25 * 0.75)$$

**Table S4: Life cycle inventory for packaging material used in scenario 2 where a shampoo container is refilled from a 5 l tinplate canister**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Scenario 2: Provision of 5 l tinplate canister + clean bottle to be refilled</b>	<b>5</b>	<b>kg</b>	<b>data referring to 5 kg shampoo</b>
Primary packaging: tinplate canister			
Steel, low-alloyed, hot rolled {GLO}  market for	109	g	primary material
Iron scrap, sorted, pressed {GLO}  market for	338	g	recycled material
Sheet rolling, steel {RER}  processing	338	g	processing of recycled material
Tin plating, pieces {RER}  processing, excluding tin  Cut-off, U	0.398	m <sup>2</sup>	modified dataset, excluding tin
Tin {GLO}  market for	382	mg	primary material
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	323	kgkm	Transportation to shampoo manufactory

Primary packaging: plastic tap of canister			
Polypropylene, granulate {RER}  production	12	g	
Extrusion, plastic pipes {RER}  extrusion, plastic pipes	12	g	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	11.5	kgkm	
Secondary packaging			
Corrugated board box {RER}  production, 95% recycled	266	g	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	20	kgkm	Transportation to shampoo manufactory
Rinsing of shampoo container to be refilled			
Tap water {CH}  market for	10	l	container rinsed twice with hot water
Heat, for warm water heating, energy mix, Zurich	1.46	MJ	energy mix see Table S2
Wastewater treatment:	10	l	
Wastewater, unpolluted {CH}  treatment of, capacity 5E9l/year			

**Table S5: Life cycle inventory for packaging material used in scenario 3 where a shampoo container is refilled from a 25 l PE canister**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Scenario 3:</b>			
<b>Provision of 25 l plastic canister + clean bottle to be refilled</b>	<b>25</b>	<b>kg</b>	<b>data referring to 25 kg shampoo</b>
Primary packaging: plastic canister			
Polyethylene, high density, granulate {RER}  production	1.18	kg	
Blow moulding {RER}  blow moulding	1.18	kg	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	732	kgkm	Transportation to shampoo manufactory
Rinsing of shampoo container to be refilled			
Tap water {CH}  market for	50	l	assumption: container rinsed twice with hot water
Heat, for warm water heating, energy mix, Zurich	7.62	MJ	energy mix see Table S2
Wastewater treatment:	50	l	
Wastewater, unpolluted {CH}  treatment of, capacity 5E9l/year			

**Table S6: Life cycle inventory for packaging material used in scenario 4 where 500 ml PET stand-up pouches are sold for refilling shampoo containers**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Scenario 4:</b>			
<b>Provision of 0.5 ml PET standup pouch + clean bottle to be refilled</b>	<b>0.5</b>	<b>kg</b>	<b>data referring to 0.5 kg shampoo</b>
Primary packaging: standup pouch			
Polyethylene terephthalate, granulate, bottle grade {RER}  production	10.22	g	PET pouch, assumption: non-recycled material
Extrusion, plastic film {RER}  extrusion, plastic film	10.22	m <sup>2</sup>	processing PET
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	5.11	kgkm	Transportation to shampoo manufactory
Secondary packaging			
Corrugated board box {RER}  production, 95% recycled	24.1	g	*modified ecoinvent dataset; assumption: 289 g box for 12 pouches
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1.81	kgkm	Transportation to shampoo manufactory
Rinsing of shampoo container to be refilled			
Tap water {CH}  market for	1	l	assumption: container rinsed twice with hot water
Heat, for warm water heating, energy mix, Zurich	0.146	MJ	energy mix see Table S2
Wastewater treatment:	1	l	
Wastewater, unpolluted {CH}  treatment of, capacity 5E9l/year			

### 3. Provision of ingredients

The inventory of shampoo ingredients production and transportation is summarized in Tables S7 to S9. Note that alcohol, glycerine and citric acid were the only ingredients which could be modelled directly using ecoinvent datasets. Most ingredients were modelled based on intermediate products instead. To account for the last process step, the inventories of main shampoo ingredients such as propanediol include an additional energy input (heat and electricity), which was derived from the ecoinvent dataset *Soap {RER}| production*.

Deionized water was the only ingredient produced by the shampoo manufacturer. The production of deionized water requires only little amount of electricity, which is included in manufacturing process (see Table S10 below). To produce 1 l of deionized water, 2.2 l of tap water were run through a filter based on polystyrene, as estimated by the shampoo manufacturer. Therefore, 1.2 l of unpolluted water is disposed as wastewater per liter of deionized water.

For all ingredients (except deionized water), the transportation from the supplier/producer to the shampoo manufactory was modelled with an additional weight of 20% to account for packaging of the ingredients.

Essential oils were uniformly modelled as orange oil, as shown in Table S9. As the investigated shampoo contains only essential oil from organic cultivations, the ecoinvent dataset *Orange, fresh grade {ES}| orange production, fresh grade* was modified in the way that no pesticides and synthetic fertilizers were included. Due to lack of specific data, the crop yield was not adjusted.

**Table S7: Life cycle inventory for the provision of shampoo ingredients (part 1)**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
Water, deionized	1	kg	
Input, material			
Tap water {CH}  market for	2.2	kg	
Polystyrene foam slab, 10% recycled {CH}  production	0.13	g	Filter material
Waste			
Waste polystyrene {CH}  treatment of, municipal incineration	0.13	g	Deposition of filter
Wastewater, unpolluted, from residence {CH}  treatment of, capacity 1.1E10l/year	1.2	l	
Propanediol	1	kg	
Input, material			
Ethanol, without water, in 95% solution state, from fermentation {US}  ethanol production from maize	1	kg	Proxy
Transport, freight, lorry, unspecified {RoW}  market for transport, freight, lorry, unspecified	960	kgkm	
Transport, freight, sea, transoceanic ship {GLO}  market for	10530	kgkm	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	972	kgkm	
Input, energy			
Heat, district or industrial, natural gas {RoW}  market for heat, district or industrial, natural gas	2.98	MJ	
Heat, district or industrial, other than natural gas {RoW}  market for	1.66	MJ	
Electricity, medium voltage {US}  market group for	0.050	kWh	
Disodium Cocoyl Glutamate/Sodium Cocoyl Glutamate	1	kg	
Input, material			
Fatty acid {GLO}  market for, ONLY from coconut oil	0.5	kg	modified ecoinvent dataset
Molasses, from sugar beet {GLO}  market for	0.5	kg	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	402	kgkm	
Input, energy			
Heat, district or industrial, natural gas {RER}  market group for	2.98	MJ	
Heat, district or industrial, other than natural gas {RER}  market group for	1.66	MJ	
Electricity, medium voltage {RER}  market group for	0.050	kWh	

**Table S8: Life cycle inventory for the provision of shampoo ingredients (part 2)**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
<b>Glycerin</b>	1	kg	
Input, material			
Glycerine {RER}  market for glycerine	0.5	kg	
Glycerine {BR}  esterification of soybean oil	0.5	kg	
Transport, freight, sea, transoceanic ship {GLO}  market for	6380	kgkm	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1310	kgkm	Transport from vendor to shampoo manufactory
<b>Sodium PCA</b>	1	kg	
Input, material			
Vinasse, from fermentation of sugarcane {GLO}  market for	0.424	kg	proxy for glutamic acid, manufacturer's data
Sodium hydroxide, without water, in 50% solution state {GLO}  market for	0.132	kg	manufacturer's data
Tap water {RoW}  market for	0.444	kg	manufacturer's data
Transport, freight, sea, transoceanic ship {GLO}  market for	12178	kgkm	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1310	kgkm	
Input, energy			
Heat, district or industrial, natural gas {RoW}  market for heat, district or industrial, natural gas	2.98	MJ	
Heat, district or industrial, other than natural gas {RoW}  market for	1.66	MJ	
Electricity, medium voltage {BR}  market for	0.050	kWh	
<b>Sodium levulinate</b>	1	kg	
Input, material			
Carboxymethyl cellulose, powder {GLO}  market for	1	kg	proxy
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1310	kgkm	
<b>Alcohol</b>	1	kg	
Input, material			
Ethanol, without water, in 95% solution state, from fermentation {GLO}  market for	1	kg	
Transport, freight train {RER}  market group for transport, freight train	420	kgkm	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	336	kgkm	
<b>Citric Acid</b>	1	kg	
Input, material			
Citric acid {RER}  production	1	kg	
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	752	kgkm	
<b>Xanthan GUM</b>	1	kg	
Input, material			
Vinasse, from fermentation of sugar beet {GLO}  market for	1	kg	proxy
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	750	kgkm	
<b>Cocodimonium hydroxylpropyl hydrolyzed wheat protein</b>	1	kg	
Input, material			
Wheat grain {GLO}  market for	1	kg	proxy for gluten, allocation based on weight
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	341	kgkm	
Input, energy			
Heat, district or industrial, natural gas {RER}  market group for	2.98	MJ	
Heat, district or industrial, other than natural gas {RER}  market group for	1.66	MJ	
Electricity, medium voltage {IT}  market for	0.050	kWh	

**Table S9: Life cycle inventory for the provision of shampoo ingredients (part 3)**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
Caprylyl/capryl glucoside	1	kg	
<b>Input, material</b>			
Fatty alcohol {GLO}  market for, only plant-based	0.5	kg	modified ecoinvent dataset
Glucose {GLO}  market for glucose	0.5	kg	
Transport, freight, sea, transoceanic ship {GLO}  market for	24000	kgkm	Transport from China to Europe
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1190	kgkm	
<b>Input, energy</b>			
Heat, district or industrial, natural gas {RoW}  market for heat, district or industrial, natural gas	2.98	MJ	
Heat, district or industrial, other than natural gas {RoW}  market for	1.66	MJ	
Electricity, medium voltage {CN}  market group for	0.050	kWh	
Essential oils and plant extracts	1	kg	proxy for all essential oils
<b>Input, material</b>			
Oranges, organic, fresh grade {ES}  orange production, fresh grade	22.7	kg	modified ecoinvent dataset
Transport, freight, aircraft {RER}  intercontinental	3760	kgkm	
Transport, freight, lorry, unspecified {GLO}  market group for transport, freight, lorry, unspecified	600	kgkm	
<b>Input, energy</b>			
Electricity, low voltage {RoW}  market for	6.5	kWh	

#### 4. Shampoo manufacturing

The inventory of the shampoo manufacturing is summarized in Table S10.

With respect to the building, dimensions as given by the shampoo manufacturer were used, allocating building cubature to 1 kg shampoo taking into account the mass of the annual total production output for 2019 and assuming a building lifetime of 80 years. Copper was excluded from the generic ecoinvent dataset use for the building, as it appeared to be overestimated in the generic dataset and led to unrealistically high contributions to the final results.

As machinery, only the shampoo mixer made of steel was considered which formed the only heavy machinery at the manufacturing site. Here, the allocation was done considering the mass of the annual total production output and assuming a mixer lifetime of 40 years. The shampoo mixer is periodically sanitized and rinsed with ethanol and tap water. It was assumed that the ethanol was entirely rinsed together with the tap water and no evaporation of ethanol was considered. With respect to ethanol emissions after the wastewater treatment facility, a removal rate of 0.9 was assumed.

**Table S10: Life cycle inventory of shampoo manufacturing phase**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
Shampoo, production, Zurich, Switzerland	1	kg	
<b>Input, material</b>			
Building, multi-storey {GLO}  market for	0.00237	m <sup>3</sup>	manufacturing building, without copper
Steel, chromium steel 18/8 {GLO}  market for   Cut-off, U	6.58	g	Shampoo mixer
Tap water {CH}  market for	0.205	kg	cleaning shampoo mixer
Ethanol, without water, in 95% solution state, from fermentation {CH}  ethanol production from sugar beet molasses	405	mg	cleaning shampoo mixer
<b>Input, energy</b>			
Heat, central or small-scale, other than natural gas {CH}  heat production, light fuel oil, at boiler 100kW, non-modulating	27	MJ	
Electricity, low voltage {CH}  market for	2.4	kWh	
<b>Emissions to water</b>			
Ethanol, river	0.450	mg	cleaning shampoo mixer, emission after wastewater treatment facility

Waste			
Wastewater, unpolluted, from residence {CH}  treatment of, capacity 1.1E10l/year	0.205	l	Wastewater from cleaning shampoo mixer

## 5. Distribution

Table S11 summarizes the inventory of the distribution phase. The given value for transportation from manufacturer to the shop refers to scenario 1, assuming a glass bottle as shampoo packaging.

**Table S11: Life cycle inventory of distribution phase of the investigated shampoo**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
Shampoo distribution, Zurich	1	kg	
Input, material			
Building, multi-storey {RER}  construction	15	m <sup>3</sup>	shop building, without copper
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	14.5	kgkm	transportation from manufacturing site to shop
Transport, trolleybus {CH}  processing	1	personkm	transportation from shop to costumer
Input, energy			
Electricity, low voltage, Zurich, Switzerland	5.77	MJ	Electricity consumption at shop
Heat, central or small-scale, natural gas {CH}  market for heat, central or small-scale, natural gas	0.228	kWh	Heating of shop

## 6. Use phase

The inventory of the use phase, i.e. for one hair wash with the investigated shampoo in Zurich, is given in Table S12. It is assumed that 15 l tap water was heated up from 15°C to 38°C with 90% energy efficiency, resulting in a total energy demand of 1.6 MJ per hair wash.

**Table S12: Life cycle inventory of use phase of shampoo**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
Hair wash, Zurich	1	-	
Input, material			
Tap water {CH}  market for	15	kg	
Input, energy			
Heat, for warm water heating, energy mix, Zurich, Switzerland	1.6	MJ	see Table S2

## 7. Packaging end-of-life

The inventories of packaging disposal for each investigated scenario are given in Table S13. This life phase includes the incineration of all materials which are not recycled and the transportation of these materials to the municipal incineration facility. The transportation was model based on the dataset *Waste glass {CH}| market for waste glass*, which includes 28.7 kgkm per kg waste.

**Table S13: Life cycle inventory of packaging end-of-life**

Name, ecoinvent-v3.5 dataset	Amount	Unit	Comment
<b>Scenario 1, 500 ml glass bottle: Disposal of packaging of shampoo</b>	<b>0.5</b>	<b>kg</b>	<b>data referring to 0.5 kg shampoo</b>
Input, material			
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	1.19	kgkm	Transportation to incineration facility.
Waste			
Waste glass {CH}  market for waste glass	0.016	g	6% of glass material (94% recycling rate)
Waste polypropylene {CH}  treatment of, municipal incineration with fly ash extraction	10.84	g	100% of PE/PP parts of dispenser pump (no recycling)
Scrap steel {CH}  treatment of, municipal incineration	0.78	g	100% of steel spring within dispenser pump (no recycling)
Waste paperboard {CH}  treatment of, municipal incineration with fly ash extraction	5.1	g	18% of carton box, primary packaging (recycling rate 82%)
Waste paperboard {CH}  treatment of, municipal incineration with fly ash extraction	8.7	g	cardboard secondary packaging
<b>Scenario 2, 5l tinplate canister: Disposal of packaging of shampoo</b>	<b>5</b>	<b>kg</b>	<b>data referring to 5 kg shampoo</b>
Input, material			
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	2.59	kgkm	Transportation to incineration facility
Waste			
Waste paperboard {CH}  treatment of, municipal incineration with fly ash extraction	52	g	cardboard secondary packaging
Waste polypropylene {CH}  treatment of, municipal incineration with fly ash extraction	12	g	PP tap, 100% disposed via incineration
Scrap tin sheet, 0.2% tin {CH}  treatment of, municipal incineration with fly ash extraction	26.2	g	Recycling rate 94%
<b>Scenario 3, 25l PE canister: Disposal of packaging of shampoo</b>	<b>25</b>	<b>kg</b>	<b>data referring to 25 kg shampoo</b>
Input, material			
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	33.8	kgkm	Transportation to incineration facility
Waste			
Waste polyethylene {CH}  treatment of, municipal incineration with fly ash extraction	1.18	kg	canister 100% disposed via incineration
<b>Scenario 4, 500ml PET stand-up pouch: Disposal of packaging of shampoo</b>	<b>0.5</b>	<b>kg</b>	<b>data referring to 0.5 kg shampoo</b>
Input, material			
Transport, freight, lorry, unspecified {RER}  market for transport, freight, lorry, unspecified	0.417	kgkm	Transportation to incineration facility
Waste			
Waste polyethylene {CH}  treatment of, municipal incineration with fly ash extraction	10.22	g	PET pouch 100% disposed via incineration
Waste paperboard {CH}  treatment of, municipal incineration with fly ash extraction	4.33	g	cardboard secondary packaging



8. *Product end-of-life*

The inventory of the product end-of-life, which includes wastewater treatment and emissions of residual shampoo ingredients after wastewater treatment, is given in Table S14.

The inventory of the wastewater treatment was accessed via an excel-based inventory tool taking into account the wastewater volume, the chemical composition of the shampoo as well as the size of the municipal wastewater treatment plant. Emissions after the wastewater treatment facility were modelled for shampoo components for which datasets and characterization factors were available, assuming removal rates of 99.9% for fragrances and 90% for other ingredients. Emissions of fragrances were modelled based on the declared content of aromatic substances (e.g. D-limonene and linalool) which form part of essential oils and for which characterization factors were widely available.

**Table S14: Life cycle inventory of product end-of-life**

Name, ecoinvent-v3.5 dataset	amount	unit	Comment
End-of-Life, product, one hair wash, Zurich	1	p	
Input, material			
Wastewater treatment, one hair wash, Zurich	1	p	derived according to (Doka, 2003)
Emissions to water (river)			
1,3-Propanediol	90.0	mg	shampoo ingredient
Glycerol	13.44	mg	shampoo ingredient
Ethanol	8.413	mg	shampoo ingredient
Citric acid	8.086	mg	shampoo ingredient
D-limonene	1.753	mg	aromatic substance
Benzyl benzoate	0.022	mg	aromatic substance
Linalool	0.042	mg	aromatic substance
Citral	8.65	µg	aromatic substance
Eugenol	3.13	µg	aromatic substance
Benzyl alcohol	2.99	µg	aromatic substance
Geraniol	1.45	µg	aromatic substance