

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 |
|--|----------|------------|---------|
| Electricity, low voltage, Zurich, Switzerland | 1 | kWh | |
| Input, energy | | | |
| 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 |
|--|----------|-----------|--------------------------------|
| Heat, for warm water heating, Zurich, Switzerland | 1 | MJ | |
| Input, energy | | | |
| 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 |
|---|------------|-----------|---|
| Scenario 1: Provision of 500 ml glass bottles with pump dispenser | 0.5 | kg | data referring to 0.5 kg shampoo |
| 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 tinsplate 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 tinsplate included the recovery of tin which could then be reused for tinsplating. However, only 75% of tin within tinsplate 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 tinsplate canister

| Name, ecoinvent-v3.5 dataset | Amount | Unit | Comment |
|---|----------|----------------|---------------------------------------|
| Scenario 2: Provision of 5 l tinsplate canister + clean bottle to be refilled | 5 | kg | data referring to 5 kg shampoo |
| Primary packaging: tinsplate 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 ² | 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 |
|---|-----------|-----------|---|
| Scenario 3: | | | |
| Provision of 25 l plastic canister + clean bottle to be refilled | 25 | kg | data referring to 25 kg shampoo |
| 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 |
|---|------------|----------------|---|
| Scenario 4: | | | |
| Provision of 0.5 ml PET standup pouch + clean bottle to be refilled | 0.5 | kg | data referring to 0.5 kg shampoo |
| 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 ² | 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 |
|---|--------|------|--|
| Glycerin | 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 |
| Sodium PCA | 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 | |
| Sodium levulinate | 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 | |
| Alcohol | 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 | |
| Citric Acid | 1 | kg | |
| Input, material | | | |
| Citric acid {RER} production | 1 | kg | |
| Transport, freight, lorry, unspecified {RER} market for transport, freight, lorry, unspecified | 752 | kgkm | |
| Xanthan GUM | 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 | |
| Cocodimonium hydroxylpropyl hydrolyzed wheat protein | 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 | |
| Input, material | | | |
| 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 | |
| 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 {CN} market group for | 0.050 | kWh | |
| Essential oils and plant extracts | 1 | kg | proxy for all essential oils |
| Input, material | | | |
| 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 | |
| Input, energy | | | |
| 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 | |
| Input, material | | | |
| Building, multi-storey {GLO} market for | 0.00237 | m ³ | 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 |
| Input, energy | | | |
| 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 | |
| Emissions to water | | | |
| 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 ³ | 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 |
|--|------------|-----------|---|
| Scenario 1, 500 ml glass bottle: Disposal of packaging of shampoo | 0.5 | kg | data referring to 0.5 kg shampoo |
| 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 |
| Scenario 2, 5l tinplate canister: Disposal of packaging of shampoo | 5 | kg | data referring to 5 kg shampoo |
| 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% |
| Scenario 3, 25l PE canister: Disposal of packaging of shampoo | 25 | kg | data referring to 25 kg shampoo |
| 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 |
| Scenario 4, 500ml PET stand-up pouch: Disposal of packaging of shampoo | 0.5 | kg | data referring to 0.5 kg shampoo |
| 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 |