openLCA (1.7.2)

Case Study

Ceramic cup vs. Paper cup

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Abbreviation index

CTUh	comparative toxic unit
Eq	equivalent
g	gram
kg	kilogram
km	kilometer
LCIA	life cycle impact assessment
lid dish	ceramic mug with lid, dishwasher washed

lid hand	ceramic mug with lid, hand-washed
m^3	cubic meter
MJ	mega Joule
mL	milliliter
mol	mole
mug dish	ceramic mug, dishwasher washed
mug hand	ceramic mug, hand washed
mug hand cold	ceramic mug, hand washed, cold water
t	ton
t*km	tonkilometer

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1 Introduction

A recent study published by the *Deutschen Umwelthilfe* [1] revealed that every day in Berlin, 460,000 disposable cups are used and thrown away, leading to more than 2.400 tons of waste per year. On a global scale, more than 500 billion of these cups end up in landfills annually.[2] That is why Berlin politicians decided to propose a deposit system, using reusable cups instead of disposable paper cups.[3] However, despite the bad reputation of disposable cups, no scientific study has so far been able to establish a clear winner between disposable and reusable cups.[4] These latter are indeed mostly made of ceramic, metal, glass or hard plastic, and consequently require more energy to be produced than disposable cups.

Life Cycle assessments determine the environmental impact of a product adopting a “cradle-to-grave” approach. To do so, the product life cycle is divided into different unit processes, for which the energy and material in and outputs are identified and quantified. This method enables to draw conclusions on the significance of every flow on the total environmental impact of the analyzed product as well as to compare different products. Nevertheless, many variables and uncertainties come into play while performing a life cycle analysis. For example, some data for the inputs or outputs of individual processes are not yet available in the existing databases. Data from similar products are then needed to perform an exhaustive analysis. In order to avoid uncertainty and distortion, a precise goal and scope must be defined for each study. The results thus depend on this study-specific definition. Nevertheless, through precisely defined, modeled situations, it is possible to assess and compare different products under the same conditions. The results can ultimately lead to a systematic optimization of the products and the consequent improvement of their environmental impacts. Further information on LCA can be found in the General guide for Life Cycle Assessment – Detailed Guidance, published by the European Commission, or in the ISO 14040:2006 and ISO 14044:2006.

In this study, LCA is applied to compare the environmental impacts of a traditional reusable ceramic mug with and without lid are with those of a paper cup. For reusable cups (both with lid and without lid), the production, the transport, the washing, the use phase and the eventual disposal of the product are taken into account. Two washing options have been considered: by hand or by a dishwasher. For the paper cup (modeled with lid), the considered processes are instead production, use and final disposal. The three products are compared through 15 different environmental impact categories.

2 System modelling: causal loop diagram approach

Causal loop diagrams are a common tool in modeling and systems analysisThey effectively support the understanding of the system and the identification of the system parameters that have a stronger influence on the final outcome. The elements composing the causal loop diagrams are:

- Variables, corresponding to external decisions that have an influence on the operation. They are drawn as light blue rectangles.
- State descriptions are represented as white boxes; possible risks (i.e. uncertainty for the system) belong to this category, and are shown as purple hexagons.
- Arrows show the relations within the system. Blue arrows indicate a positive relation (a → b, b increases if a increases), whereas green arrows stand for negative relations.
- Elementary flow inputs of the system are shown as black boxes.

Vensim software was used to create the diagrams reported in Figure 1, 2 and 3.

The three systems under study show a complex network of both positive and negative relations. For example, when using a reusable cup (see Figures 1 and 2), an increase of the share of by-hand washings will lead to an increasing washing effort. This then requires greater elementary flows inputs such as water, energy – to heat the water – and materials such as detergent inputs, having thus a bigger impact on the environment.

Similarly, when producing a paper cup (see Figure 3), a bigger share of biobased plastic would have several outcomes. On the one hand, the amount of fossil feedstock used would decrease, reducing the extraction of oil and natural gas, the elementary flows it requires (water, land, energy and materials) and the environmental impacts. But on the other hand, producing more biopolymer (in our case polylactic acid) would also increase the amount of corn produced, leading to an increase of water, land, energy and materials inputs necessary.

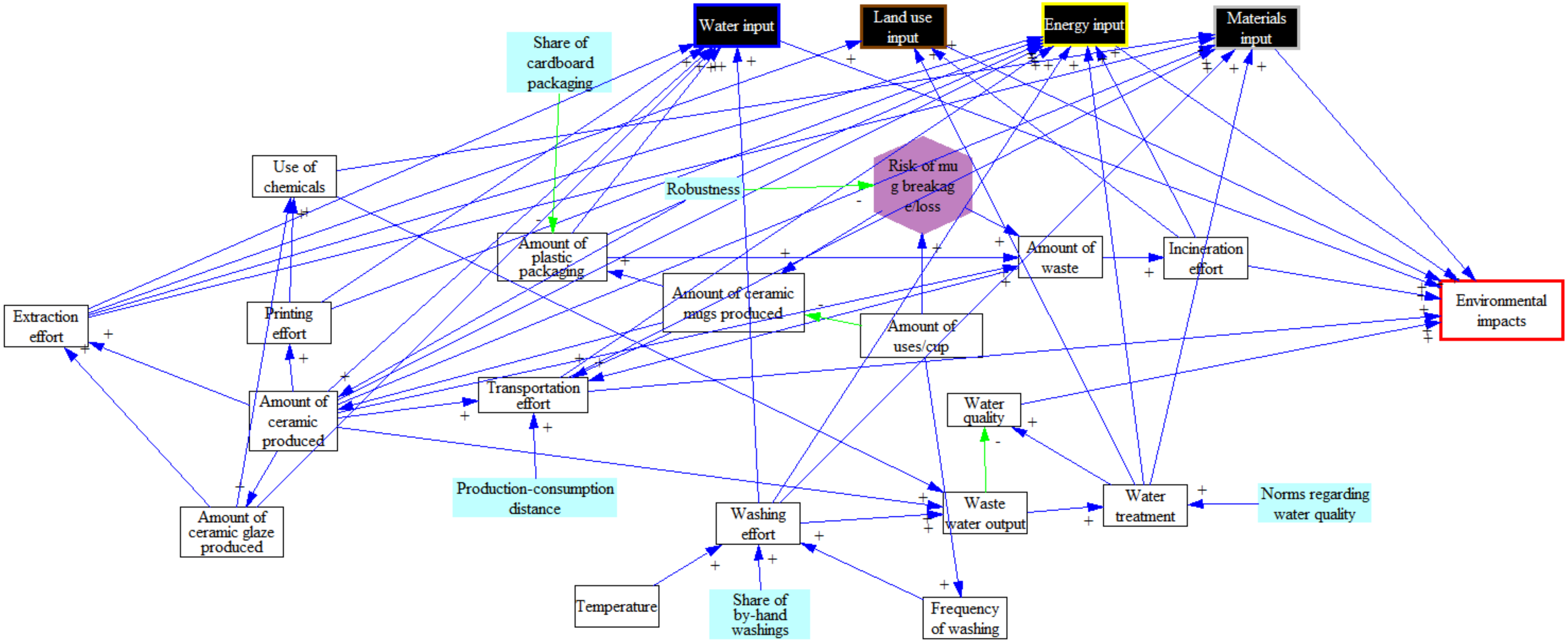

Fig.1: Causal loop diagram: ceramic mug

Ceramic cup vs. Paper cup

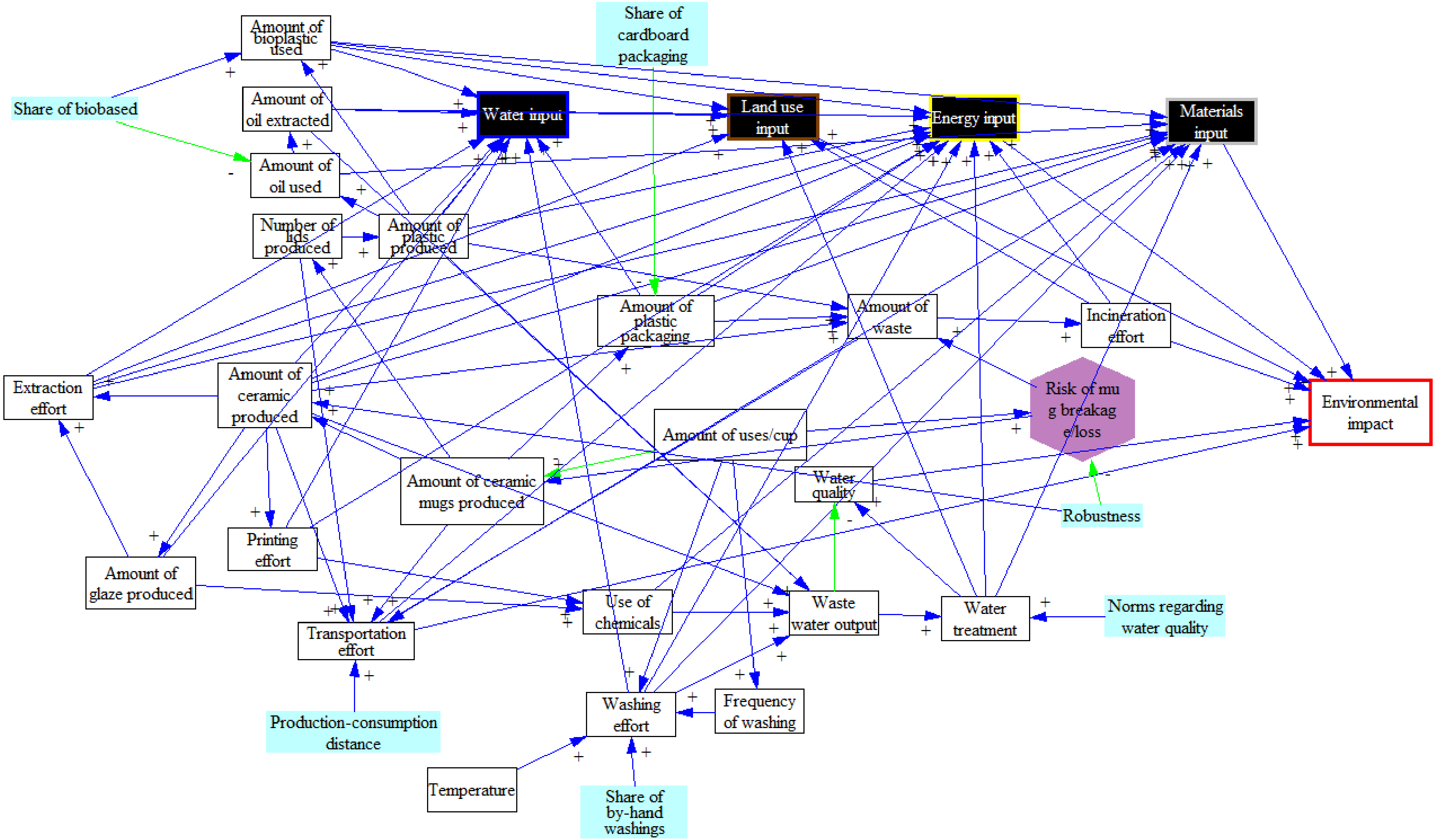

Fig.2: Causal loop diagram: ceramic cup with a lid

Ceramic cup vs. Paper cup

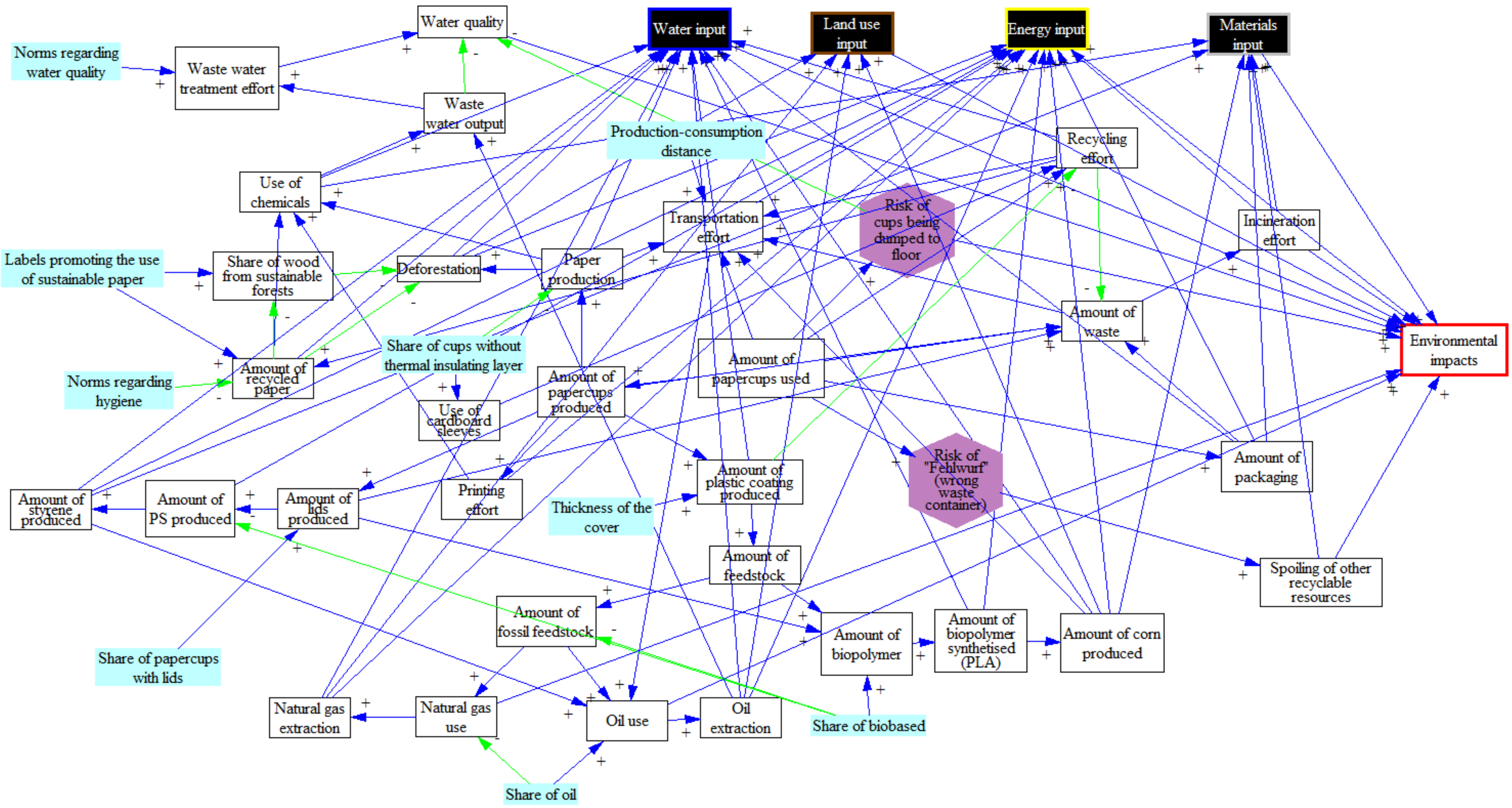

Fig.3: Causal loop diagram: paper cup

3 Goal and scope definition

This study aims to compare three different types of cups in terms of environmental impacts. The functional unit defined for such comparison is “Coffee served in cup”, i.e. the total volume of coffee served. The break-even point in term of potential for climate change and the best alternative for every impact category will be determined using the ecoinvent 3.4 database and the open LCA 1.7.2 software.

In order to better frame the scope of the study and the analysis, the following assumptions have been hypothesized:

- The cups are bought and used in Berlin.
- Sponge, sink and dishwasher production or disposal were not considered.
- Water is electrically heated in the washing process.
- No garbage materials are produced during production and transportation.
- The reusable cups last for the entire usage assumed in the functional unit. The lifespan of a ceramic mug was here considered with a risk of breakage. Indeed, if the cup breaks, a new cup must be produced, and the resulting waste is to be treated. To represent this risk a parameter “broken” was created and applied in the use and washing phases (Figures 5 and 6) to model this risk. If the cup breaks, a new cup must be produced, and the resulting waste is to be treated.
- The amount of recycled paper cups was not considered, and thus that every used paper cup was incinerated. In Germany, only 2/3 of the used cups are indeed disposed in the appropriate recycling bin. Besides, the recycling process is not optimal: due to the inner plastic layer, most of the paper doesn’t dissolve and ends up being incinerated as well. [5]
- The functional unit considered is 750*300 mL of coffee served, i.e. 750 drinks. For every drink, a new paper cup is produced, whereas a reusable cup can be used as long as it is not broken.

Fig.4: Representation of the three cups considered (from left to right, ceramic mug, ceramic cup with lid, paper cup)

The life cycle of ceramic cups processes are divided into four unit processes: production, use, washing and waste treatment (Figures 5 and 6). Whereas the paper cup includes only three different unit processes: production, packaging, and use, while the waste disposal is part of the use process (Figure 7).

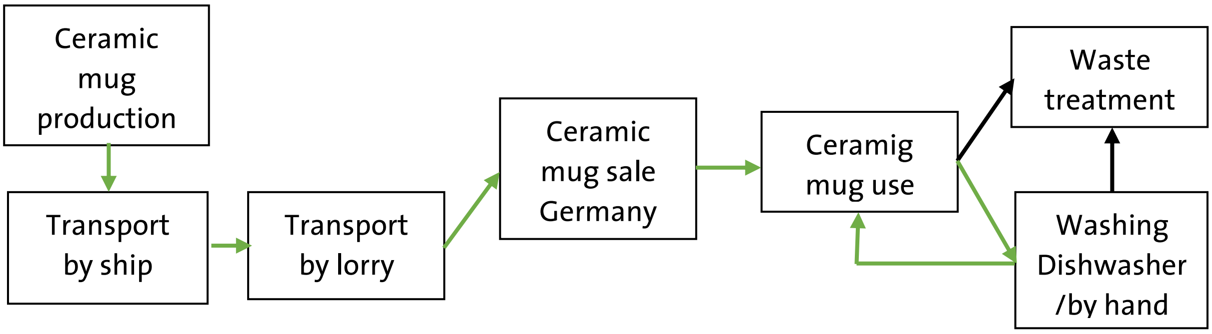

Fig.5: Ceramic mug life cycle

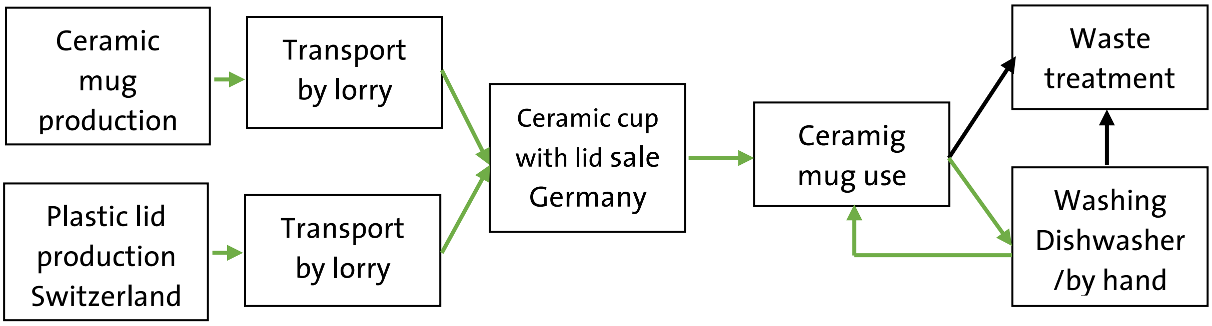

Fig.6: Ceramic cup with lid life cycle

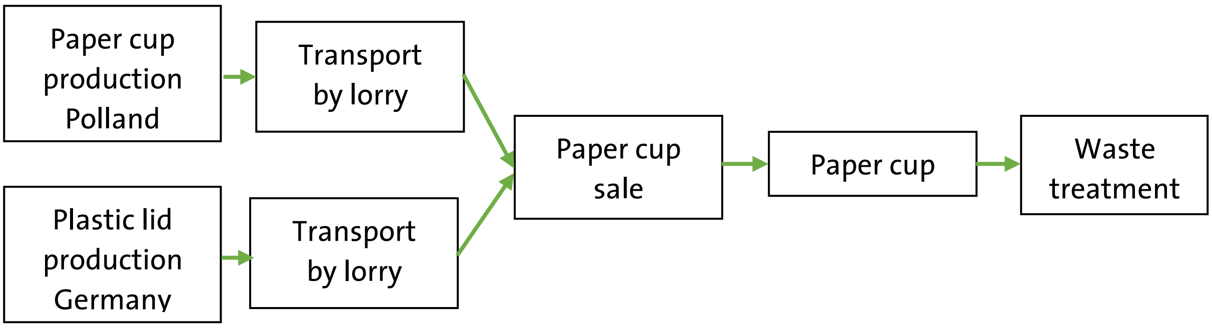

Fig.7: Paper cup life cycle

4 Inventory analysis

All three cups were modeled after existing cups (see figure 4). They have the same capacity of 300 mL. The traditional ceramic mug is modeled according to the Ulla model of the online trade “Highflyers Werbeartikel GmbH”, [6] which weighs 310 g. Through contact with the online retailer (see appendix), it is known that the mug is produced in China. After further research, a ceramics factory in Shenzhen was designated as the production site. Ceramic production was assimilated to the production of sanitary ceramics. Therefore, a transport route for the entire life cycle of 18521.51 km was measured for the sea route to Hamburg and 300 km by truck to Berlin.

The ceramic cup with plastic lid was created after the Coffee-2-go provider models. [7] It is however not made of ceramics but of porcelain. Due to the lack of data on porcelain production, the cup was also modeled as a ceramic cup. It is manufactured in Czech Republic, while the matching lid comes from Switzerland. A transport distance of 1195 km was computed for this type of cup, corresponding to the Zurich-Berlin and Prague-Berlin routes. For both cups, the printing process could was neither provided by the producer nor available in the database. A similar process was therefore chosen.

As already mentioned, the washing behavior of reusable cups is a determinant factor for the final outcome, which is why two alternatives have been assessed. For manual washing, energy and detergent consumption data were taken from an existing study,[8] and the amount of hot water was determined by an experiment. For the dishwasher, energy and water consumption were taken from an A++++ certified machine.[9] All values of the wash process were divided by 20 for the cups because it was assumed that 20 ceramic cups could be washed during a single cycle, and by 50 for the lids. As per the detergent, no dish detergent was found on the Ecoinvent 3.4 database. Consequently, it was chosen to take the different existing components[10] as inputs. To limit the uncertainty due to the lack of information on detergent manufacturing, it was considered that half of the detergent was regular soap.

The paper cup is modeled (see Fig.7) after the model Café D [11] of the online retailer allesbecher.de and the matching polystyrene lid of the same company. The cup weighs 8.3 g and has an inner plastic (polyethylene) coating of 0.1 g. The lid weighs 0.93 g. Through email contact with the company, it is known that the cup is produced in Poland and the lid in Germany. A more accurate production location was unfortunately not given. The transport path of the paper cup was then defined over 300 km and the one of the cover over 400 km. Because of a lack of information on the inner coating of the paper cup, a similar process was chosen. The resulting waste represents all parts of the paper cup, including its packaging. To report the percentage of sorted packaging cardboard, a "sorted" parameter has been created.

Besides the data collected directly from the producers, secondary and tertiary data used in this study is based on the ecoinvent 3.4 database. Swiss data had to be used several times, it was assumed that identical conditions prevail in Berlin. Tables presenting parameters definition and all in- and outputs are to be found in the appendix.

5 Results

In this section, the impact assessment results (LCIA) for the three alternatives cups are reported. The ILCD Midpoint method (August 2016) was selected for this phase and all the 15 impact categories are considered to compare the considered cups (see Table 1). Two alternatives were added to the three cups described in section 3, differentiating through the washing phase (dishwasher vs. hand-washing).

Tab.1: Environmental impact categories of the ILCD Midpoint method

Impact category			**Unit**
Climate change	1	100-year global warming potential	kg CO2-Eq
Ecosystem quality	2	Freshwater and terrestrial acidification	mol H^+-Eq
	3	Freshwater ecotoxicity	CTUh.m^3.yr
	4	Freshwater eutrophication	kg P-Eq
	5	Ionising radiation	mol N-Eq
	6	Marine eutrophication	kg N-Eq
	7	Terrestrial eutrophication	mol N-Eq
Human health	8	Carcinogenic effects	CTUh
	9	Ionising radiation	kg ^{235}U-Eq
	10	Non-carcinogenic effects	CTUh
	11	Ozone layer depletion	kg CFC-11-Eq
	12	Photochemical ozone creation	kg ethylene-Eq
	13	Respiratory effects, inorganics	kg PM2.5-Eq
Resources	14	Land use	kg Soil Organic Carbon
	15	Mineral, fossils and renewables	kg Sb-Eq

5.1 Global results

In table 2, the LCIA results of the entire life cycle of the considered alternatives are reported. Overall, the use of ceramic cups (both with and without lid, i.e., “Mug dish” and “Lid dish”) washed with a dishwasher represent the best alternative. Paper cups (“Paper”) show the best performance in terms of freshwater eutrophication. Ceramic cups with lid washed by hand (“Lid hand”) result instead on average the worst alternative.

Tab.2: Life Cycle Impact Assessment results for the different cups, per impact category. In this table, "hand" and "dish" stand for the washing method, respectively by hand and by dishwasher. "Mug" is for the traditional ceramic mug, "Lid" for the ceramic cup with lid, and "Paper" for the paper cup option.

	Impact category	Unit	Mug hand	Mug dish	Lid hand	Lid dish	Paper
Climate change	100 year global warming potential	kg CO2-Eq	3,66E+01	1,10E+01	5,31E+01	1,32E+01	3,97E+01
Ecosystem quality	Freshwater and terrestrial acidification	mol H+-Eq	1,86E-01	5,96E-02	2,48E-01	6,25E-02	1,47E-01
	Freshwater ecotoxicity	CTUh.m^3.yr	4,09E+02	1,20E+02	6,00E+02	1,44E+02	8,62E+02
	Freshwater eutrophication	kg P-Eq	4,26E-02	1,04E-02	6,35E-02	1,10E-02	8,47E-03
	Ionising radiation	mol N-Eq	1,69E-05	4,91E-06	2,37E-05	5,51E-06	9,47E-06
	Marine eutrophication	kg N-eq	4,14E-02	1,86E-02	5,83E-02	2,40E-02	3,21E-02
	Terrestrial eutrophication	mol N-eq	6,10E-01	1,85E-01	8,48E-01	1,96E-01	3,22E-01
Human health	Carcinogenic effects	CTUh	3,28E-06	9,10E-07	4,83E-06	1,01E-06	2,18E-06
	Ionising radiation	kg U235-Eq	7,89E+00	2,13E+00	1,13E+01	2,31E+00	3,21E+00
	Non-carcinogenic effects	CTUh	1,23E-05	3,75E-06	1,81E-05	4,45E-06	1,30E-05
	Ozone layer depletion	kg CFC-11-Eq	2,21E-06	7,72E-07	3,09E-06	9,59E-07	1,71E-06
	Photochemical ozone creation	kg ethylene-Eq	5,25E-02	2,09E-02	6,40E-02	2,27E-02	1,04E-01
	Respiratory effects, inorganics	kg PM2.5-Eq	4,18E-02	1,88E-02	4,47E-02	1,97E-02	3,08E-02
Ressources	Land use	kg Soil Organic Carbon	3,10E+01	1,61E+01	4,25E+01	2,16E+01	9,64E+01
	Mineral, fossils and renewables	kg Sb-Eq	8,80E-04	4,90E-04	2,23E-03	1,10E-03	7,30E-04

Figure 8 reports the LCIA results expressed in relative terms. As emerged from Table 2, "Lid hand" overall causes the highest environmental impacts (assuming 1 as a value).

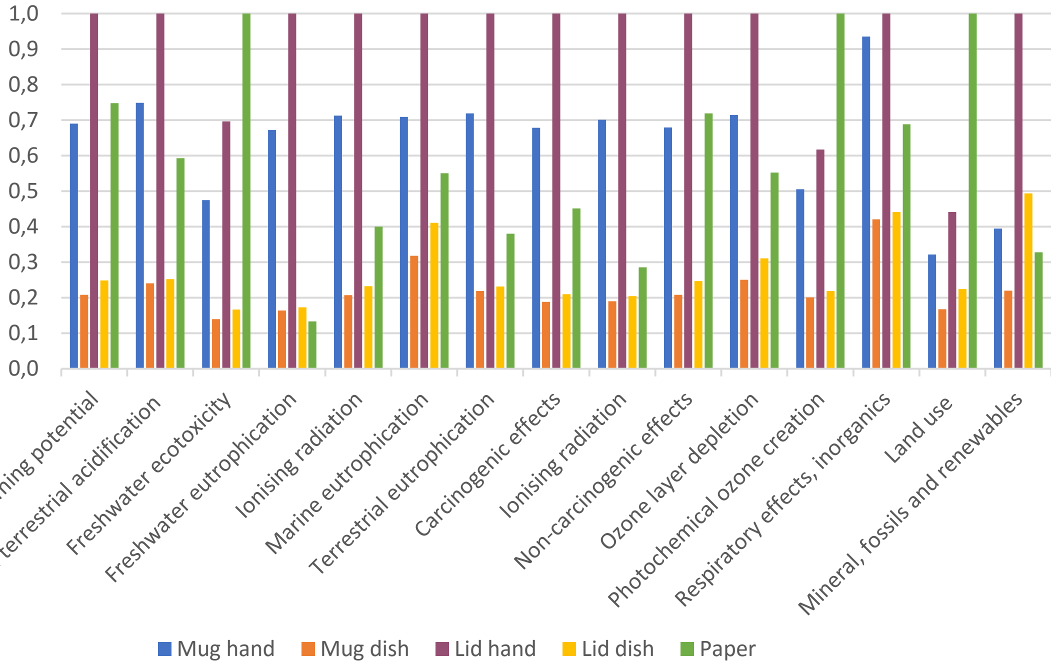

Fig.8: Relative indicator results for every cup type, per impact category. For each indicator, the maximum result (i.e. the worst in terms of environmental impacts) is set to 1 and the results of the other variants are displayed in relation to this result.

5.2 Relative impact of the different processes on the use of ceramic mugs

Figure 9 details the influence of the different processes involved during the lifetime of a ceramic mug (without lid). The washing phase causes overall the highest environmental impacts, except for the photochemical ozone creation and the mineral, fossils and renewables categories.

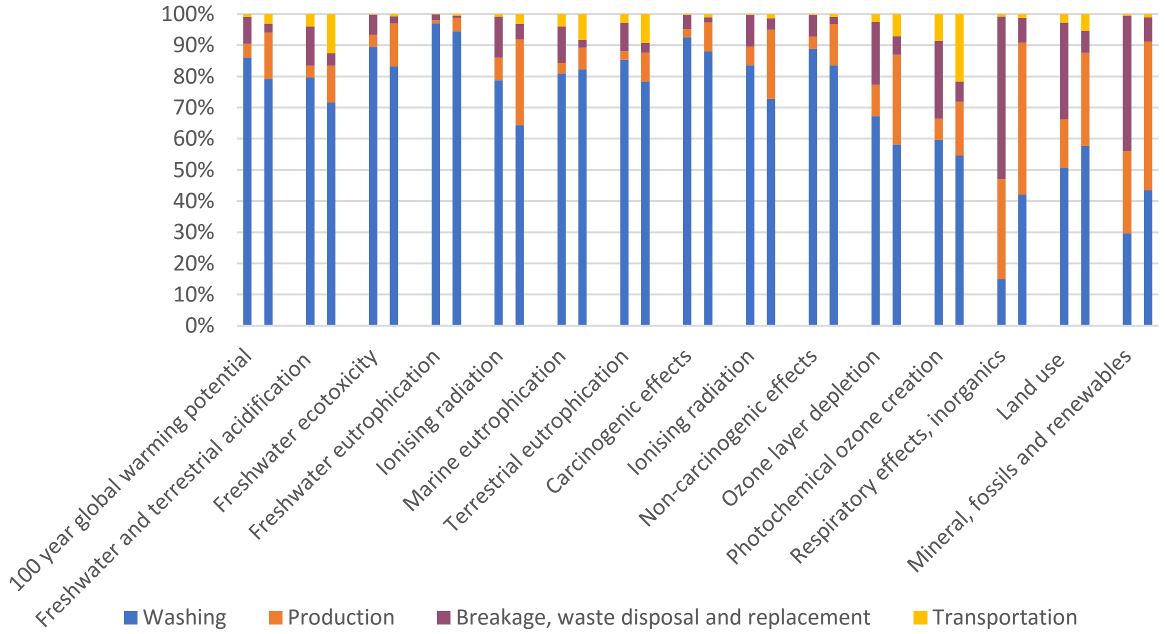

Fig.9: Influence of the different processes – washing, production, transportation, waste treatment – on the use of a ceramic mug, expressed by a percentage per environmental impact category. On the left is the hand-washed version represented.

5.3 Impact of the washing process on the use of ceramic mugs

Given the significant contribution of the use phase of the ceramic cups, in particular of the washing phase, the analysis of this unit process was deepened to identify the main causes. Electricity – used for heating – plays a determining role, its contribution varies between 19% and 99%.

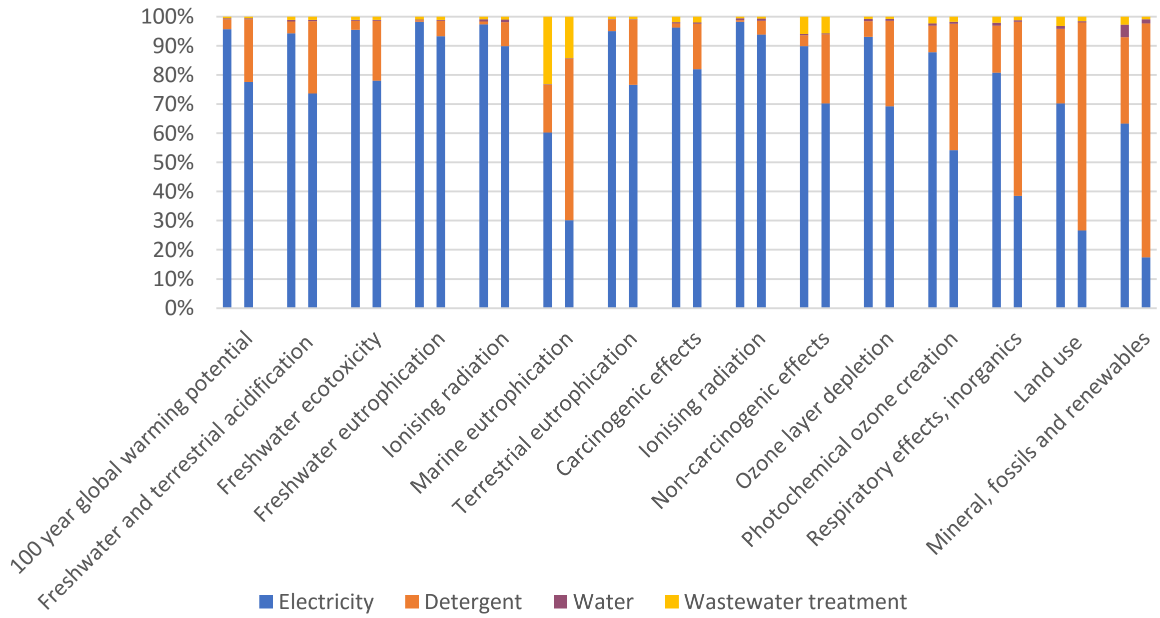

Fig. 10: Influence of the different processes – electricity, detergent, water, waste water treatment – on the washing of a ceramic mug, expressed by a percentage per environmental category. On the left is the hand-washed version represented.

Ceramic cup vs. Paper cup

Given the importance of the electricity used for warming up the water, we tested an additional alternative in which the washing phase is performed with cold water. By comparing this last alternative with the previous five (Table 8), a reusable hand-washed – with cold water only – mug (without lid) appears to be the best choice in 13 environmental impact categories.

Tab.8: Relative Life Cycle Impact Assessment results for the different cups (including the ceramic mug washed with cold water), per impact category. For each indicator, the maximum result is set to 1 and the results of the other variants are displayed in relation to this result. In this table, "hand" and "dish" stand for the washing method, respectively by hand and by dishwasher. "Mug" is for the traditional ceramic mug, "Lid" for the ceramic cup with lid, and "Paper" for the paper cup option. Finally, "Hand cold" stands for the ceramic mug (without lid) washed by hand with cold water.

	Impact category	Unit	Mug hand	Mug dish	Lid hand	Lid dish	Paper	Hand cold
Climate change	100 year global warming potential	kg CO2-Eq	6,90E-01	2,08E-01	1,00E+00	2,48E-01	7,48E-01	1,22E-01
Ecosystem quality	Freshwater and terrestrial acidification	mol H+-Eq	7,48E-01	2,40E-01	1,00E+00	2,52E-01	5,92E-01	1,86E-01
	Freshwater ecotoxicity	CTUh.m^3.yr	4,74E-01	1,40E-01	6,96E-01	1,67E-01	1,00E+00	7,13E-02
	Freshwater eutrophication	kg P-Eq	6,72E-01	1,63E-01	1,00E+00	1,73E-01	1,33E-01	3,18E-02
	Ionising radiation	mol N-Eq	7,12E-01	2,07E-01	1,00E+00	2,33E-01	4,00E-01	1,79E-01
	Marine eutrophication	kg N-eq	7,09E-01	3,18E-01	1,00E+00	4,11E-01	5,50E-01	3,58E-01
	Terrestrial eutrophication	mol N-eq	7,19E-01	2,19E-01	1,00E+00	2,31E-01	3,80E-01	1,36E-01
Human health	Carcinogenic effects	CTUh	6,78E-01	1,88E-01	1,00E+00	2,09E-01	4,51E-01	7,44E-02
	Ionising radiation	kg U235-Eq	7,01E-01	1,90E-01	1,00E+00	2,05E-01	2,85E-01	1,25E-01
	Non-carcinogenic effects	CTUh	6,79E-01	2,08E-01	1,00E+00	2,46E-01	7,19E-01	1,37E-01
	Ozone layer depletion	kg CFC-11-Eq	7,14E-01	2,50E-01	1,00E+00	3,10E-01	5,52E-01	2,67E-01
	Photochemical ozone creation	kg ethylene-Eq	5,06E-01	2,01E-01	6,17E-01	2,19E-01	1,00E+00	2,41E-01
	Respiratory effects, inorganics	kg PM2.5-Eq	9,35E-01	4,21E-01	1,00E+00	4,41E-01	6,88E-01	8,22E-01
Ressources	Land use	kg Soil Organic Carbon	3,22E-01	1,67E-01	4,41E-01	2,24E-01	1,00E+00	2,07E-01
	Mineral, fossils and renewables	kg Sb-Eq	3,95E-01	2,20E-01	1,00E+00	4,93E-01	3,27E-01	3,18E-01
	Scale	%	100	50	25	10	5	1

Finally, the frequency of washing was diminished in Figure 11. Instead of washing the reusable cups after every use, it was considered that they were washed only every three uses.

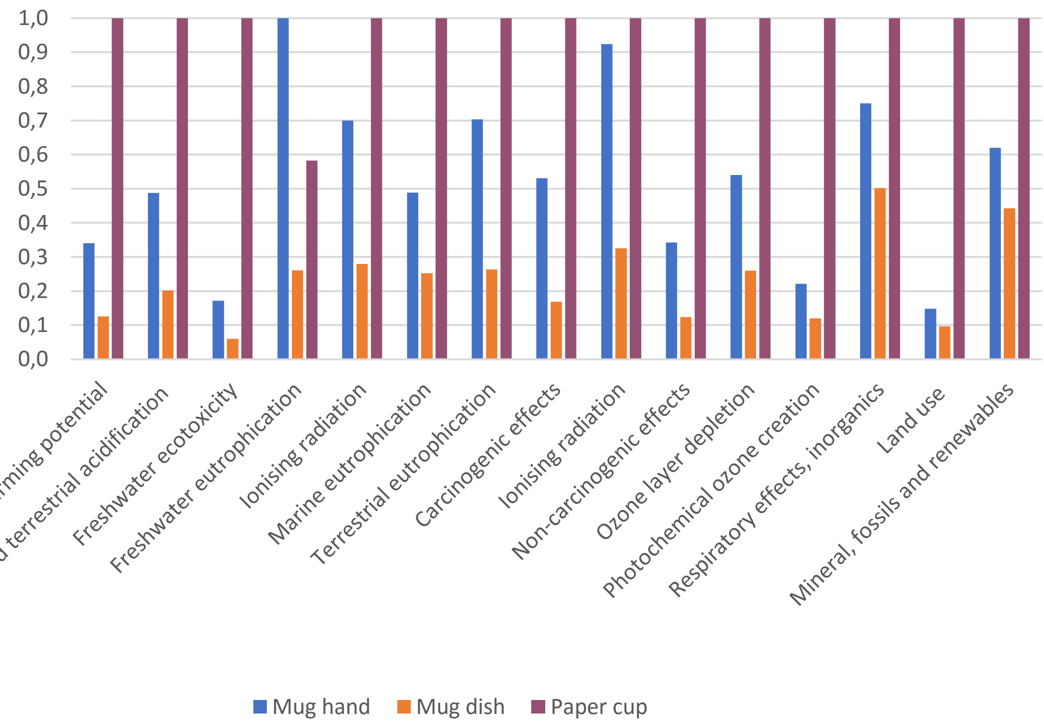

Fig.11: Relative Life Cycle Impact Assessment results for the different cups, per impact category. 750 uses, but only 250 washings. For each indicator, the maximum result is set to 1 and the results of the other variants are displayed in relation to this result.

5.4 Relative impact of the different processes on the use of paper cups

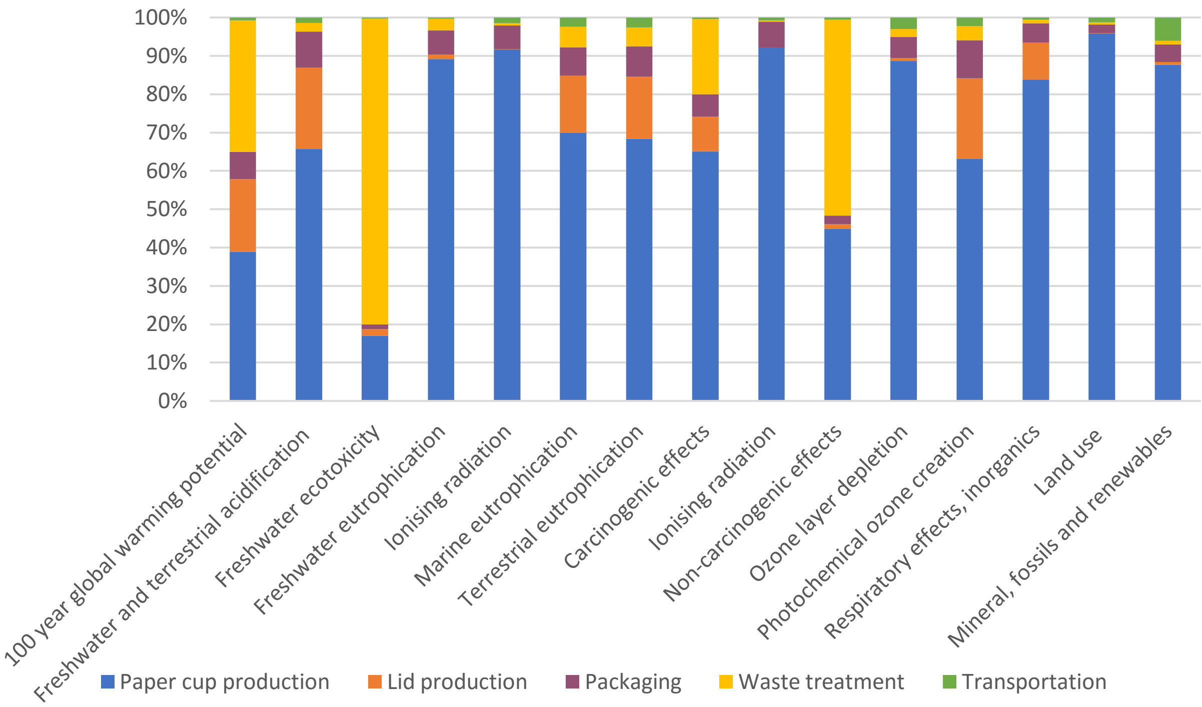

Fig.12: Influence of the different processes – production, transportation, waste treatment – on the use of a paper cup, expressed by a percentage per environmental category.

5.5 Location impacts

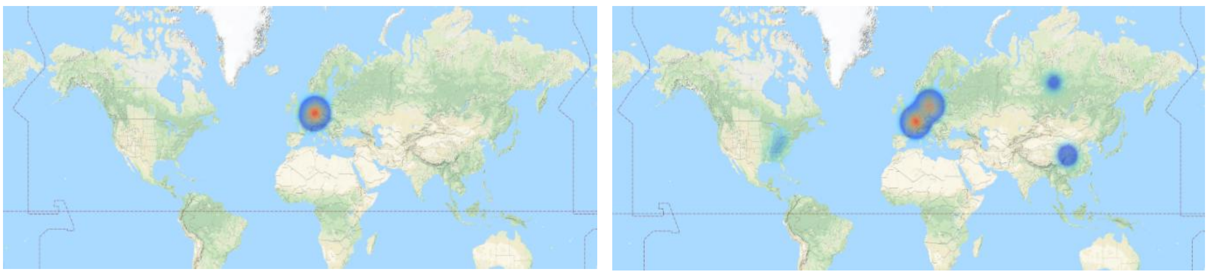

Fig.13: Comparison of the location of the emissions contributing to climate change between reusable cups and paper cups. On the left is the reusable version represented.

5.6 Break-Even Point determination

To differentiate between the three types of cups, it is investigated how long it takes until a reusable cup has an environmental return on investment, i.e. that its impact equals the one of a paper cup. This period is called the environmental Break-Even Point.

Ceramic cup vs. Paper cup

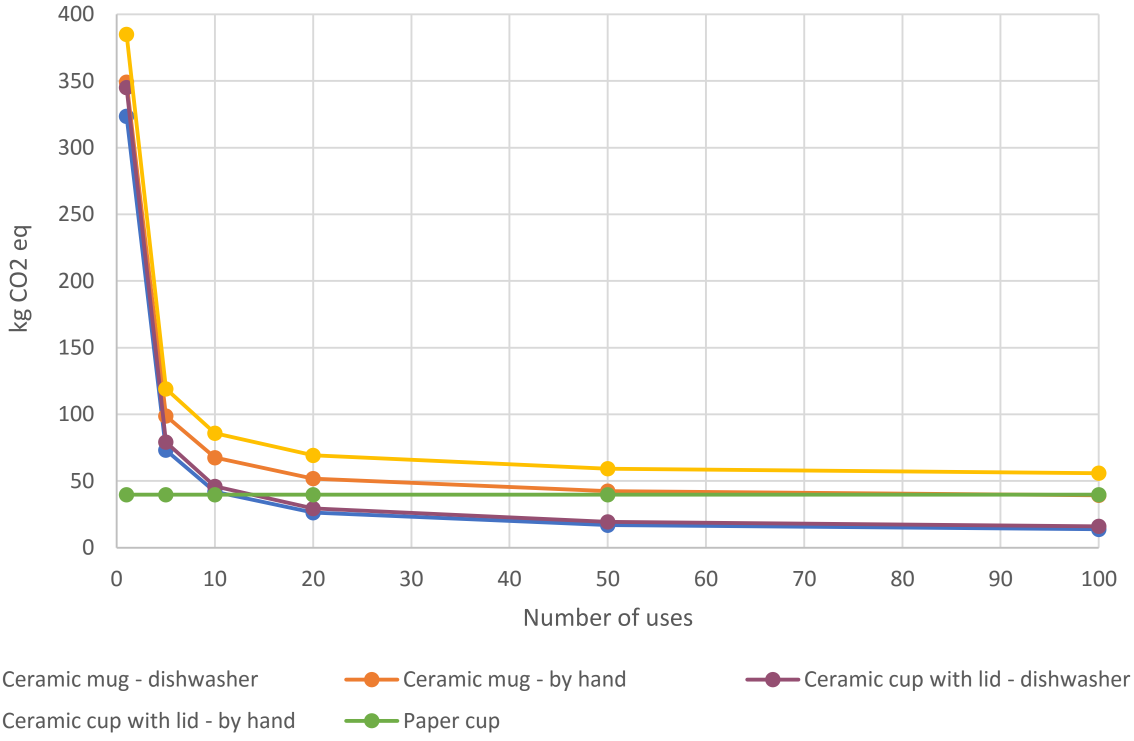

Fig.14: Break-Even-Point of the ceramic cups for the climate change category.

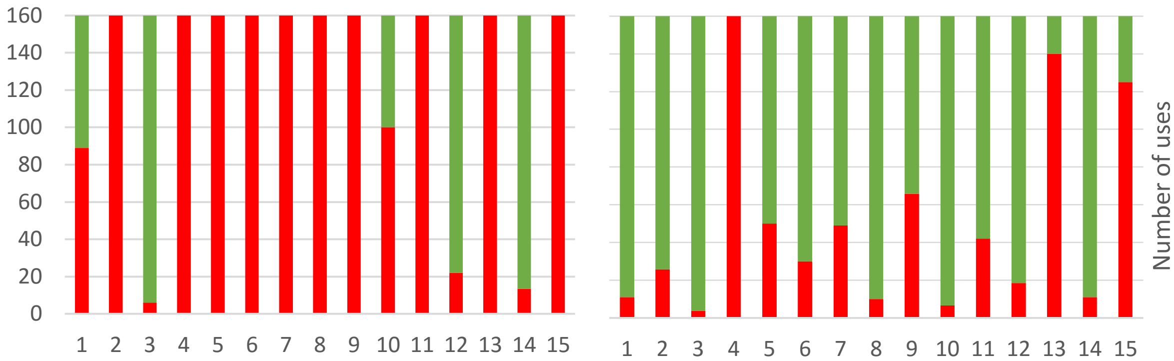

Fig.15: Break-Even-Point of the ceramic mugs for each category.[1] *On the left is the hand-washed option, on the right, the dishwasher washed. In red are displayed the uses under the break-even point, and in green those above.*

[1] 1: Climate change – 100-year global warming potential; 2: Ecosystem quality – Freshwater and terrestrial acidification; 3: Ecosystem quality – Freshwater ecotoxicity; 4: Ecosystem quality – Freshwater eutrophication; 5: Ecosystem quality – Ionising radiation; 6: Ecosystem quality – Marine eutrophication; 7: Ecosystem quality – Terrestrial eutrophication; 8: Human health – Carcinogenic effects; 9: Human health – Ionising radiation; 10: Human health – Non-carcinogenic effects; 11: Human health – Ozone layer depletion; 12: Human health – Photochemical ozone creation; 13: Human health – Respiratory effects, inorganics; 14: Resources – Land use; 15: Resources – Mineral, fossils and renewables

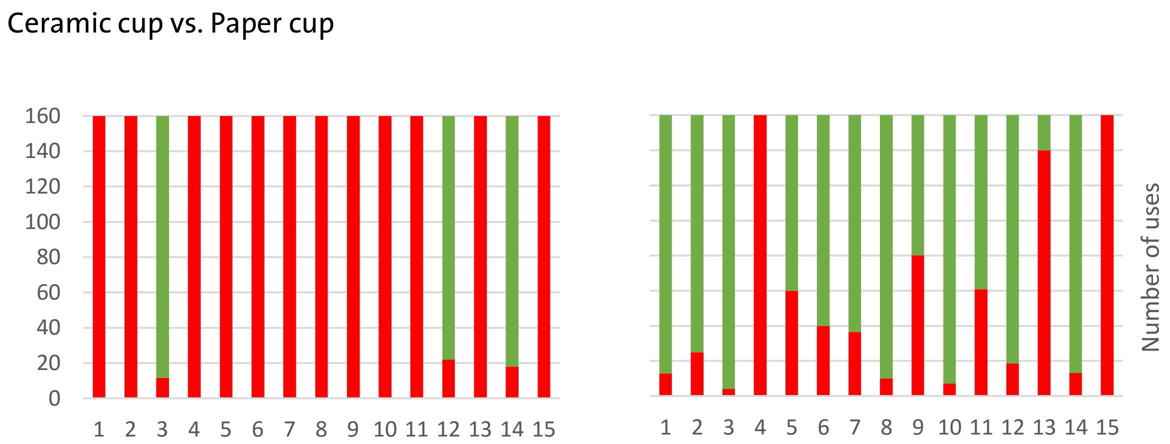

Fig.16: Break-Even-Point of the ceramic cups with lid for each category. On the left is the hand-washed option, on the right, the dishwasher washed. In red are displayed the uses under the break-even point, and in green those above.

6 Interpretation and discussion

In table 2 and figure 8, all results are displayed and compared by environmental impact category. The ceramic mug has the best outcomes in 14 impact categories out of 15 when using a dishwasher. Yet, the hand-washed option appears to be far worse: it is never the most environmental friendly choice, and all the results are average or below. The same tendency can be observed when studying the ceramic cup with lid. In the dishwasher, it has average or above results. But hand-washed, it is the worst of all alternatives, being the least environmental friendly in 12 categories. As expected, the washing method thus appears to have a huge impact on the final outcome.

The paper cup, on the other hand, turns out to be the best choice in one impact category (freshwater eutrophication), and the worst in three (freshwater ecotoxicity, photochemical ozone creation and land use), the rest of the outcomes being average. Adding other factors could yet change the results. For instance, considering the contents of the paper cup, such as the inner-polymer-coating or the polystyrene lid during the use of the cup, would affect the human health. Since these effects are discussed very differently in research studies, they could not be clearly determined. Besides, figure 12 shows the contributions of the different processes on the paper cups impact. The paper production has an important influence in every impact category, but one can also notice the role played by the disposal and waste treatment of the cup. If the recycling effort were to be increased, this could make the paper cup an even greener solution.

It still can be stated that the ceramic mug performs significantly better than the reusable cup with lid. The production but also the additional washing of this plastic lid is the reason for the relatively poor performance compared to the traditional mug.

Figure 10 details the effects of the most influential process for the ceramic mug – washing (see figure 9). For both variants, in almost all categories, electricity is the relevant factor that explains the environmental impact. A new option was therefore created in this study: a ceramic mug, hand-washed with cold water. This option turned out to be the most environmental friendly in comparison with all other options. Beyond the washing process, water temperature plays a determining role in the total environmental impact (see table 8). In the figure 11 is the frequency of washing studied. If the cups have been used 750 but washed only every three uses, the impacts of the washing are reduced and the paper cup becomes then the worst choice.

More surprisingly, the transportation factor, and thus the production location (see figures 9 and 12) does not have a significant influence on the global impact. From a global environmental perspective, it is consequently almost irrelevant whether the cups are produced in Asia or Europe. Nevertheless, one can observe different effects on climate change depending on the location, especially for the paper cup (see figure 14). It has indeed an impact on Europe, mostly due to waste treatment and polystyrene production, but also in Asia because of the paper production. On the contrary, for reusable cups, the effects are concentrated in Europe since the main process – washing – requires electricity production.

Finally, the break-even points of the reusable cups are calculated (see figures 14-15-16). After 11 uses, the impact of the entire life cycle on climate change of the ceramic mug, dishwasher washed, equals the impact of the paper cups. This phenomenon happens after 13 uses of the dishwasher-washed ceramic cup with lid. When hand-washed, the ceramic cup with lid never reaches a break-even point, whereas without, it requires 89 uses. Based on these outcomes, considering all impact categories, it is then recommended that hot drinks should be consumed in ceramic mugs, provided that these cups are washed with a modern dishwasher and used at least 140 times.

The Life Cycle Analysis of the cups faces a high level of uncertainty. In some cases, variables could only be estimated and values of similar products had to replace missing data, which influences the results. The washing data are particularly decisive for assessing the impact. Individual washing habits could not be considered either. Using an older dishwasher would change the final results, and the ceramic mug would tend to have a bigger impact. Based on the results of this study, it is generally recommended to use a conventional ceramic cup over a long period of time and to wash it off continuously by means of a dishwasher, or by hand without hot water. However, to enjoy an occasional coffee-to-go, the paper cup remains a greener option.

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Feedback & Contact

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8 Appendix

9.1 Inventory analysis

9.1.1 Parameters

Tab. 4: Parameters definition and formula

Parameters	Formula	Meaning
total	750	total amount of cups used
broken_use	0,01*total	percentage of breaks during use
Dishwasher		
dishwasher	total-broken_use	total amount of mugs cleaned
broken	0,001	part of breaks during washing
clean	1-broken	part of mug washed
Hand-washed		
hand	total-broken_use	total amount of mugs cleaned
broken	0,01	part of breaks during washing
clean	1-broken	part of mugs washed
Paper cup		
sorted	0,8*total	part of paperboard sorted (recycled)
unsorted	total-sorted	part of paperboard unsorted (incinerated)

9.1.2 Ceramic mug – dishwasher

Tab.5: Flow inventory for the use of a ceramic mug, dishwasher-washed

Flow	Type	Quantity	Unit	Matched ecoinvent dataset
Ceramic mug use				
Ceramic mug	Input	1+broken	Item(s)	
Clean mug - dishwasher	Input	dishwasher	Item(s)	
Broken mug	Output	broken	Item(s)	
Coffee served in mug	Output	300*total	mL	
Ceramic mug production				
Ceramics	Input	310	g	sanitary ceramics production | sanitary ceramics | Cutoff, U - CH
Painting	Input	5	g	alkyd paint production, white, solvent-based, product in 60% solution state | alkyd paint, white, without solvent, in 60% solution state | Cutoff, U - RER
Transport	Input	0,09	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Transport	Input	5,17417	t*km	transport, freight, sea, transoceanic ship | transport, freight, sea, transoceanic ship | Cutoff, U - GLO
Ceramic mug	Output	1	Item(s)	
Mug washing				
Tap water	Input	0,14	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,0504	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U -

				DE
Detergent component	Input	0,7	g	soap production | soap | Cutoff, U - RER
Non-ionic surfactant	Input	0,7*0,05	g	market for non-ionic surfactant | non-ionic surfactant | Cutoff, U - GLO
Builder	Input	0,7*0,05	g	polycarboxylates production, 40% active substance | polycarboxylates, 40% active substance | Cutoff, S - RER
Bleaching agent	Input	0,7*0,15	g	sodium perborate production, monohydrate, powder | sodium perborate, monohydrate, powder | Cutoff, S - RER
Water softener	Input	0,7*0,05	g	sodium phosphate production | sodium phosphate | Cutoff, U - RER
Waste water treatment	Input	-0,00014	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Ceramic mug	Input	broken	Item(s)	
Broken mug	Output	broken	Item(s)	
Clean mug - dishwasher	Output	clean	Item(s)	
Waste treatment				
Broken mug	Input	1	Item(s)	
Inert waste	Input	-0,31	kg	treatment of inert waste, inert material landfill | inert waste, for final disposal | Cutoff, U - CH
Incineration residue	Output	0,31	kg	average incineration residue

9.1.3 Ceramic mug – hand washed

Tab.6: Flow inventory for the use of a ceramic mug, hand-washed

Flow	Type	Quantity	Unit	Matched ecoinvent dataset
Ceramic mug use				

Ceramic cup vs. Paper cup

Ceramic mug	Input	1+broken	Item(s)	
Clean mug - hand-washed	Input	hand	Item(s)	
Broken mug	Output	broken	Item(s)	
Coffee served in mug	Output	300*total	mL	
Ceramic mug production				
Ceramics	Input	310	g	sanitary ceramics production | sanitary ceramics | Cutoff, U - CH
Painting	Input	5	g	alkyd paint production, white, solvent-based, product in 60% solution state | alkyd paint, white, without solvent, in 60% solution state | Cutoff, U - RER
Transport	Input	0,09	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Transport	Input	5,17417	t*km	transport, freight, sea, transoceanic ship | transport, freight, sea, transoceanic ship | Cutoff, U - GLO
Ceramic mug	Output	1	Item(s)	
Mug washing				
Tap water	Input	0,5	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,222	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U - DE
Detergent component	Input	0,5	g	soap production | soap | Cutoff, U - RER
Anionic surfactant	Input	0,5*0,135	g	alkylbenzene sulfonate production, linear, petrochemical | alkylbenzene sulfonate, linear, petrochemical |

				Cutoff, U - RER
Detergent component	Input	0,5*0,0397	g	chlor-alkali electrolysis, diaphragm cell | sodium hydroxide, without water, in 50% solution state | Cutoff, U - RER
Detergent solvent	Input	0,5*0,730	kg	water production, completely softened, from decarbonised water, at user | water, completely softened, from decarbonised water, at user | Cutoff, U - RER
Waste water treatment	Input	-0,005	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Ceramic mug	Input	broken	Item(s)	
Broken mug	Output	broken	Item(s)	
Clean mug - hand-washed	Output	clean	Item(s)	
Waste treatment				
Broken mug	Input	1	Item(s)	
Inert waste	Input	-0,31	kg	treatment of inert waste, inert material landfill | inert waste, for final disposal | Cutoff, U - CH
Incineration residue	Output	0,31	kg	average incineration residue

9.1.4 Ceramic cup with lid – dishwasher

Tab.7: Flow inventory for the use of a ceramic cup with lid, dishwasher-washed

Flow	Type	Quantity	Unit	Matched ecoinvent dataset
Ceramic cup with lid use				
Ceramic mug	Input	1+broken	Item(s)	
Clean mug - dishwasher	Input	dishwasher	Item(s)	
Plastic lid	Input	1+broken	Item(s)	
Clean lid - dishwasher	Input	dishwasher	Item(s)	
Broken mug	Output	broken	Item(s)	

Coffee served in mug	Output	300*total	mL	
Ceramic part production				
Ceramics	Input	300	g	sanitary ceramics production | sanitary ceramics | Cutoff, U - CH
Painting	Input	5	g	alkyd paint production, white, solvent-based, product in 60% solution state | alkyd paint, white, without solvent, in 60% solution state | Cutoff, U - RER
Transport	Input	0,105	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Ceramic mug	Output	1	Item(s)	
Lid production				
Synthetic rubber	Input	35	g	synthetic rubber production | synthetic rubber | Cutoff, U - RER
Transport	Input	0,02900	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Plastic lid	Output	1	Item(s)	
Mug washing				
Tap water	Input	0,14	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,0504	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U - DE
Detergent component	Input	0,7	g	soap production | soap | Cutoff, U - RER

Non-ionic surfactant	Input	0,7*0,05	g	market for non-ionic surfactant | non-ionic surfactant | Cutoff, U - GLO
Builder	Input	0,7*0,05	g	polycarboxylates production, 40% active substance | polycarboxylates, 40% active substance | Cutoff, S - RER
Bleaching agent	Input	0,7*0,15	g	sodium perborate production, monohydrate, powder | sodium perborate, monohydrate, powder | Cutoff, S - RER
Water softener	Input	0,7*0,05	g	sodium phosphate production | sodium phosphate | Cutoff, U - RER
Waste water treatment	Input	-0,00014	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Ceramic mug	Input	broken	Item(s)	
Plastic lid	Input	broken	Item(s)	
Broken mug	Output	broken	Item(s)	
Clean mug - dishwasher	Output	clean	Item(s)	
Lid washing				
Tap water	Input	0,07	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,0252	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U - DE
Detergent component	Input	0,4	g	soap production | soap | Cutoff, U - RER
Non-ionic surfactant	Input	0,4*0,05	g	market for non-ionic surfactant | non-ionic surfactant | Cutoff, U - GLO

Builder	Input	0,4*0,05	g	polycarboxylates production, 40% active substance | polycarboxylates, 40% active substance | Cutoff, S - RER
Bleaching agent	Input	0,4*0,15	g	sodium perborate production, monohydrate, powder | sodium perborate, monohydrate, powder | Cutoff, S - RER
Water softener	Input	0,4*0,05	g	sodium phosphate production | sodium phosphate | Cutoff, U - RER
Waste water treatment	Input	-0,00007	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Clean lid	Output	1	Item(s)	
Waste treatment				
Broken mug	Input	1	Item(s)	
Inert waste	Input	-300	g	treatment of inert waste, inert material landfill | inert waste, for final disposal | Cutoff, U - CH
Plastic waste	Input	-35	g	treatment of waste plastic plaster, collection for final disposal | waste plastic plaster | Cutoff, U - CH

9.1.5 Ceramic cup with lid – hand washed

Tab.8: Flow inventory for the use of a ceramic cup with lid, hand-washed

Flow	Type	Quantity	Unit	Matched ecoinvent dataset
Ceramic cup with lid use				
Ceramic mug	Input	1+broken	Item(s)	
Clean mug - hand-washed	Input	hand	Item(s)	
Plastic lid	Input	1+broken	Item(s)	
Clean lid – hand-washed	Input	hand	Item(s)	
Broken mug	Output	broken	Item(s)	

Coffee served in mug	Output	300*total	mL	
Ceramic part production				
Ceramics	Input	300	g	sanitary ceramics production | sanitary ceramics | Cutoff, U - CH
Painting	Input	5	g	alkyd paint production, white, solvent-based, product in 60% solution state | alkyd paint, white, without solvent, in 60% solution state | Cutoff, U - RER
Transport	Input	0,105	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Ceramic mug	Output	1	Item(s)	
Lid production				
Synthetic rubber	Input	35	g	synthetic rubber production | synthetic rubber | Cutoff, U - RER
Transport	Input	0,02900	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Plastic lid	Output	1	Item(s)	
Mug washing				
Tap water	Input	0,5	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,222	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U - DE
Detergent component	Input	0,5	g	soap production | soap | Cutoff, U - RER

Anionic surfactant	Input	0,5*0,135	g	alkylbenzene sulfonate production, linear, petrochemical | alkylbenzene sulfonate, linear, petrochemical | Cutoff, U - RER
Detergent component	Input	0,5*0,0397	g	chlor-alkali electrolysis, diaphragm cell | sodium hydroxide, without water, in 50% solution state | Cutoff, U - RER
Detergent solvent	Input	0,5*0,730	kg	water production, completely softened, from decarbonised water, at user | water, completely softened, from decarbonised water, at user | Cutoff, U - RER
Waste water treatment	Input	-0,005	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Ceramic mug	Input	broken	Item(s)	
Broken mug	Output	broken	Item(s)	
Plastic lid	Input	broken	Item(s)	
Clean mug - hand-washed	Output	clean	Item(s)	
Lid washing				
Tap water	Input	0,25	kg	tap water production, conventional treatment | tap water | Cutoff, U - Europe without Switzerland
Electricity	Input	0,111	MJ	electricity voltage transformation from medium to low voltage | electricity, low voltage | Cutoff, U - DE
Detergent component	Input	0,5	g	soap production | soap | Cutoff, U - RER
Anionic surfactant	Input	0,5*0,135	g	alkylbenzene sulfonate production, linear, petrochemical | alkylbenzene sulfonate, linear, petrochemical | Cutoff, U - RER

Detergent component	Input	0,5*0,0397	g	chlor-alkali electrolysis, diaphragm cell | sodium hydroxide, without water, in 50% solution state | Cutoff, U - RER
Detergent solvent	Input	0,5*0,730	kg	water production, completely softened, from decarbonised water, at user | water, completely softened, from decarbonised water, at user | Cutoff, U - RER
Waste water treatment	Input	-0,00025	m^3	treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | Cutoff, U - CH
Clean lid	Output	1	Item(s)	
Waste treatment				
Broken mug	Input	1	Item(s)	
Inert waste	Input	-300	g	treatment of inert waste, inert material landfill | inert waste, for final disposal | Cutoff, U - CH
Plastic waste	Input	-35	g	treatment of waste plastic plaster, collection for final disposal | waste plastic plaster | Cutoff, U - CH

9.1.6 Paper cup

Tab.9: Flow inventory for the use of a paper cup

Flow	Type	Quantity	Unit	Matched ecoinvent dataset
Paper cup use				
Paper cup	Input	total	Item(s)	
Plastic lid	Input	total	Item(s)	
Packaging	Input	total	Item(s)	
Waste paper cup	Input	-0,0083* total	kg	treatment of municipal solid waste, incineration | municipal solid waste | Cutoff, U - DE

Waste paper cup	Input	-0,5*total	g	treatment of waste polyethylene, municipal incineration | waste polyethylene | Cutoff, U - Europe without Switzerland
Waste plastic packaging	Input	-1,05*total	g	treatment of waste polyethylene, municipal incineration | waste polyethylene | Cutoff, U - Europe without Switzerland
Waste paperboard packaging - sorted	Input	-0,9*sorted	g	treatment of waste paperboard, sorting plant | waste paperboard | Cutoff, U - Europe without Switzerland
Waste paperboard packaging - unsorted	Input	-0,9* unsorted	g	treatment of waste paperboard, municipal incineration | waste paperboard | Cutoff, U - Europe without Switzerland
Waste lid	Input	-2,86*total	g	treatment of waste polystyrene, municipal incineration | waste polystyrene | Cutoff, U - Europe without Switzerland
Coffee served in cup	Output	300*total	mL	
Paper cup production				
Paper	Input	8,3	g	market for printed paper, offset | printed paper, offset | Cutoff, U - CH
Plastic coating	Input	0,5	g	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U - RER
Transport	Input	0,00249	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Paper cup	Output	1	Item(s)	
Lid production				

Polystyrene	Input	2,86	g	polystyrene production, high impact | polystyrene, high impact | Cutoff, U - RER
Transport	Input	0,00037	t*km	transport, freight, lorry, all sizes, EURO3 to generic market for transport, freight, lorry, unspecified | transport, freight, lorry, unspecified | Cutoff, U - RER
Plastic lid	Output	1	Item(s)	
Packaging				
Boxboard	Input	0,9/1000	kg	folding boxboard production | folding boxboard/chipboard | Cutoff, U - RER
Packaging film	Input	1,05	g	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U - RER
Packaging	Output	1	Item(s)	

9.2 Contacts

Email Allesbecher

Allesbecher.de
An:
AW: Coffe-To-Go Becher

Neue Kontaktinformationen in dieser E-Mail: Allesbecher. de |

Sehr geehrte Frau

die Becher werden in Polen hergestellt. Der passende Deckel in Deutschland.
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An:
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Sehr geehrte Frau

herzlichen Dank für Ihre Anfrage. Die Porzellanbecher werden in Tschechien gefertigt und die Deckel in der Schweiz.

Für Fragen erreichen Sie mich jederzeit unter

Herzliche Grüsse

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