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Life cycle assessment of tap water: Analysis and comparison with other beverages

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Commissioner

Swiss Gas and Water Association (SVGW)

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Imprint

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Abstract

Drinking water is a basic necessity. We should drink at least two litres a day. But how can we satisfy this basic need in a manner that is as environmentally friendly as possible? What contribution can tap water make in this context? This is the topic of an in-depth study commissioned by the Swiss Gas and Water Association (SVGW). This study traces the entire life cycle from water catchment/extraction to serving it up in a glass in a life cycle assessment (LCA). Tap water is compared with mineral water and other beverages. The study shows that from an environmental point of view, tap water is preferable to bottled water as a beverage.

Abbreviations

CH	Switzerland
DE	Germany
FJ	Fiji
FR	France
IT	Italy
SVGW	Swiss Gas and Water Association
SWG	Seeländische Wasserversorgung
UBP	Eco-points according to the Swiss ecological scarcity method
ZH	Zurich

Summary

The Swiss Gas and Water Association (SVGW) has commissioned a life cycle assessment study to analyse the environmental impacts of tap water and compare it with mineral water and other beverages. The study investigates the life cycle from cradle to grave. Thus it starts with the water catchment, includes purification, storage and pumping. Furthermore the necessary installations in the private household and individual treatment of tap water in the household are included. For beverages, the life cycle includes the agricultural production of raw materials, processing, packaging, distribution and transportation up to the private household.

The functional unit for the comparison is 1 litre (1kg) of the beverage ready for consumption. The glass and treatment of urine is not included in the system boundaries. Environmental impacts are evaluated with the ecological scarcity method 2013. This method allows summarizing different types of environmental impacts to one final score. In this method, the weighting of different kinds of impacts is based on legislative goals in Switzerland.

The analysis of results shows that the infrastructure and ductwork represent a considerable share of the impacts for tap water. Thus, it is important to maintain and construct the necessary installations in an environmentally sound manner. Another important factor is the electricity use for pumping water which is necessary for its distribution to the final consumer.

Environmental impacts of tap water represent only a small share compared to these of mineral water in the direct comparison of unchilled beverages. Also for chilled and carbonized water, the impacts of tap water are only an eighth compared to mineral water. Other beverages such as milk, orange juice, coffee or beer cause much higher impacts than mineral water.

From an environmental point of view tap water is the most environmentally friendly beverage. For mineral water, transporting from the source to the private household is the most important factor to be considered. For some other beverages like juices the agricultural production of raw materials dominates the environmental impacts.

If drinking water is set in relation to total environmental impacts of consumption than it is of minor importance. Thus, e.g. drinking tap instead of mineral water as one example can lead only to a small reduction of environmental impacts compared e.g. to eating less meat or driving less with the car. The highest reduction potential in the area “water” has been found for saving a quarter of present tap water consumption. This could reduce the total environmental impacts of the Swiss consumption by about 0.5%. The broader view on the area water shows that heating water and treatment of polluted water is much more relevant than the impacts due to the supply of tap water.

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1 Introduction

Drinking water is a basic necessity. We should drink at least two litres a day. The water can be provided to consumers directly from the tap or it can be bottled and transported home. Furthermore there are many more beverage options to satisfy thirst.

But how can we satisfy this basic need in a manner that is as environmentally friendly as possible and what contribution can tap water make in this context? This is the topic of an in-depth study commissioned by the Swiss Gas and Water Association (SVGW).

Average tap water consumption has dropped slightly during the past couple of years, after rising slowly but steadily until well into the 1980s. Today 142 litres of tap water is consumed on average per person and day in private households in Switzerland. Of this amount, only a small fraction is drunk.

The per capita consumption of bottled mineral water in Switzerland has grown continuously until 2003. From 2003 until 2007 it was stable at around 120 litres per year and capita. In 2011 it dropped and is currently amounting to 111 litres per year. Imports of bottled water have more than tripled during the past decade, now accounting for almost one third of Swiss consumption of bottled water.

ESU-services Ltd. investigated the environmental impacts of tap water and compared it with mineral water for the first time in a life cycle assessment study (LCA) in 2005 [1, 2]. In 2014 the SVGW has commissioned an in-depth update and extension of this study for the reference year 2013 [3]. Here we translate the summary of this study [4].

An LCA is a method for assessing the environmental impact associated with a product. The environmental impact is examined throughout a product's entire life cycle from cradle to grave, i.e. from resource extraction, production and usage until the disposal of the product and production waste. Here we conducted a comparative study which is following most of the basic rules laid down in ISO 14040ff [5].

2 System boundaries

The LCA investigates a range of different scenarios for the provision of tap water, mineral water and other beverages for drinking. The basis of comparison is 1 litre (1 kg) of beverage available to consumers for drinking.

In this study the entire life cycle of the beverage is traced from water catchment/extraction to serving it in a glass (Fig. 1). This includes water catchment/extraction or production of agricultural raw materials, treatment, bottling or processing, packaging as applicable, distribution via wholesale and retail channels, transportation home, distribution via water pipes including the requisite infrastructure, plumbing; and treatment at the consumption site (house installations, refrigeration, soda maker, etc.).

The assessment does not include the drinking receptacle (glass, cup) or disposal of the flushed toilet water as it is assumed that these two stages do not differ for the different scenarios investigating the consumption of beverages.

The LCA is conducted for the situation in Switzerland, which might deviate from the situation in other countries e.g. because of different structure of water works or different types of packages used for beverages. Thus all conclusions in this study are only valid for this country.

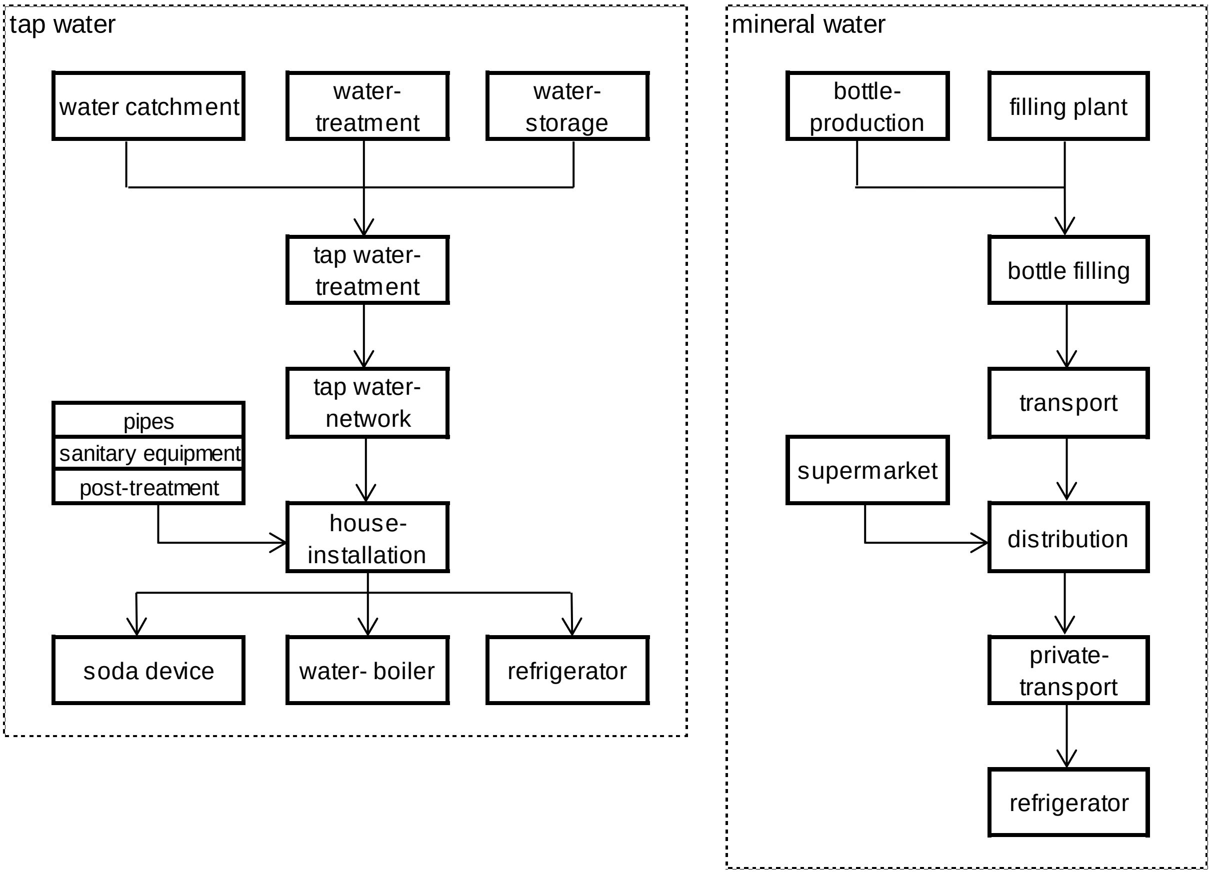

Fig. 1 Investigated life cycle stages for tap water and mineral water

3 Life cycle inventory data

In the study, life cycle inventory data is collected on material and energy flows for all essential process steps. As to including background processes in the LCA, e.g. sewage disposal, packaging materials, transportation and construction materials, data is taken from the ecoinvent database v2.2 and updates publicly available [6, 7].

The following areas were taken as examples for tap water supply: an urban area (the city of Zurich (ZH)) and a rural area (Seeländische Wasserversorgung (SWG), a regional water supply facility located in the Canton of Bern). Furthermore the average supply in Switzerland (CH) is investigated. A series of scenarios were analysed for the use of tap water as a beverage (Tab. 1). This always includes some losses with first running of tap water e.g. because of waiting for cooler or fresher water and for cleaning the containers.

Scenarios 1 to 5 examine the impacts of consumer behaviour (cooling in a refrigerator or water dispenser, soda maker) as based on the Swiss water supply. Various water supplies are compared with each another in scenarios 1, 6, 7. In scenario 8, boiled water is investigated. Scenario 9 considers warm water with 40°C used e.g. for hand washing and mixed from hot and cold water at the tap. Scenario 10 considers the delivery of water from the tap without the first running.

Tab. 1 Scenarios investigated for the provision of tap water as a beverage

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9	Scenario 10
	TW, at tap, CH	TW, chilled, at tap	TW, carbonized, chilled, at soda device	TW, carbonized, at soda device	TW, chilled, at water dispenser	TW, at tap, SWG	TW, at tap, ZH	TW, boiling, at boiler	TW, 40°C, at tap	TW, direct at tap
Region	CH	CH	CH	CH	CH	SWG	ZH	CH	CH	CH
Provision	tap	tap	soda device	soda device	water dispenser	tap	tap	boiler	tap	tap
Carbonation	still	still	carbonized	carbonized	still	still	still	still	still	still
First running	no	yes	yes	yes	no	no	no	no	no	no
Temperature	unchilled	chilled	chilled	unchilled	chilled	unchilled	unchilled	boiling	40°C	unchilled

The consumption of bottled mineral water is examined using the following scenarios: production in Switzerland (CH) and imported from several different countries, 1.5-litre PET bottles, 1-litre glass returnable bottles and gallons accommodating 18.9 litres, carbonated or non-carbonated, refrigerated or unrefrigerated. These distinguishing features were used to create the scenarios shown in Tab. 2. They cover the possible spectrum between minimum and maximum values without taking into consideration every product available in a Swiss supermarket.

For bottled water in gallons, a transportation distance by lorry of over 10 km to the consumer is assumed. The water is served via a water dispenser. Scenario 13 models a minimum situation with local mineral water consumed directly after purchase in the shop.

The data pertaining to bottled mineral water is based on various environmental reports and can be considered to be reliable. The LCA of packages is based on a series of studies and is thus well founded. For transporting mineral water to a shop in Berne (Switzerland), real transport distances for different well-known brands and origins have been investigated. The home transport is modelled with average data for purchasing in Switzerland considering the share and distance of common transport modes.

Tab. 2 Scenarios investigated for the provision of mineral water as a beverage

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
	MW, glass-RE, at restaurant	MW, PET	MW, gallon, at office	MW, PET, carbonated	MW, PET, chilled	MW, PET, carbonated, chilled	MW, chilled, gallon, at office
Production	CH	CH	CH	CH	CH	CH	CH
Transport truck [km]	162	162	162	162	162	162	162
Transport train [km]	42	42	42	42	42	42	42
Transport Schiff [km]	0	0	0	0	0	0	0
Distribution [km]	10	home transport	10	home transport	home transport	home transport	10
Carbonation	still	still	still	carbonated	still	carbonated	still
Temperature	unchilled	unchilled	unchilled	unchilled	chilled	chilled	chilled
Packaging	Glass-RE	PET-NON-RE	container	PET-NON-RE	PET-NON-RE	PET-NON-RE	container

	Scenario 8	Scenario 9	Scenario 10	Scenario 11	Scenario 12	Scenario 13
	MW, production mix CH	MW, PET, Production FR	MW, PET, Production IT	MW, PET, Production GB	MW, PET, Production FJ	MW, PET, at shop
Production	mix	FR	IT	UK	FJ	CH
Transport truck [km]	373	325	547	1204	510	50
Transport train [km]	45	0	130	0	0	0
Transport Schiff [km]	102	0	0	0	20330	0
Distribution [km]	home transport	home transport	home transport	home transport	home transport	none
Carbonation	Mix	still	still	still	still	still
Temperature	unchilled	unchilled	unchilled	unchilled	unchilled	unchilled
Packaging	PET/Glass	PET-NON-RE	PET-NON-RE	PET-NON-RE	PET-NON-RE	PET-NON-RE

RE Returnable bottle

NON-RE Non-returnable bottle

The data for other beverages such as milk, orange juice, apple juice, beer, ice tea, black tea, coffee and wine are based on the ESU data-on-demand [8-12]. All data include a typical packaging and the necessary distribution. They are evaluated for this LCA. For milk, juices, beer and ice tea chilled scenarios are used. For all beverages, assumptions similar to those for mineral water are used concerning chilling and home transportation.

4 Impact assessment

Environmental impacts are evaluated in this study with the ecological scarcity method 2013. This method allows summarizing different types of environmental impacts to one final score that is called eco-points. The relative importance of environmental problems is weighted based on legislative goals in Switzerland [13]. Within the detailed study [3] also results for the global warming potential and the cumulative energy demand are presented and discussed [14, 15].

4.1 Share of life cycle stages

Fig. 1 compares the direct provision of tap water with tap water chilled and carbonated for consumption as a beverage. The house installation is responsible for about 40% of the impacts. The post-treatment of tap water in the house accounts for about 9% of total impacts. Sanitary equipment and pipes are other important factors for the house installation. Energy use for central treatment and pumping and also the distribution network are additional important stages in the provision of tap water.

The picture changes totally if carbonization and chilling are included in the assessment. These two processes contribute each 40 - 50% to the total impacts. Thus the relative importance of process stages and the total impacts vary with the way how tap water is used and consumed.

For average mineral water according to scenario 8, home transportation has a share of 40% of total impacts (Fig. 4). Here a car transport of 4.5 km for 12 kg of purchases is the most important factor in the average scenario for home transportation. The transport between source and supermarket, which is about 500 km in average, accounts for one quarter of the environmental impacts of average mineral water.

Chilling and the bottle each account for one fifth of the total impacts. The type of packaging can influence the environmental impacts of beverages. For short distances, it is preferable to use a refillable bottle. For longer distances, PET bottles might be better due to their lower weight compared to glass bottles. Impacts of transportation are not linear with the distance. The mode of transportation is very relevant. The impacts of mineral water from Fiji were expected to be much higher, but since it is assumed that the bottles are transported for the main part of the distance with very efficient container ships, the difference is not that big. The long distance transport from Fiji to Genoa has about the same impacts as a truck transport over 1’400 km. Carbonized mineral water has only slightly higher impacts than still water.

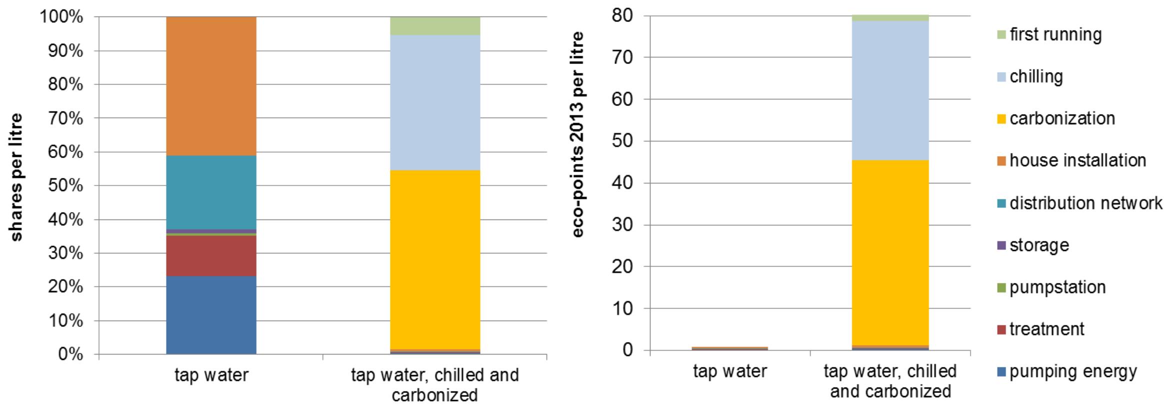

Fig.1 Share of process stages in the provision of tap water for total environmental impacts according to the ecological scarcity method 2013

4.2 Comparison of carbonized water

The comparison of carbonized beverages in Fig. 2 shows clear advantages for the use of soda devices to carbonize tap water compared to the purchase of carbonated mineral water. The main aspects for mineral water are transports and bottles. This is also visible in Fig. 2, were the air emissions of trucks cause considerable impacts in the areas of global warming and main air pollutants. A prerequisite for the reduction of environmental impacts with a soda device is its usage frequency. Here it was calculated with 2 litres per day and a life time of the device of 5 years. It the device is used less frequently, the impacts would be higher.

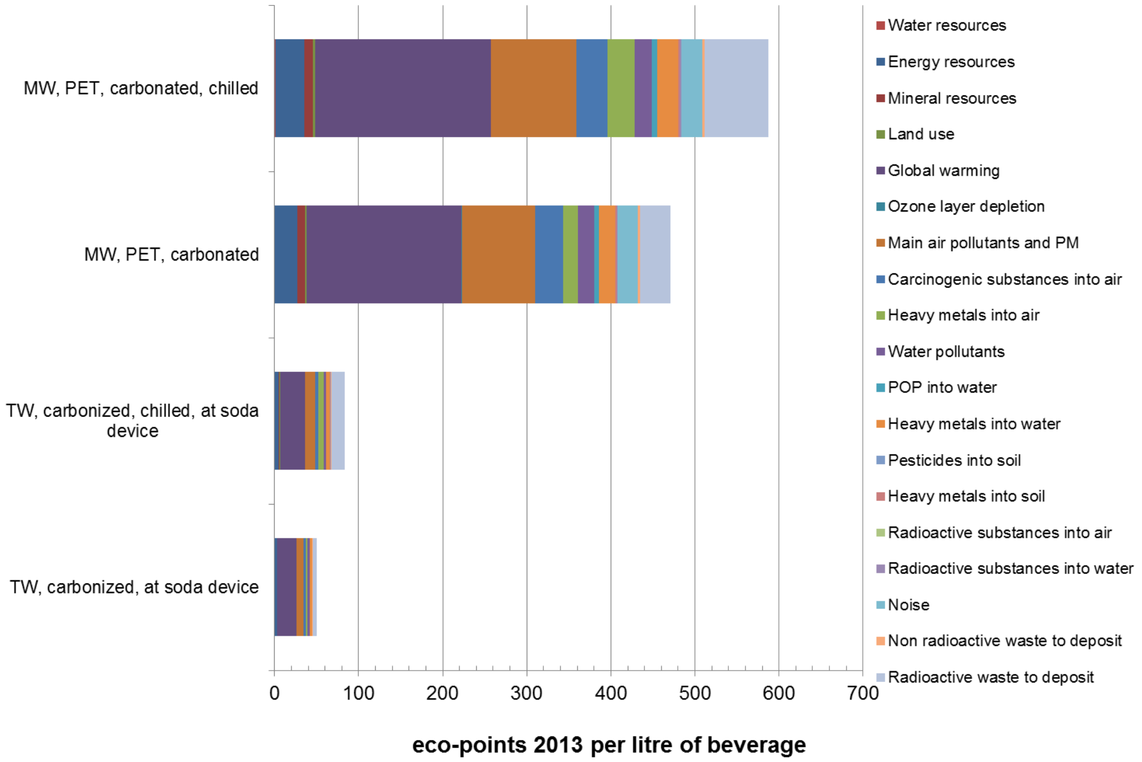

Fig. 2 Comparison of different scenarios for the provision of carbonized water with the ecological scarcity method 2013 (MW – mineral water, TW – tap water)

4.3 Comparison of still beverages

Tap water is the most environmentally friendly option even if it is compared with a range of different still beverages (Fig. 4). Impacts between different tap water suppliers in Switzerland differ. A relevant factor is the length of the distribution network and differences in the electricity consumption.

The average mineral water causes impacts that are about 450 times higher than the impacts of Swiss tap water. Environmental impacts of tap water without carbonisation are remarkable lower compared to the carbonized version. For mineral water, there is not a large difference between the still and carbonized option.

Most other beverages cause higher impacts than the mineral water. Black tea prepared from boiling tap water is an option with impacts between tap and mineral water. Coffee has considerable higher impacts per litre due to the higher impacts in its agricultural production and the necessary processing. For all beverages produced from agricultural raw materials, the impacts are higher than for mineral water since impacts from agriculture have to be added to those of packaging and transportation. The highest impacts have been found for red wine (more than 9500 eco-points per litre). This is mainly due to the use of copper and pesticides in the grape production.

It has to be kept in mind that the beverages compared here do not fulfil the same function. While tap and mineral water mainly satisfy the thirst, other options might also provide nutritional value (e.g. vitamins in fruit juice or proteins in milk). Alcoholic beverages are rather used for pleasure.

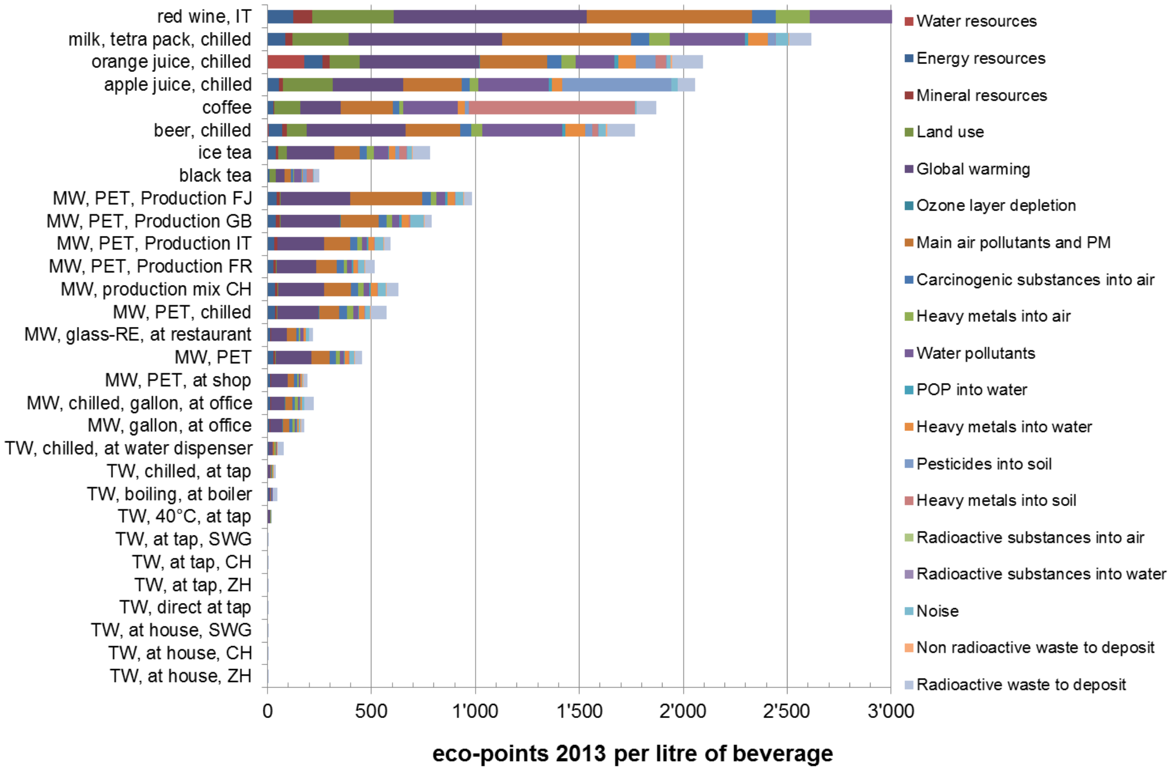

Fig. 4 Comparison of different scenarios for the provision of still beverages with the ecological scarcity method 2013

4.4 Relevance of beverages and water compared to total consumption

Tab. 3 shows the environmental impacts in relation to the total environmental impacts caused per capita in Switzerland [16]. In this case we use the ecological scarcity method 2006 instead of the version 2013 in order to allow comparability with former investigations about impacts of production and consumption [17]. This assessment shows the relevance of the present consumption of warm and cold tap water. Therefore a daily consumption of 142 litres is used as a basis. Warm water accounts for about 50 litres per day.

The evaluation shows that the waste water treatment is more relevant from an environmental point of view than the tap water supply. Also warm water heating in the household is more relevant than the supply of water.

Mineral water and tap water consumption have about equal impacts, because the much higher amount of tap water levels with the higher specific impacts of mineral water, i.e. impact per litre. The “water-related” impacts account for about 2.4% of total environmental impacts due to the consumption patterns of Swiss households.

It has to be noted that Tab. 3 (and Tab. 4) only consider the central warm water supply, but not cooking of water e.g. for tea, coffee or meals. Also heating of water in washing machines and dish washers is not yet included in this assessment. Taking this into account, impacts of heating would even be higher than assumed here.

Tab. 3 Relevance of water related impacts compared to total environmental impacts of consumption in Switzerland

eco-points 2006 per person and year	present situation	share	amount (litre/a)
tap water use	40'128	0.2%	51'830
water heating	174'648	0.9%	17'276
waste water treatment	201'243	1.0%	51'830
consumption of mineral water	63'053	0.3%	111
total impacts related to water	**479'072**	**2.4%**	**-**
total impacts of consumption	20'000'000	100%	-

4.5 Reduction potentials

The annual environmental impacts due to the use of tap and mineral water are shown in Tab. 4 together with possible reduction potentials. The methodology for calculating the reduction potentials has been developed by ESU-services for different projects [18, 19]. The highest reduction potential could be achieved by a 25% reduction of the tap water consumption using e.g. water saving installations and appliances. By doing so, the total environmental impacts in Switzerland could be reduced by 0.5%. Drinking tap water instead of mineral water would reduce the total impacts by about 0.3%. A reduction of the warm water consumption by 25% could potentially reduce the total impacts by 0.4%. Adding these different options would lead to a potential reduction of 1.1% of total environmental impacts per person (or 47% of the water related impacts).

Tab. 4 Reduction potentials of different behavioural changes related to water consumption

eco-points 2006 per person and year	present situation	saving water	tap instead of mineral water	cold instead of warm water	combination of options
In relation to the impacts related to water	479'072	-20%	-13%	-18%	-47%
In relation to total environmental impacts	20'000'000	-0.48%	-0.31%	-0.44%	-1.12%

5 Summary and discussion

Tap water is the most environmentally friendly beverage and food product. This is the main result of the life cycle assessment of different beverages conducted for the SVGW. Unchilled and still mineral water causes about 450-times the environmental impacts of drinking tap water. Cooling and carbonization increases the environmental impacts of tap water considerable, but still it causes less impacts than the comparable mineral water options bought in a shop. Thus carbonization in a soda device is the recommended option if the consumers like this type of water more. For such positive results the device should be used frequently (at least for 1 litre a day) and over a reasonable period (more than five years) in order to pay-back the environmental investment for its production.

The origin and thus transports are more relevant than the packaging of mineral water. Thus, mineral water coming from nearby is preferable compared to mineral water transported over longer distances. Refillable bottles and containers only make sense if they are not transported over long distances. Bringing purchased beverages home can be very relevant if a car is used for transportation.

The consumption of tap and mineral water is responsible for only a very small share of total impacts due to consumption. Thus, a replacement of mineral water with tap water or reducing the use of tap water would only slightly decrease the total environmental impacts in Switzerland. But, food and beverages often lead to discussions about general environmental aspects. Thus, recommendations for shorter transport distances, less use of private cars or efficient cooling are valid for all types of food purchases and they are not only relevant for the consumption of water.

In a more general discussion it has been shown that reducing the consumption of animal products has the highest potentials for reducing environmental impacts of nutrition [18]. High potentials exist also for reducing impacts of private mobility and heating of homes. This should be taken into account while discussing the reduction potential in the area of drinking beverages.

A further relevant aspect is the heating of warm water in households. A reduction of the used warm water (e.g. taking a shower instead of a full bath, lower temperatures for washing and hand washing with cold water) can reduce the environmental impacts much more than a reduction of the cold water use.

For the operators of water supply networks and for house owners the following recommendations can be derived from this study. The infrastructure and especially the distribution network are quite relevant for the water supply. Installations in the consumer's house also have a remarkable share of the total impacts due to tap water supply. Thus, environmentally friendly materials and processes should be used during construction and maintenance of this infrastructure. Further important issues are the electricity use for pumping and the loss of water. Losses of water increase the impacts per m^3 of water sold. Internal use e.g. for public water sources are counted as losses in this study. This makes it difficult to directly compare the different water suppliers investigated in this study.

The system boundaries of this study are only valid for Switzerland. The situation in other countries might be quite different. Thus, e.g. the impacts form electricity use and the necessary pumping energy for tap water differs between different countries. The distance between the water source and the consumer can be different. Also systems used for beverage bottles are not the same. In Germany, e.g., a refill system for PET-bottles is common while this is not known in Switzerland.

Comparing the results of the updated study with the first version published in 2006 [2] shows generally higher results for both options. This is not caused by an increase of certain energy or material uses in the life cycle. It is mainly due to a more complete investigation of environmental impacts. For tap water, the installations in the house have been investigated in more detail. For mineral water, the study shows that the home transportation is a quite relevant factor. Thus the higher impacts compared to the former study are not an indicator for a worse situation.

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