Comparison of the Environmental Impact of Drinking Water vs. Bottled Mineral Water

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Impressum

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Management Summary

Drinking water is a basic necessity. We should drink at least two liters a day. But how can we satisfy this basic need in an as environmentally friendly manner as possible and what contribution can tap water make in this connection? This is the topic of the present 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). Different variants are compared with one another, e.g. carbonated vs. non-carbonated (CO_2), refrigerated vs. unrefrigerated, etc.

A direct comparison of drinking water from the tap with unrefrigerated bottled water shows an environmental impact of tap water which is less than one percent of that of bottled water. Even when refrigerated and carbonated, the environmental impact of tap water is approximately only one fourth of that of bottled water. Thus, from an environmental point of view, tap water is preferable to bottled water as a beverage.

1 Introduction

Drinking water is a basic necessity. We should drink at least two liters a day. But how can we satisfy this basic need in an as environmentally friendly manner as possible and what contribution can tap water make in this connection? This is the topic of an in-depth study commissioned by the Swiss Gas and Water Association (SVGW) (Jungbluth & Faist Emmenegger 2005).

Average drinking water consumption has dropped slightly during the past couple of years, after rising slowly but steadily until well into the 1980s. Today ca. 162 liters of drinking water is consumed on average per person and day in private households in Switzerland. Of this amount, only a fraction is drunk.

The per capita consumption of bottled mineral water in Switzerland has grown continuously during the past couple of years, currently amounting to approximately 130 liters/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.

There have been only a handful of detailed studies published to date which delve into the various aspects pertaining to the environmental impact of bottled water vs. tap water caused as the result of production, packaging and transportation. In the study at hand, various waters are analyzed by way of a Life Cycle Assessment (LCA) or Life Cycle Impact Assessment (LCIA).

An LCA is a method for assessing the environmental impact associated with a product. In so doing, the environmental impact is examined throughout a product's entire life cycle from cradle to grave, i.e. from resource extraction, production and usage to disposal of the product and production waste.

2 Goal of the Study and System Description

ESU-services was commissioned by the Swiss Gas and Water Association (SVGW) to perform a well-founded LCA analyzing and comparing the environmental impact of bottled water vs. tap water.

The main focus of the study is devoted to a direct comparison of tap water vs. bottled mineral water. This involves juxtaposing comparable variants for each scenario. Other aspects like an in-depth analysis of the water supply, comparison of various beverage packages, or optimizing logistics concepts are not covered in the study.

The basis of comparison is 1 liter (1 kg) of beverage available to consumers for drinking. In so doing, the LCA does not make any comparative statements with regard to the positive or negative effects on health of substances contained in the water. Consequently, it is assumed that both alternatives are equally suitable for consumers to quench their thirst.

In the study the entire life cycle of tap and bottled water is traced from water catchment/extraction to serving it up in a glass. This includes water catchment/extraction, treatment; bottling including 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 (refrigeration, soda water 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 process steps do not differ for the different variants.

The following evaluation methods are applied in assessing the computed pollutant emissions and resource consumption:

- Cumulative primary energy consumption: nuclear, fossil and hydrology resources, however excluding biological and other renewable resources like wind, solar and geothermal energy (Frischknecht et a. 2004); the cumulative primary energy consumption is converted into COE to facilitate comparison.
- Climate change potential within 100 years (greenhouse emissions, IPCC 2001) for describing the potential impact of provisioning beverages on the climate.
- Environmental impact points (EIPs) 1997 (Brand et al. 1998): assessment method which performs a weighting of various contaminants, resources and waste on the basis of Swiss environmental policy objectives.
- Eco-indicator 99 H/A (Goedkoop & Spriensma 2000): assessment method in which the various contaminants and resources are weighted with regard to the damage caused by them to the environment and health.

3 Life Cycle Inventory Data

In the study, 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 current ecoinvent database (ecoinvent Centre 2004).

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). These water supply networks can be considered somewhat representative for the situation in Switzerland (CH). A series of variants were analyzed for the use of tap water as a beverage (Tab. 3.1).

Variants 1 to 5 examine the impacts of consumer behavior (refrigeration in a refrigerator or water dispenser, soda water maker[1]) as based on the Swiss water supply. Various water supplies are compared with one another in variants 1, 6, 7, 8.

Tab. 3.1 Variants in Assessing the Consumption of Tap Water in Private Households

	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6	Variant 7	Variant 8
Region	CH	CH	CH	CH	CH	SWG	ZH	RER
Source/ dispenser	Tap	Tap	Soda water maker	Soda water maker	Water dispenser	Tap	Tap	Tap
Carbonation	Non-carbonated	Non-carbonated	Carbonated	Carbonated	Non-carbonated	Non-carbonated	Non-carbonated	Non-carbonated
Wash-up	No	Yes	Yes	Yes	No	No	No	No
Temperature	Unrefrigerated	Refrigerated	Refrigerated	Unrefrigerated	Refrigerated	Unrefrigerated	Unrefrigerated	Unrefrigerated
Process name	Drinking water, CH, non-carbonated, unrefrigerated, from tap	Drinking water, CH, non-carbonated, refrigerated, from tap	Drinking water, CH, carbonated, refrigerated, from soda water maker	Drinking water, CH, carbonated, unrefrigerated, from soda water maker	Drinking water, CH, non-carbonated, refrigerated, from water dispenser	Drinking water, SWG, non-carbonated, unrefrigerated, from tap	Drinking water, ZH, non-carbonated, unrefrigerated, from tap	Drinking water, RER, non-carbonated, unrefrigerated, from tap

Wash-up = Washing the drinking bottle when refrigerating water in a refrigerator vs. using a soda water maker

The consumption of bottled mineral water is examined using the following variants: production in Switzerland (CH) or Europe (RER), 1.5-liter PET bottles, 1-liter glass returnable bottles and jugs accommodating 18.9 liters each capable of being reused 50 times, carbonated or non-carbonated, transportation scenarios, refrigerated or unrefrigerated. These distinguishing features were used to create the scenarios shown in Tab. 3.2. They cover the possible spectrum between minimum and maximum values without taking into consideration every product available in a supermarket.

The data pertaining to bottling mineral water is based on various environmental reports and can be considered to be relatively reliable. The LCA of packages is based on a series of studies and thus is relatively well founded. As to transportation, minimum and maximum scenarios were estimated. However, the actual average transportation costs are not known.

As to bottled water in jugs, a transportation distance by lorry of over 10 km to the consumer is assumed. The water is served via a water dispenser. In variants 6 and 9, the bottled mineral water is assumed to be transported home by car, with a distance of 5 km being posited for each purchase of 36 liters of water. The other variants assume transportation home on foot or via a bicycle. Variant 9 represents a maximum estimate with regard to environmental impact. Variant 10 contains an estimate for the average situation pertaining to the consumption of bottled water.

[1] The soda water maker is a countertop model without refrigeration, requiring CO_2 cylinders.

Tab. 3.2 Variants in Computing the Consumption of Bottled Mineral Water in Private Households

	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6	Variant 7	Variant 8	Variant 9	Variant 10
Production site	CH	CH	CH	CH	CH	CH	CH	RER	RER	CH/RER
Transportation, lorry	50	50	50	50	50	50	50	1000	1000	200
Transportation, car, delivery van	-	-	10	-	-	5	10	-	5	-
Carbonation	Non-carbonated	Non-carbonated	Non-carbonated	Carbonated	Non-carbonated	Carbonated	Non-carbonated	Non-carbonated	Carbonated	Non-carbonated
Temperature	Unrefrigerated	Unrefrigerated	Unrefrigerated	Unrefrigerated	Refrigerated	Refrigerated	Refrigerated	Unrefrigerated	Refrigerated	Unrefrigerated
Packaging	Glass RE	PET NON-RE	Jug	PET NON-RE	PET NON-RE	PET NON-RE	Container	PET NON-RE	Glass RE	PET/glass
Process name	Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, glass RE, in private household	Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, PET NON-RE, in private household	Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, jug, in private household	Bottled mineral water, produced in CH, carbonated, unrefrigerated, PET NON-RE, in private household	Bottled mineral water, produced in CH, non-carbonated, refrigerated, PET NON-RE, in private household	Bottled mineral water, produced in CH, carbonated, refrigerated, PET NON-RE, in private household	Bottled mineral water, produced in CH, non-carbonated, refrigerated, jug, in private household	Bottled mineral water, produced in RER, non-carbonated, unrefrigerated, PET NON-RE, in private household	Bottled mineral water, produced in RER, carbonated, refrigerated, glass RE, in private household	Bottled mineral water, produced in CH/RER, non-carbonated, unrefrigerated, PET/glass, in private household

RE Returnable bottle

NON-RE Non-returnable bottle

4 Impact Assessment

4.1 Drinking Water Provisioning

The analysis of the key inputs for the Zurich water supply is shown in Fig. 4. The environmental impact of drinking water supply is determined by power requirements and by the requisite infrastructure, i.e. pipe distribution network and plumbing. By contrast, the machinery and equipment used in water treatment is less relevant in this context. The power consumption figures are relatively accurate. By contrast, there is substantial uncertainty as concerns the infrastructure with regard to the actual amounts of materials used, construction expenses and service life. The key factor for assessment using the Eco-indicator 99 H/A method is the consumption of primary energy resources and some pollutants like particulate, NOx and SOx emissions.

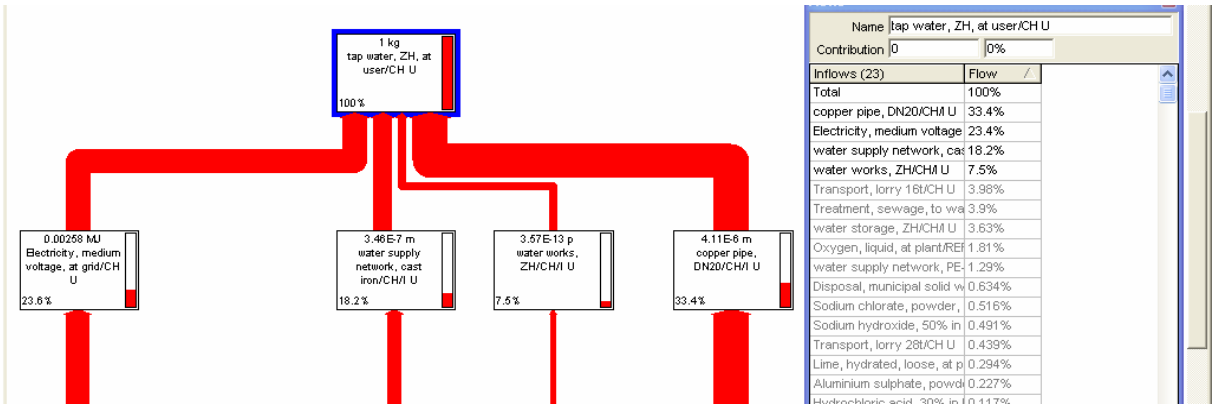

Fig. 4.1 Key Inputs for the Drinking Water Supply in Zurich Analyzed Using Eco-indicator 99 H/A Methodology

4.2 Overview of Findings

Tab. 4.1 shows an overview of the findings obtained for all variants using the four assessment methods and conversion to Crude Oil Equivalent (COE). For example, ca. 320 ml COE per

liter is consumed for bottled mineral water transported over an extended distance to the consumer. By contrast, the COE value for tap water is only 0.3 ml, i.e. approximately one thousandth of this amount.

In this assessment, two water supply networks are examined in detail with regard to the Swiss average and mean environmental impact. However, since comparatively little use is made of home soda water makers and CO_2 is delivered to customers in small cylinders, carbonation increases the overall environmental impact of tap water relatively substantially. Refrigerating tap water also results in a substantial increase in environmental impact per liter.

The environmental impact of bottled mineral water is essentially determined by refrigeration, packaging and transportation. Other expenses at the production site and in the wholesale and retail channels are relatively insignificant. There are no major differences with regard to packaging. Returnable bottles and jugs result in somewhat better results for short distances. However, the higher weight of glass bottles when transported over extended distances results in an on the whole higher environmental impact as compared to PET bottles. Carbonated mineral water possesses only a marginally higher environmental impact than non-carbonated water. Refrigeration in a refrigerator or using a water dispenser increases the environmental impact somewhat.

Tab. 4.1 Overall Assessment of the Different Variants Applying the Methods *Cumulative Primary Energy Consumption*, *Greenhouse Emissions*, *Eco-indicator 99 H/A* and *Environmental Impact Points 1997*. All figures based on per liter of water.

	Cumulative primary energy consumption	COE	Greenhouse emissions	Eco-indicator 99 H/A	EIPs 1997
	MJ eq	dl of oil	kg CO2 eq	Pts.	Pts.
Drinking water, CH, non-carbonated, unrefrigerated, from tap	0.0106	0.003	4.36E-4	3.93E-5	1.1
Drinking water, RER, non-carbonated, unrefrigerated, from tap	0.0108	0.003	6.16E-4	3.92E-5	1.0
Drinking water, SWG, non-carbonated, unrefrigerated, from tap	0.0132	0.004	4.27E-4	4.12E-5	1.2
Drinking water, ZH, non-carbonated, unrefrigerated, from tap	0.0136	0.004	4.06E-4	3.47E-5	1.1
Drinking water, CH, carbonated, unrefrigerated, from soda water maker	0.593	0.160	3.98E-2	2.02E-3	35.6
Drinking water, CH, non-carbonated, boiling, from electric kettle	1.070	0.288	1.65E-2	9.31E-4	46.2
Drinking water, CH, non-carbonated, refrigerated, from tap	1.490	0.401	2.88E-2	1.86E-3	66.1
Drinking water, CH, non-carbonated, refrigerated, from water dispenser	1.730	0.466	3.34E-2	2.04E-3	75.6
Drinking water, CH, carbonated, refrigerated, from soda water maker	2.040	0.549	6.61E-2	3.72E-3	98.5
Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, jug, in private household	1.860	0.501	8.98E-2	6.98E-3	98.6
Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, glass RE, in private household	2.410	0.649	1.07E-1	9.44E-3	123.0
Bottled mineral water, produced in CH, non-carbonated, refrigerated, container, in private household	3.390	0.912	1.11E-1	8.13E-3	162.0
Bottled mineral water, produced in CH, non-carbonated, unrefrigerated, PET NON-RE, in private household	4.230	1.139	1.78E-1	1.48E-2	183.0
Bottled mineral water, produced in CH, carbonated, unrefrigerated, PET NON-RE, in private household	4.350	1.171	1.98E-1	1.53E-2	195.0
Bottled mineral water, produced in CH/RER, non-carbonated, unrefrigerated, PET/glass, in private household	4.380	1.179	2.01E-1	1.82E-2	223.0
Bottled mineral water, produced in CH, non-carbonated, refrigerated, PET NON-RE, in private household	5.680	1.529	2.04E-1	1.65E-2	246.0
Bottled mineral water, produced in CH, carbonated, refrigerated, PET NON-RE, in private household	7.400	1.992	3.19E-1	2.45E-2	341.0
Bottled mineral water, produced in RER, non-carbonated, unrefrigerated, PET NON-RE, in private household	8.340	2.245	4.25E-1	4.24E-2	508.0
Bottled mineral water, produced in RER, carbonated, refrigerated, glass RE, in private household	11.800	3.176	6.18E-1	6.07E-2	771.0

4.3 Overall Comparison — Tap Water vs. Bottled Water

In Fig. 4.2 a relative comparison is made of the environmental impact of bottled mineral water vs. tap water. The figures show how high the environmental impact of the tap water variant is in relation to the bottled water variant. On the whole, the various methods produce similar results with relatively large absolute differences among the different variants for the provisioning of tap water vs. bottled water.

Unrefrigerated, non-carbonated bottled water makes for an environmental impact between 90 and 1000+ times that of tap water. The difference becomes more pronounced the farther the bottled water has to be transported to the customer. Apart from the transportation distance from the bottling site to the consumer, the chosen modes of transportation are also highly significant. That is why traveling even short differences by car can play a major role.

As to refrigerated beverages, tap water leads to better results as compared to bottled water. The relative difference here is less, amounting to approximately one fourth to 50% of that of bottled water.

The comparison of various carbonated beverages points to advantages associated with the use of soda water makers as compared to carbonated mineral water. When comparing unrefrigerated, carbonated tap water with bottled mineral water, the environmental impact of the latter is 5 to 8 times higher than that of the former.

On the whole, in all comparable variants, beverages based on tap water lead to better results than those based on bottled water. This finding also holds true when taking into account the limitation posed by exact figures being subject to larger fluctuation in part, since they are dependent on difficult-to-determine factors like consumer behavior. The exact transportation distances for bottled water cannot be determined with any accuracy due to the large number of different supplies. The conclusions are underpinned by the fact that rather conservative estimates were posited for drinking water, whereas for bottled water variants with minimal environmental impacts were also evaluated in cases of doubt.

Plain drinking water which is bottled, transported and sold like bottled mineral water doesn't provide for any ecological advantage as it also necessitates packaging and transportation by road or rail.

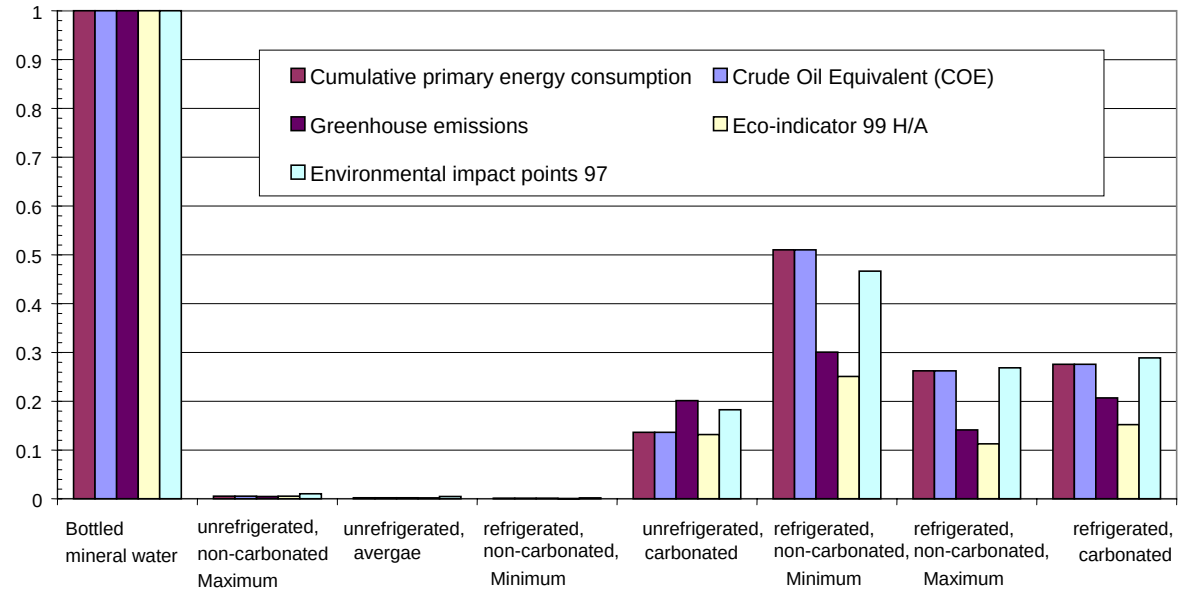

Fig. 4.2 Relative Comparison of the Environmental Impact of Bottled Mineral Water vs. Tap Water. The height of the bar indicates the environmental impact of the tap water variants as compared to the corresponding variant for bottled mineral water.

5 Recommendations

This life cycle assessment has been used to conduct, for the first time, a detailed study of different variants of tap water and bottled mineral water available in Switzerland. The findings can be directly translated into recommendations for consumers.

Thus, from an environmental point of view, tap water is generally preferable to bottled water as a beverage. However, refrigeration in a refrigerator or a water dispenser increases environmental impact substantially. If carbonated water is preferred for reasons of taste, a soda water maker is justifiable ecologically speaking. However, the unit and the associated CO_2 cylinders have to be used regularly (more than 1 liter/day) and over an extended period (> five years) before the purchase is amortized from an environmental (and financial) point of view.

If, as an exception, bottled water is consumed, its origin is much more relevant for its environmental impact than its packaging. Generally speaking, the distance between the bottling site to the consumer should be as short as possible. Only then is giving preference to returnable bottles or jugs a viable alternative.

As to refrigeration it is difficult to make clear-cut recommendations in favor of a specific equipment type. The decision in favor of the best unit depends on actual usage and power consumption. If a unit is already present (e.g. a refrigerator), purchasing an additional water dispenser increases power consumption substantially.

On the whole, dispensing with bottled water or reducing one's consumption of water leads to a relatively small contribution to lessening one's environmental impact as the consumption of water accounts for only a small portion of overall environmental impact. However, food and beverages are frequently a consumer's first point of departure in examining his or her

ecological behavior. The recommendations pertaining to short transportation distances, less refrigeration or economical use of resources also apply to other beverages (e.g. beer, wine, juices, etc.) or food and thus can attain greater significance.

The following tips can be derived from the evaluations for the owners and operators of water supply networks: The key environmental impact is caused by the infrastructure in general and pipes in particular. Environmentally friendly materials and processes should be used for new construction and maintenance, servicing and repair work. A key factor in this context is power consumption. Water lost in the distribution network and personal consumption can substantially increase a customer's environmental impact. Both should be reduced as much as possible.

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