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Environmental Impacts of Tap vs. Bottled Water

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Executive Summary

The systematic assessment of environmental impacts of tap and bottled water systems consistently show that bottling of water, transport, and disposal of bottles after use result in a wide range of adverse impacts that far exceed those linked to tap water. Continuing expansion of bottled water sales are a curiosity, since drinking water from municipal water systems (tap water) is reliably safe all across the United States and many other nations. Bottled water has been found to be no safer than tap water, and in some regions of the U.S., less reliably safe. Moreover, taste test results suggest that people cannot consistently distinguish between different brands of bottled water, or between tap and bottled water. We conclude that consumption of bottled water, outside of a public health or emergency situation, has a disproportionately high environmental impact in comparison to safe tap water sources. A reduction in the consumption of bottled water would reduce consumer expenses and significantly benefit the environment.

Key Findings from the Systematic Assessment of Impacts of Tap vs. Bottled Water Systems

Comprehensive life cycle assessments of tap water and bottled water systems consistently show large environmental impacts of bottled water. Comparisons of tap water with and without filtering, home/office delivery (HOD) water systems, and single-use bottled water systems have shown that:

- Single-use bottled water systems consume 11-90 times more energy than tap systems, with longer transport distances resulting in the greatest differences.
- For long-haul delivery, transport dominates energy consumption. In general, the greater the transport distance, the greater the impact.
- Tap water systems yield lower carbon emissions than bottled water systems, and by similar margins to lower energy consumption.
- Adverse impacts across a wide range of environmental impact measures (including eco-toxicity, potential for acidification, eutrophication, ozone depletion, and smog, and a range of human health indicators)[i] are substantially greater for bottled water systems than for tap systems.
- For locally sourced bottled water, bottle manufacturing dominates energy consumption.
- Because of high-energy-consumption in bottle manufacturing, the impact of small bottles of water (such as 6 or 8 ounce bottles) is higher than for larger bottles since the proportion of plastic to water is greater in a small bottle.
- The greatest consumption of energy in bottle manufacturing is in production of plastic resin.
- With bottled water systems, collection of discarded bottles for recycling[1], and transport of bottles to landfills adds to energy consumption and greenhouse gas emissions and other impact indicators.

[1] Plastic from those bottles that are recycled commonly goes into products other than bottles, such as plastic pipe, shopping bags, carpeting, and plastic packaging.

There is some good news regarding bottled water in that the weight of bottles (and plastic resin consumption per ton of bottles) has been considerably reduced in recent years. The result is that while plastic resin consumption continues to rise, the increase is considerably less than the rate of increase in bottled water consumption.

Strategies for Reducing Environmental Impacts

There are a number of things that individuals can do to reduce the environmental impact of bottled water consumption:

- Reduce consumption of bottled water.
- Obtain one or more durable, refillable bottles and develop a habit of filling with tap water and using in place of bottled water.
- At meeting venues or office gatherings provide tap water in pitchers or dispensers to attendees and do not provide bottled water as an alternative.
- Support placement of more drinking water fountains in public places.
- Support bottle deposit laws
- If you do purchase bottled water
    - Select brands bottled closest to home.
    - Avoid water bottled thousands of miles distant.
    - Avoid small (6-8 oz bottles)
    - Refill bottles with tap water for re-use.
    - Drink water contained in bottles to the last drop – discarding half-full bottles doubles the impact of the water consumed.
    - Place bottles in recycling bins once finished with them.

U.S. a World Leader in Bottled Water Consumption

In the United States tap water is safe virtually everywhere, yet the U.S. has the highest total consumption of bottled water in the world – 13.7 billion gallons in 2017. Per capita consumption in the U.S. ranked fourth behind Mexico (where tap water is not reliably safe), Thailand, and Italy.

Leadership in bottled water consumption translates to millions of tons of packaging to contain that water. In 2016 4.9 million tons of plastic bottles (exclusive of the liquid contents) were purchased by U.S. consumers, about half of which contained bottled water. Just under 30% of discarded bottles were collected for recycling, with the rest (over 3.4 million tons) mostly going to landfills.

Consumption of bottled water worldwide is growing at a rate of about 10% annually, with U.S. annual consumption growth at a lower, but nonetheless robust rate, of 4-5%. If these rates of growth were to continue, U.S. consumption would double within 15 years, and global consumption within 7 years. Significant increases in bottled water transport as well as bottle discards are all but certain in the years ahead without a change in consumer habits.

A Curious Situation

At a recent theater outing in St. Paul, Minnesota, 500ml (16.9 fluid ounce) bottles of water were selling for $3.00. And, they were being sold in close proximity to a public water fountain. At $3.00 per bottle, the water cost $22.72 per gallon. Had it been necessary to pay for water obtained from the drinking fountain, the cost would have been $0.0038 per gallon.* In other words, the bottled water cost 5,980 times more than water from the tap. The label identified the source as municipal bottled water. The label further identified the source as a small town in Indiana, about 550 miles from St. Paul.

Although the water was sold at a place where an inflated price could be expected, the price difference was stunning. Not as obvious were the environmental costs. At the bottling plant, water was put in a bottle made of petroleum-derived plastic, shipped, likely by truck, over 500 miles to St. Paul, unloaded in bulk at a warehouse, and then conveyed via a smaller truck to the theater, requiring consumption of energy at every step. The bottle itself likely had a 4-5% recycled content, and upon disposal had less than a 30% chance of being recycled. All of this for a drink of water to displace freely available locally sourced water of equal or superior quality.

It this situation, consumer willingness to pay thousands of times more for bottled water was perhaps driven by convenience or maybe fear of drinking from a public fountain. Bottles would also be easier to carry into the theater – something that is allowed.

So what could be done to reduce impacts in the future?

Theater patrons could

- bring their own refillable containers
- point out to theater management the impacts of bottled water, and particularly bottled water from distant locations, and request that steps be taken to reduce them.

The theater, recognizing the impact their water sales are having, could

- provide free water from concession stand dispensers (as many fast-foot restaurants currently do), or from dispensers placed throughout the lobby.
- add drinking fountains and upgrade to include refillable bottle spigots.
- source water bottled locally.

* $0.0038 is the per gallon cost of municipal water in the city of St. Paul, a city where the tap water is noted for its high quality and great taste.

Water Safety and Quality – Bottled vs. Tap

Numerous consumer surveys have identified a common perception that bottled water is safer than tap water. Those surveyed also often cite convenience and better taste. Yet, laboratory testing of bottled and tap water consistently finds little or no difference.

Water Safety

Tap Water

When public drinking water is compromised in some way because of catastrophic events, such as severe flooding, or improperly monitored and treated as in the recent Flint, Michigan situation, containerized water becomes a necessity. The same is true for ground water pumped from individual wells that might become contaminated. However, in normal

circumstances, drinking water from municipal water systems is reliably safe across the United States, with safety ensured by testing mandated by the Environmental Protection Agency (EPA) as required by the Clean Water Act. This Act requires the EPA to set national contaminant standards for drinking water and to establish regulations to ensure source water protection, treatment, monitoring, compliance, enforcement, proper waste water handling and treatment, and public access to water quality information.

Testing is required frequently to ensure adherence to water safety standards. The EPA requires coliform testing, for example, at least 60 times each month for systems serving 50,000 customers or more, and at least 420 times per month (about every 90 minutes) for systems serving 2.5 million or more. Testing is also required for giardia and cryptosporidium, for chemicals including arsenic, copper, lead, radionuclides, lead, and phosphorous, and for any residual disinfectant materials.

Bottled Water

Bottled water is regulated by a different set of standards than tap water, and the Food and Drug Administration (FDA) is the regulatory authority. Though different, both standards are for the most part viewed as ensuring safety of water for human consumption. One special circumstance in FDA requirements is a regulatory exemption for bottled water sold within the state in which it is bottled, provided that all materials used in making the bottle, the cap, the label, and shipping cases also originate from that state. In effect, very little water bottled in the United States escapes federal regulation. In addition to federal standards, forty states also require varying levels of oversight, with some state standards more rigorous than those of the FDA. And, in all states, the International Bottled Water Association oversees voluntary self-regulation by its members who produce about 80% of bottled water purchased in the U.S.

Concern about bottled water standards in 2009 led Congress to request the Government Accounting Office (GAO) to investigate differences in tap and bottled water standards. Findings of the investigation were that water bottling companies are not required to disclose as much information as municipal water utilities because of gaps in federal oversight authority. The problem stems from the fact that the FDA regulates bottled water as a food and cannot, by law, require laboratory testing or reporting of test results, even if violations of prescribed standards are found. Despite these findings, no changes have been made to FDA standards for bottled water.

In view of differences in standards, a 2014 University of Wisconsin study concluded that the quality of bottled water is less certain than the quality of tap water.

Water Quality

In that there is virtually no difference between the safety of tap and bottled water in the United States, the decision of which to drink rests largely on taste preference and convenience. With regard to taste, blind taste tests of various water brands against one another, and against tap water, have generally found that consumers cannot distinguish different bottled water brands from one another or bottled water from tap water.

Several publicized non-scientific tests, such as conducted by the ABC program "20/20", then later by ABC's "Good Morning America" found no clear preference of bottled water over tap

water. A recent test in the UK, as reported by "Business Insider", showed the same thing; in this case, an expensive brand of water imported from thousands of miles away scored dead last in taste tests, ranking below tap water from several different sources.

One of the more interesting taste tests was conducted by several professors at the American University of Paris. Using techniques similar to those employed in taste testing of wine and beer, 100 subjects were recruited to participate in three successive experiments. Four brands of bottled water as well as tap water from the city of Paris were used in the test. The bottled water was from among the 20 best tasting brands identified by a noted bottled water connoisseur, and also listed in the 2006 book "Fine Waters: A Connoisseur's Guide to the World's Most Distinctive Bottled Waters." In taste tests, participants scored no better than random chance at either distinguishing tap water from bottled water, or in matching descriptions provided by water experts to the various bottled waters used in the test. It was concluded that consumers appear largely indifferent, based on taste, to water from various sources, suggesting that taste cannot be a major reason why consumers purchase and pay more for bottled water than tap or for some brands of bottled waters than others.

Environmental Impacts of Drinking Water

Tap Water

As explained by the Centers for Disease Control, public drinking water systems use various methods to treat water before it is distributed. The four steps common to virtually all municipal water treatment systems are:

- **Coagulation and Flocculation**
  Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water[2]. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc.
- **Sedimentation**
  During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation.
- **Filtration**
  Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals.
- **Disinfection**
  After the water has been filtered, a disinfectant (for example, chlorine, chloramine) may be added in order to kill any remaining parasites, bacteria, and viruses, and to protect the water from germs when it is piped to homes and businesses.

Additional steps are employed as needed to remove specific contaminants.

[2] Chemicals used in this stage of water treatment are typically either aluminum or iron based, including aluminum sulfate, aluminum chloride, and sodium aluminate, or ferrous sulfate, ferric sulfate, ferric chloride, or ferric chlorite sulfate.

Once water is treated, it is pumped to holding tanks from which water is distributed to customers. When a consumer fills a glass from the tap, that glass is subsequently washed by hand or in a dishwasher, completing the cycle. All of these steps require chemical and energy inputs that result in environmental impact.

Bottled Water

Single Use Bottles

Bottling of water begins with production of plastic resins (primarily petroleum-derived and non-renewable) which are then shipped to bottling plants in the form of pellets for use in making bottles. Most are made of polyethylene terephthalate (PET), and have polypropylene (PP) caps and labels.

Water used to fill the bottles comes either from municipal water systems (approximately 50% of all bottled water) or from naturally occurring springs. Water from municipal systems is sometimes subjected to additional treatment, such as filtration and reverse osmosis. Minerals are sometimes added as well. Once bottled, water is then transported to distribution points which may be nearby or distant. Some brands are transported thousands of miles. Once at a retail store, bottles are again transported, this time by consumers. After the water is consumed, there is no need for washing of containers. Instead, bottles are discarded. Nationwide, 29.7% of these were collected for recycling in 2016, while most of the rest went to landfill. Environmental impacts result from each step in the process.

Home/Office Delivery (HOD) Containers

Steps involved in producing bottles and bringing them to market in home/office delivery containers are essentially the same as for one-use bottled water, including the need to transport water from the bottling site. However, in this case bottles are reused many times, reducing significantly the relative impact of energy used for bottle production per unit of water sold. Disposal issues are also largely eliminated. Such systems do require washing of bottles with each fill cycle.

Summary

In normal circumstances, drinking water from municipal water systems (tap water) is reliably safe all across the United States, with safety ensured by testing mandated by the EPA. While taste is not quantifiable, taste test results suggest that people cannot reliably distinguish between different brands of bottled water, or between tap and bottled water. In view of the fact that the cost of bottled water is hundreds to thousands of times greater than tap water, and that the bottling of water, transport, and disposal of bottles after use result in a wide range of adverse environmental impacts that far exceed those linked to tap water, sharp reduction in consumption of bottled water is recommended.

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[i] **Acidification** – Commonly associated with atmospheric pollution linked to emissions of sulfur and nitrogen compounds such as ammonia. Such emissions can reduce the pH (increase the acidity) of rainfall such that the natural neutralizing capacity of soils is exceeded. This can in turn stunt the growth of, and eventually kill, forest trees, and also kill aquatic organisms including fish in lakes and streams.

Eco-toxicity – This impact measure encompasses a number of acute and chronic toxicity effects on different species in soil and water which are linked to releases of various chemical substances to air, water, and soil, and their biodegradability and potential bioaccumulation.

Eutrophication – A condition described by excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen.

Ozone depletion - The concentration of the reactive oxygen compound ozone O_3 is significantly higher in the stratosphere than in other parts of the atmosphere, and serves reduce the amount of ultraviolet radiation that reaches the earth's surface. Reduction in atmospheric ozone is strongly linked to increased skin cancer and retinal damage.

Smog potential - Under certain climatic conditions, air emissions from industry and transportation can be trapped at ground level where, in the presence of sunlight, they produce photochemical smog. It is a product of interactions of volatile organic compounds (VOCs) and nitrogen oxides (NOx).

Human health risks – In an LCA context the impact indicator covers a number of different effects: acute toxicity, irritation/corrosive effects, allergenic effects, irreversible damage/organ damage, genotoxicity, carcinogenic effects, toxicity to reproductive system/teratogenic effects, and neurotoxicity. Calculation of risk is based on accumulated knowledge, obtained through medical research, of impacts of exposure to various chemical compounds.