Bottled Water: Better Than Tap?

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We all need water to sustain life. In fact, a significant fraction of the human body is water. Blood contains 95% water, even bone is made up of over 20% water. Skin contains much water and if we want to preserve a 'fresh' and healthy look, even slight dehydration must be prevented.

Adipose tissue contains less than 10% water and the percentage of body weight that is water varies inversely with body fat. In the average lean adult male around 90% of the body weight is water. The remaining body weight consists of 96-98% fat with 92-94% protein, carbohydrate and other solids. In the female the percentage of body weight that is water is lower due to a relatively greater amount of subcutaneous fat.[1]

Body water is broken down into the following compartments:

- Intracellular fluid (2/3 of Body Water)
- Extracellular fluid (1/3 of Body Water)
  - Plasma (1/5 of Extracellular fluid)
  - Interstitial fluid (4/5 of Extracellular fluid)
  - Transcellular fluid (normally ignored in calculations) is contained inside organs, such as the gastrointestinal, cerebrospinal, peritoneal, and ocular fluids.

To determine an individual's total body water, a simple calculation is the 60-40-20 rule.

- Total Body Water = 60% of Body Weight
- Intracellular fluid = 40% of Body Weight
- Extracellular fluid = 20% of Body Weight

This is consistent with the above relations between total body water and the compartmental fluids.

American society uses more water than any other country in the world, but surveys indicate that most of us do not drink enough water. So how do we use up all this water?

On average, an American uses almost 100 gallons of tap water per person per day. A typical family of four on a public water supply uses about 350 gallons per day at home. Most of that water is used for lawn and garden sprinkling, automobile washing, kitchen and laundry appliances, such as garbage disposals, clothes washers, and automatic dish washers.[3] In contrast, a typical household that gets its water from a private well or cistern uses 'only' about 200 gallons for a family of four. In our communities an additional 35 gallons of water per person are used for public activities such as fire fighting, street washing, and park maintenance. By comparison, only 8 glasses of water are used for drinking.

Table 1: Water use in Different Countries

Country	Annual Water Use per Capita (Gallons)	Percentage of Total Water Use by Category	
		Residential	Industry/ Agriculture*
United States	525,000	10	90
Canada	310,000	13	87
Belgium	221,000	6	94
India	132,000	3	97
China	122,000	6	94
Poland	112,000	14	86
Nicaragua	72,000	18	82
Malta	16,000	100	0
*Includes water used for electrical power and for cooling.			
Source: Van Der Leeden, F., F.L. Troise, and D.K. Todd. *The Water Encyclopedia*, Lewis Publishers, Inc., Second Edition, 1990.			

In the past, Americans drank tap water, and this habit is rapidly changing. In 2001, Americans were drinking bottled water in record numbers--a whopping 5 billion gallons, according to the International Bottled Water Association (IBWA), an industry trade group. That's about the same amount of water that falls from the American Falls at Niagara Falls in two hours. [2]

Water has been bottled and sold far from its source for thousands of years. In Europe, water from mineral springs was often, and still is, thought to have curative powers. Clean water aids detoxification and provides essential elements. Pioneers trekking west across the United States during the 19th century typically considered drinkable (potable) water a staple to be purchased in anticipation of the long trip across the arid West.

Today, a bottle of water may cost over $1.50, which is 1900 times the price of tap water. Is it worth it? Do we need flavoured or fizzy water? Is bottled water so much better and healthier? Is it safe?

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Federal Regulations for Drinking (Tap) Water

The EPA (Environmental Protection Agency) regulates the safety of our tap water. It has set Primary and Secondary Maximum Contaminant Levels. A **Maximum Contaminant Level (MCL)** is defined as the highest level of a contaminant that is allowed in drinking water. MCLs are enforceable standards.

A **Maximum Contaminant Level Goal (MCLG)**, however, is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are *non-enforceable public health goals.* As the table below indicates, for metals MCLs and MCLGs may be the same. Is this logical? EPA thinks so.

Table 2: Maximum Contaminant Level (MCL) for Inorganic Chemicals

Units are listed in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.

Contaminant	MCLG	MCL	WHO	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Antimony	0.006	0.006	0.005	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic		0.01 as of 01/23/06	0.01	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes
Asbestos (fiber >10 micrometers)	7 million fibers per liter	7 MFL	No guideline	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits
Barium	2	2	0,3	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	0.004	0.004	No guideline	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defence industries
Cadmium	0.005	0.005	0.003	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	0.1	0.1	0.05	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	TT[8]; Action Level=1.3	2	Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits
Cyanide (as free cyanide)	0.2	0.2	0.07	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4	4	1.5	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminium factories

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Lead	zero	TT[8]; Action Level=0.015	0.01	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (inorganic)	0.002	0.002	0.001	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Nitrate and Nitrite (measured as Nitrogen)	10	10	50 As total nitrogen	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits
Selenium	0.05	0.05	0.01	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.0005	0.002		Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics

The Secondary Drinking Water Regulations established by the EPA set non-mandatory water quality standards for 15 contaminants. Some are listed below. EPA does not enforce these **"secondary maximum contaminant levels"**. **"SMCLs"** were established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. Contaminants listed as SMCLs are not considered to present a risk to human health and no action is required if drinking water levels exceed these. Is this in the public's best interest? EPA and WHO (World Health Organization) thinks so. It must be noted, however, that MCLs or SMCLs have been adjusted downward over time, mostly because our knowledge and testing ability improved in the last few decades. As more health problems are linked to chemical exposure, further adjustments may be anticipated.

Table 3: Secondary Maximum Contaminant Levels

Contaminant	**Secondary MCL**	**WHO guidelines**	**Noticeable Effects above the Secondary MCL**
Aluminum	0.05 to 0.2 mg/L	0.2 mg/L	colored water
Chloride	250 mg/L	250 mg/L	salty taste
Color	15 color units	Not mentioned	visible tint
Copper	1.0 mg/L	2.0 mg/L	metallic taste; blue-green staining
Corrosivity	Non-corrosive	Not mentioned	metallic taste; corroded pipes/ fixtures staining
Fluoride	2.0 mg/L	1.5 mg/L	tooth discoloration
Foaming agents	0.5 mg/L	Not mentioned	frothy, cloudy; bitter taste; odor
Iron	0.3 mg/L	0.01 mg/L	rusty color; sediment; metallic taste; reddish or orange staining
Manganese	0.05 mg/L	0.05 mg/L	black to brown color; black staining; bitter metallic taste
Odor	3 TON (threshold odor number)	Not mentioned	"rotten-egg", musty or chemical smell
pH	6.5 - 8.5		*low pH:* bitter metallic taste; corrosion *high pH:* slippery feel; soda taste; deposits
Silver	0.1 mg/L	No guideline	skin discoloration; graying of the white part of the eye
Sulfate	250 mg/L	500 mg/L	salty taste
Total Dissolved Solids (TDS)	500 mg/L	Not mentioned	hardness; deposits; colored water; staining; salty taste
Zinc	5 mg/L	3 mg/L	metallic taste

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Federal Regulations for Bottled Water

The regulatory jungle gets more dense when we include bottled water. In the U.S., bottled water and tap water are regulated by two different agencies; the **FDA** regulates bottled water and the **EPA** regulates tap water (also referred to as municipal water or public drinking water).

The FDA regulates bottled water as a food, and regulations are relatively lax. FDA describes bottled water as water that is intended for human consumption and that is sealed in bottles or other containers with no added ingredients except that it may contain safe and suitable antimicrobial agents. Fluoride may also be added within the limits set by the FDA. The name of the food is "bottled water" or "drinking water." FDA has also defined various other types of bottled water, such as "artesian water," "artesian well water," "ground water," "mineral water," "purified water," "sparkling bottled water," and "spring water". From the list below we see that the origin of bottled water is not necessarily what we are made to believe by clever advertising.

Table 4. Defining types of bottled water.

TYPE	DEFINITION
Artesian Water	Water from a well tapping a confined aquifer in which the water level stands at some height above the top of the aquifer.
Mineral Water	Water containing not less than 250 ppm total dissolved solids that originates from a geologically and physically protected underground water source. Mineral water is characterized by constant levels and relative proportions of minerals and trace elements at the source. No minerals may be added to mineral water.
Purified Water	Water that is produced by distillation, deionization, reverse osmosis or other suitable processes and that meets the definition of "purified water" in the U.S. Pharmacopeia, 23d Revision, Jan. 1, 1995. As appropriate, also may be called "demineralized water," "deionized water," "distilled water," and "reverse osmosis water."
Sparkling Bottled Water	Water that, after treatment and possible replacement of carbon dioxide, contains the same amount of carbon dioxide that it had at emergence from the source.
Spring Water	Water derived from an underground formation from which water flows naturally to the surface of the earth at an identified location. Spring water may be collected at the spring or through a bore hole tapping the underground formation feeding the spring.

Some bottled water comes from municipal sources--in other words--the tap. According to government and industry estimates, about one fourth of bottled water is bottled tap water (and by some accounts, as much as 40 percent is derived from tap water). It is a good thing that municipal water is usually treated before it is bottled.

Under the standard of quality, FDA establishes allowable levels for contaminants in bottled water. There are microbiological standards that set allowable coliform levels; physical standards that set allowable levels for turbidity, color and odor; and radiological standards that set levels for radium-226 and radium-228 activity, alpha-particle activity, and beta particle and photon radioactivity. The standard of quality also includes allowable levels for more than 70 different chemical contaminants.

What happens if bottled water contains a substance at a level greater than that allowed under the quality standard? FDA states that when the microbiological, physical, chemical or radiological quality of bottled water is below that prescribed in the quality standard, the label of the bottled water bottle must contain a statement of substandard quality, such as "Contains Excessive Bromate," "Contains Excessive Bacteria," or "Excessively Radioactive."!! FDA states that bottled water, unlike tap water, '*may contain a safe and suitable antimicrobial agent.*' Fluoride may also be added to bottled water within the limits set by the FDA.

The Exploding (and troublesome) Bottled Water Market

There has been an explosion in bottled water use in the United States, driven in large measure by marketing designed to convince the public of bottled water's purity and safety, and capitalizing on public concern about tap water quality. On average, people spend about $400/yr on bottled water.

Some marketing is misleading, implying the bottled water comes from pristine sources when it does not. For example, NRDC (National Resource Defense Council) evaluated and tested a number of bottled water brands. One brand of 'Spring Water' showed a label picturing a lake and mountains, but the water actually came from a well in an industrial facility's parking lot, near a hazardous waste dump. Investigators found that it was periodically contaminated with industrial chemicals at levels above FDA standards.

Arsenic has been a problem with bottled water for some time. In 1985, the arsenic levels of 23 mineral waters on sale to the public in the United Kingdom were measured. The statutory limits of 50 mcg/L (0.05mg/L) for natural mineral waters and 100 mcg/L

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(0.1mg/L) for non-alcoholic beverages were exceeded by the French mineral water, Vichy Célestins, which was found to contain 220 mcg/L. Regular consumption of mineral water of such elevated concentration could make a significant contribution to the intake of the more toxic inorganic species of arsenic, with possible adverse long-term effects on the health of some individuals.

On March 27, 2007, the FDA send out a news release, warning consumers not to drink the mineral water "Jermuk". This brand of bottled water, recalled because of its high arsenic count, is imported from Armenia and distributed under different labels in California. Five brands of these products have been recalled since March 7, 2007.

Just recently, the German government issued a warning about Uranium in bottled 'mineral water'. *Foodwatch* reported that every 8th brand of bottled water contains elevated uranium levels. Test values of 55 brands of bottled water showed uranium levels greater than the maximum contaminant level of 2mcg/l. The German Environmental Protection Agency send out a warning that an elevated uranium content of water may cause kidney problems, particularly in infants and young children.

Major Regulatory Gaps

The FDA regulates water as a food and it has been forced to adapt to EPA water rules. However, FDA rules completely exempt 60-70 percent of the bottled water sold in the United States from the agency's bottled water standards, because FDA says its rules do not apply to water packaged and sold within the same state. Nearly 40 states say they *do* regulate such waters (generally with few or no resources dedicated to policing this); therefore, about one out of five states do not.

The Natural Resources Defense Council (NRDC) performed testing on bottled water and contracted with an independent data verification firm to confirm the accuracy of its test results. They found:

- Nearly one in four of the waters tested (23 of the 103 waters, or 22 percent) violated strict applicable state (California) limits for bottled water in at least one sample, most commonly for arsenic or certain cancer-causing man-made ("synthetic") organic compounds. Another three waters sold outside of California (3 percent of the national total) violated industry-recommended standards for synthetic organic compounds in at least one sample, but unlike in California, those industry standards were not enforceable in the states (Florida and Texas) in which they were sold.

- Nearly one in five tested waters (18 of the 103, or 17 percent) contained, in at least one sample, more bacteria than allowed under microbiological-purity "guidelines" (which are unenforceable sanitation guidelines) adopted by some states, the industry, and the EU.

- About one fifth of the waters contained synthetic organic chemicals -- such as industrial chemicals (e.g., toluene or xylene) or chemicals used in manufacturing plastic (e.g., phthalate, adipate, or styrene) -- in at least one sample, but generally at levels below state and federal standards. One sample contained phthalate -- a carcinogen that leaches from plastic -- at a level twice the tap water standard, but there is no bottled water standard for this chemical; two other samples from different batches of this same water contained no detectable phthalate.

As mentioned before, arsenic is often a problem in drinking water. The NDRC tests found that many waters contained arsenic, nitrates, or other inorganic contaminants at levels below current standards. While in most cases the levels found were not surprising, in eight cases arsenic was found at a level of potential health concern.

For purposes of comparison, it has to be noted that EPA reported that in 1996 about 1 in 10 community tap water systems (serving about one seventh of the U.S. population) violated EPA's tap water treatment or contaminant standards, and 28 percent of tap water systems violated significant water-monitoring or reporting requirements. The tap water of more than 32 million Americans (and perhaps more) exceeds 2 parts per billion (ppb) arsenic (the California Proposition 65 warning level, applicable to bottled water, is 5 ppb); and 80 to 100 million Americans drink tap water that contains very significant trihalomethane levels (over 40 ppb). Thus, while much tap water is supplied by systems that have violated EPA standards or that serve water containing substantial levels of risky contaminants, apparently the majority of the country's tap water passes EPA standards. Therefore, while much tap water is indeed risky, having compared available data we conclude that there is no assurance that bottled water is any safer than tap water.

While each city's water treatment plant regularly performs water tests, and this information is available to its consumers, water quality also depends on the pipes in which it flows. Water from households with older pipes may have a higher metal count, and many factors influence the metal concentration. Rusty or corroding pipes may result in a metallic-tasting rusty water that is high in iron, and iron supports bacteria growth. Lead pipes have long been banned, because lead intoxication

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due to lead-containing drinking water was found to be a problem, especially for children. Houses built before 1970 may still have lead pipes, but if your home has been modernized since 1970 and all of its pipe-work replaced -from the water company's stop valve outside your home to the kitchen tap-, there should be no lead pipe on your property. Be aware that frequent soldering of metal pipes affects the quality of drinking water, and copper pipes can be a source of copper-intoxication, leading to neurological and other disorders.

The metal content of water is easily tested, but it must be noted that sampling is important. To find out how pipes affect the metal content of your water, you must take the sample first thing in the morning. That water sat in the pipes overnight and testing determines how much metal pipes affected the metal content of your water. If we are less concerned about the pipes, but are interested in the actual city water (or well water) quality, we must let the water run for 5 minutes before sampling.

Collection tubes can be contaminated, especially if they were cleaned in a dishwasher. It is best to rinse out collection tubes several times with the water to be tested.

If these simple, but important sampling precautions are taken, test results will be a good indicator of your drinking water quality.

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