Tap Water and Caverns

Is water from a mountain spring pure water? Is bottled mineral water more pure than tap water? The answers are “no” and “not necessarily.” If “pure” means 100% water without anything else, then you have probably never tasted pure water. Only distilled water is 100% water. The water you drink is a solution of several minerals dissolved in water.

Sometimes people buy distilled water for purposes other than drinking, such as filling the reservoirs in clothes steamers. Distilled water will not clog up the water passageways in appliances with deposited minerals.

Minerals have precipitated around this mineral spring.

In the process of distillation, water is boiled in one container and forms steam as it evaporates. The steam is then cooled and condenses back into liquid water in a separate container. The condensate contains only pure water because the minerals do not rise with the steam. If you were to taste distilled water you would probably think it tastes funny. You have become accustomed to the taste of trace minerals in your drinking water, so water without them tastes odd.

All tap water in the United States is a solution of naturally occurring minerals. Most municipal water supplies also have other chemicals added to the water, such as chlorine (Cl_2) to kill harmful bacteria. In some cases, the ion fluoride (F^-) is added to prevent tooth decay.

You might wonder how the dissolved material, or solutes, in tap water compare to those in bottled mineral water and bottled spring water. Some bottled waters are carbonated, containing dissolved carbon dioxide (CO_2) that causes bubbling similar to sodas. The carbonation contributes more to the taste than do the minerals. Mineral spring water contains a higher concentration of dissolved minerals, and may also be naturally carbonated. Mineral water from each spring has a distinct flavor because the mineral content varies a bit at different locations. Bottled spring water is not much different from municipal tap water in mineral content, however, because the general source is very similar.

Take a close look at the concentrations of four common ions in three different sources of water. The ions come from the natural minerals dissolved in the water at it source, such as a well or reservoir. The first set of data in the table shows the average mineral content of all municipal water supplies in the United States. The second data set is the mineral content of two brands of spring water bottled in the United States. The third data set is the mineral content of two brands of French mineral water. All of the concentrations are in the units parts per million (ppm), which is equal to 0.0001 %

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The mineral content varies greatly from one brand of bottled water to another. The table shows that the solutes in some bottled spring water are essentially the same as tap water. In fact, some companies begin with municipal water, add a few minerals and/or carbonation, and add their label to the bottle. Water from mineral springs also varies greatly depending on the source.

Dissolved ions	Concentration of Ions From Five Sources in Parts Per Million (ppm)				
	Average of U.S. Municipal Water Supplies	U.S. Spring Waters		French Mineral Waters	
		Arrowhead	Crystal Springs	Evian	Perrier
Calcium, Ca^{2+}	30	20	27	78	147
Magnesium, Mg^{2+}	9	4	6	24	3
Sodium, Na^{+}	38	12	13	5	4
Potassium, K^{+}	5	1	6	1	1

Popular brands of bottled water and municipal water supplies all contain more than water.

You may have heard of water being "hard" or "soft." Hard water contains a relatively high concentration of certain dissolved minerals, especially calcium carbonate ($CaCO_3$). Hard water has a source that was once deep underground in contact with limestone rock. Limestone is mostly calcium carbonate, which explains how the $CaCO_3$ ended up dissolved in the water. Only about 1.5 g of $CaCO_3$ will dissolve in a liter of water, but that is enough to change the taste and make the water "hard." When hard water is boiled off or evaporates, the concentration of $CaCO_3$ increases and can precipitate it if gets too high. The $CaCO_3$ then precipitates as the solution cools. If you could look inside a tea kettle, you would see a white coating of this mineral lining the sides of the kettle. Calcium ions (Ca^{2+}) can also form precipitates with other materials in hard water. For example soap scum forms when dissolved calcium or magnesium ions from hard water combines with common soaps.

Where is the limestone rock that comes in contact with our drinking water? As described above, water comes in contact with limestone underground. When water flows past the underground limestone rock, it takes a little bit of dissolved $CaCO_3$ with it. This is also how limestone caves form. It takes millions of years, but slowly cracks in the rock become larger and larger until they become tunnels. These tunnels eventually form large chambers that may be miles long and several meters high. Some caves are so vast they have never been completely explored. Others have rivers running through them inhabited by species of blind, colorless fish.

Stalactites hang from the ceiling, and stalagmites grow from the floor.

Water dripping from a cave ceiling may be nearly saturated with $CaCO_3$. As the water evaporates, the mineral precipitates on the ceiling, slowly building up to form an icicle-shaped deposit called a stalactite.

This is the same compound, formed in much the same way as the scale inside your teakettle. Where the water hits the cave floor, more water evaporates to form more precipitate, resulting in a rock formation coming up from the floor of the cave, called a stalagmite. (Hint: Stalac*tite*s are the ones on the ceiling because they are stuck *tight* to the ceiling.) These impressive rock formations are formed from the same minerals that give your drinking water its flavor.