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Sodium in Drinking Water and Arizona Domestic Wells

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Figure 1. Various Sources of Table Salt: Solution-mined salt from Arizona (left), Pakistan salt from 100 million+ year-old deposits (right), and Salt crystals produced from Sea Water evaporation (center). Photo: J. Artiola.

Introduction

Table salt (sodium chloride) has been used to preserve and season food since ancient times. We need sodium to regulate our body's water balance and muscle function. However, studies have shown that too much sodium intake may be bad for your heart health and is linked with high blood pressure. High levels of total dissolved solids (TDS), which include sodium, are common in Arizona's water resources. Therefore, we should be aware of our sodium consumption from foods and drinking water sources. Sodium in drinking water may be significant in your diet. But this depends on the amount of sodium in the water, how much you drink daily, and if you are on a sodium restricted diet.

Sodium and your Health

Excess sodium consumption is a major risk factor for heart disease and stroke (CDC 2017). Based on the CDCs dietary guidelines (CDC 2017) it's recommended that Americans consume less than 2300 milligrams (mg) of sodium per day. Estimates are that American adults consuming more than 3400 mg each day. Consuming too much sodium puts Americans at risk for developing serious medical conditions like high blood pressure, heart disease, and stroke. Together heart disease and stroke kill more Americans each year than any other cause (CDC 2017). The people at greatest risk for developing problems related to high salt consumption are people over age 50, people with high or slightly elevated blood pressure, people who have diabetes, and African Americans (The Nutrition Source 2019).

According to the Harvard Public Health School, the underlying cause of health problems associated with high sodium intake result from kidney malfunction. Excess sodium in the body causes accumulation of water which in turn causes fluids around the cells to increase and the volume of the blood to increase. This increase causes more

work for the heart and more pressure on the blood vessels. Left untreated the extra work and pressure can stiffen blood vessels leading to high blood pressure, heart attack, and stroke (The Nutrition Source 2019).

Guidelines

Dietary Guidelines for Americans recommend limiting sodium intake to less than 2300 mg per day (CDC 2017). The sodium content of your water, water consumption, and dietary habits will determine your sodium overall intake levels. The table below depicts contributions of sodium intake levels from water considering water sodium concentration level and amount of drinking water consumed. Important to note in Arizona are water recommendations during the summer months. Recommendations from the Arizona Department of Health Services (ADHS) suggest people who stay mostly indoors should consume at least 2 liters of water per day, and that people who spend time outdoors should drink 1 to 2 liters per hour (to avoid Heat Safety Heat Related Illness). In Arizona during the summer months sodium intake from water can dramatically increase due to an increased need for water. Depending on the sodium concentration of your water this can impact your health; see Table 1.

Sodium in Drinking Water Guidelines

The USEPA has sodium guidelines or advisory levels in drinking water based on (salty) taste of 30-60 mg/L (milligram per liter). The World Health Organization (WHO) also raises concerns with taste when sodium is above 200 mg/L in drinking water (WHO 2015). There are no health-related advisory levels or drinking water standards for sodium in drinking water, but the USEPA has Drinking Water Equivalent Level (DWEL) of 20 mg/L for persons on a sodium limited diet of less than 500mg/day (USEPA 2003).

Total Dissolved Solids and Sodium in Arizona's Groundwater

Arizona's groundwater levels of total dissolved solids (TDS) vary greatly. The TDS value is a measure of all the minerals found in water including sodium, calcium, potassium, magnesium, chloride, sulfate, and bicarbonate. And, in general, sodium content in water increases with TDS. This is because sodium minerals (for example table salt) dissolve easily in water compared to other minerals present in water (for example limestone). A 15-year survey of groundwater quality data collected from nearly 1,800 wells in Arizona indicates about 37% of the wells sampled have TDS levels above the USEPA National Secondary Drinking Water Standards (NSDWS) of 500 mg/L, see Figure 1 (Towne & Jones 2011). A close look at the sodium levels reported in this survey indicates that well owners have a 22% chance of having sodium levels above 100 mg/L and about an 80% chance of having sodium levels above 20 mg/L (USEPA DWEL) in the well water. A USGS report (NURE 1997) of nearly 900 domestic wells in Arizona showed similar results with 22% of the wells with sodium levels above 100 mg/L sodium and 70% above 20mg/L.

Table 1. Water Quality-Quantity and Daily Sodium Intake in milligrams and % of Maximum Dietary Guideline.

If the sodium content in your water is:	And drink 2 liters/day (about 2 quarts) your daily sodium intake is:	Your Sodium Daily Intake Based on Dietary Guideline of 2300 mg/day is:	And drink 4 liters/day (about 1 gallon) your daily sodium intake is:	Your Sodium Daily Intake Based on Dietary Guideline of 2300 mg/day is:
mg/Liter	mg	%	mg	%
20	40	3.5	80	7
30	60	5.2	120	10
60	120	10	240	20
100	200	17	400	34
150	300	26	600	52
200	400	37	800	74

Note: mg/L = milligrams per liter. One mg/l is roughly equivalent to 3/4 teaspoon of salt (about 4 grams) in a 1000-gallon tank.

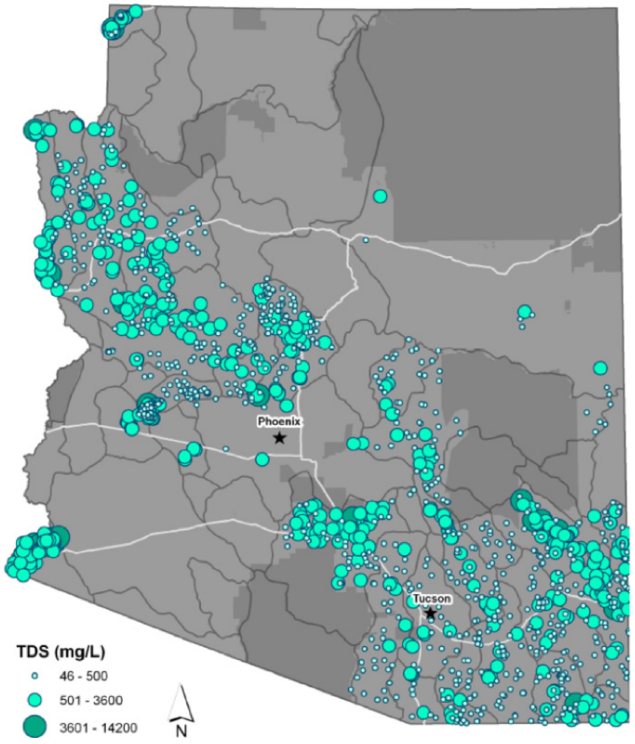


Figure 2. Levels Total Dissolved Solids, which include sodium, in groundwater. Towne & Jones 2011.

Public Water Utilities

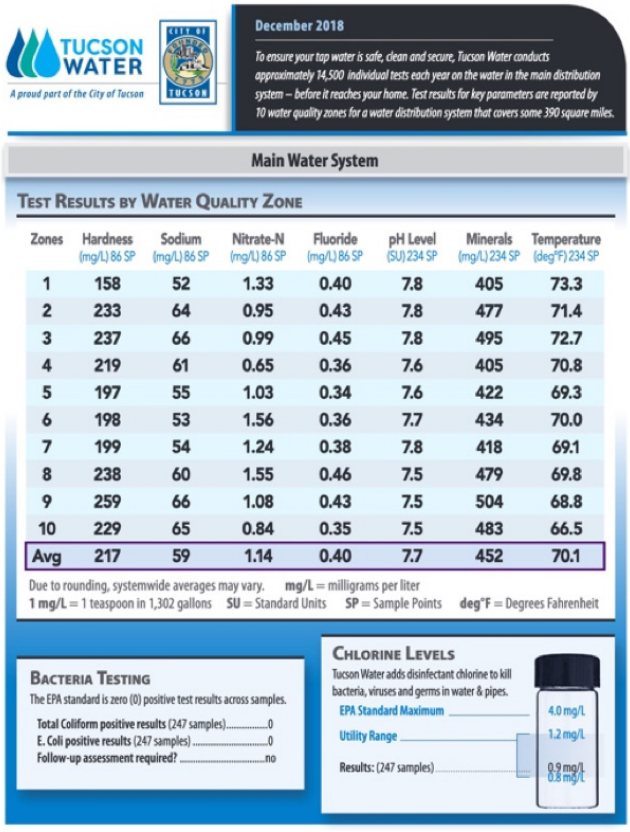
Arizona's public water providers must comply with State and Federal Drinking Water Standards. Test results exceeding drinking water standards are reported in their annual water quality reports. Some water utilities give monthly reports that include pH, TDS, hardness, sodium, and other chemicals present in drinking water. Reports from the City of Tucson Water public utility show that sodium content in tap water has increased about 35% in the last 10 years. This is because groundwater mixes with recharged Colorado River Project (CAP) water, which has a higher sodium content than Tucson's groundwater. The sodium level in Tucson's tap water is about 60 mg/L; see Table 2 (City of Tucson Water quality summary January 2018). The City of Phoenix Water Services Department 2017 Water quality report lists the sodium levels from 25 to 264 mg/L (City of Phoenix 2018). For more information about the quality of Arizona's water supplies see Artiola et al. 2014. For up to date information about sodium in your tap water, look for annual or monthly reports included in your monthly bills or on your local public water utility's website.

Water Softeners

Sodium-based water softeners, used to reduce water hardness, increase the level of sodium in your water. Water hardness is the sum of calcium and magnesium reported as calcium carbonate equivalent and measured in grains per gallon (gpg). For example, if your water has 100 mg/L sodium and is very hard, say 15 gpg, then the water softener would add about 120 mg/L of sodium for a total of 220 mg/L (see conversion factor below). Therefore, it is best to avoid drinking soft water. For more information about the pros and cons of water softeners see Artiola et al. (2017 or 2012).

Grains per Gallon of Hardness X 7.9	=	mg/Liter (ppm) of Sodium added by water softener

Table 2. Page 2 of Tucson Water (INFO NET) December 2018 water quality Data summary. Source: https://www.tucsonaz.gov/files/water/docs/wq201812.pdf



TUCSON WATER
A proud part of the City of Tucson

December 2018

To ensure your tap water is safe, clean and secure, Tucson Water conducts approximately 14,500 individual tests each year on the water in the main distribution system – before it reaches your home. Test results for key parameters are reported by 10 water quality zones for a water distribution system that covers some 390 square miles.

Main Water System

Test Results by Water Quality Zone

Zones	Hardness (mg/L) 86 SP	Sodium (mg/L) 86 SP	Nitrate-N (mg/L) 86 SP	Fluoride (mg/L) 86 SP	pH Level (SU) 234 SP	Minerals (mg/L) 234 SP	Temperature (deg°F) 234 SP
1	158	52	1.33	0.40	7.8	405	73.3
2	233	64	0.95	0.43	7.8	477	71.4
3	237	66	0.99	0.45	7.8	495	72.7
4	219	61	0.65	0.36	7.6	405	70.8
5	197	55	1.03	0.34	7.6	422	69.3
6	198	53	1.56	0.36	7.7	434	70.0
7	199	54	1.24	0.38	7.8	418	69.1
8	238	60	1.55	0.46	7.5	479	69.8
9	259	66	1.08	0.43	7.5	504	68.8
10	229	65	0.84	0.35	7.5	483	66.5
Avg	217	59	1.14	0.40	7.7	452	70.1

Due to rounding, systemwide averages may vary. **mg/L** = milligrams per liter
1 mg/L = 1 teaspoon in 1,302 gallons **SU** = Standard Units **SP** = Sample Points **deg°F** = Degrees Fahrenheit

Bacteria Testing
The EPA standard is zero (0) positive test results across samples.
Total Coliform positive results (247 samples)....0
E. Coli positive results (247 samples)....0
Follow-up assessment required?....no

Chlorine Levels
Tucson Water adds disinfectant chlorine to kill bacteria, viruses and germs in water & pipes.
EPA Standard Maximum 4.0 mg/L
Utility Range 1.2 mg/L
Results: (247 samples) 0.9 mg/L 0.8 mg/L

How to Lower Sodium Levels in Water

Reverse Osmosis (RO) systems are effective for lowering water salinity (TDS), and arsenic, nitrate, and other contaminants in water. These systems use a membrane that filters out many types of chemicals, depending on the type of membrane. See Artiola et al. (2017) for a full description and diagram of a modern RO system.

The amounts of chemicals filtered by RO systems vary with individual chemicals and membrane types. In the Table 3 example, 97% of the calcium was filtered out but the same membrane filtered out 80% of the sodium in the water. The

source water quality also affects the amounts chemicals removed. For example, hard to very hard water hardness, common in Arizona waters, makes it difficult to run RO systems efficiently due to excessive membrane fouling. Therefore, you should test the removal efficiently of sodium (or any other contaminant) of your RO system by testing the water quality before and after RO treatment. Private well owners should test the removal percent of contaminants such as arsenic if present above drinking water standards. For more information about arsenic treatment options see Artiola & Wilkinson (2015).

All filter media can develop slime and trap particles, which can plug and shorten the life of these membranes, especially when not used regularly. Replace RO membrane cartridges at manufacturer recommended intervals, or more often, depending on use.

Consumer RO systems will increase your household water use since they run at water pressure of 40-60 pounds per square inch (psi). This low operating pressure requires more frequent flushing (to control membrane fouling) than industrial RO systems that operate at 100 psi or more. Therefore, consumer RO units can produce large volumes of wastewater (concentrated brine). For example, one gallon of RO filtered water may produce ~3 to 8 gallons of wastewater, depending on the salinity and hardness of the source water. In Arizona, wastewater utilities discourage the use of home RO systems because it degrades the quality of reclaimed water. To lower wastewater flow and salt load to your septic system, you can pipe the RO wastewater outside to irrigate salt-tolerant native plants and trees.

Water distillation units remove all salts, including sodium and other contaminants from water, producing sodium-free water. Water distillation also kills pathogens disinfecting water since water is boiled. However, a lot of energy is needed to produce steam from water and table-top consumer distillation units may use as much electricity as a toaster. You should consult your physician if you plan to use only distilled water for your cooking and drinking. For additional information on water distillation see Artiola et al. 2017.

The Future of Water Quality

Less than 1% of the world's water is on land and in the air, including surface and groundwater resources, of which 97% is in the oceans and (3%) is frozen (Van der Leeden et al. 1990). During the last 5,000 years the earth's water resources have been relatively stable. However, in recent centuries the world's population has increased one thousand-fold, stressing the fresh water sources. Also, climate change trends (due to global warming) suggest that an increase in temperatures and droughts or intense rainfalls will degrade water quality in lakes, rivers, and reservoirs (IPCC 2007). And in coastal zones rising sea levels are already impacting water sources (USEPA 2018). In the US, access to good groundwater quality is the top priority among water managers in 48 states surveyed by the National Groundwater Association (Megdal 2018). We will never run out of water, but access to fresh (low salinity) water resources will be more difficult as groundwater resources become scarcer and surface waters continue to degrade.

Summary

High levels of salts, which include sodium, are common in Arizona's groundwater water resources. Excess sodium consumption is a major risk factor for heart disease and stroke. Well owners and other consumers should be aware of the level of sodium in their drinking water, regardless of the source, and how it affects their total sodium diets. Present trends suggest salt content in surface water sources is increasing and water quality in general will continue to degrade.

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Table 3. Examples of RO removal rates of major TDS constituents. Adapted from Artiola & Wilkinson 2015

Water Quality	TDS	Alkalinity	Sodium	Potassium	Chloride	Calcium	Magnesium	Sulfate
	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Before RO	400	145	38.8	2.2	12.4	69.1	12.5	143
After RO	35.8	2.5	7.6	0.66	3.3	2.3	0.5	4.4
% Removal	**91**	**98**	**80**	**70**	**73**	**97**	**96**	**97**

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