Water Chemistry

A general explanation and significance of common minerals and chemicals found in rivers, lakes, groundwater, and drinking water.

Total Alkalinity - Alkalinity in water is its quantitative capacity to react with a strong acid to a designated pH. In most waters, it is primarily a function of the bicarbonate, carbonate, and hydroxide concentrations in the water. Alkalinity in excess of alkaline earth metal (Ca, Mg) concentrations is significant in determining the suitability of water for irrigation. Damage to crops can result if alkalinity in high excess of alkaline earth metal concentrations is present. The extent of possible damage is dependent on crop and soil types.

Total Hardness (EDTA) - The sum of the calcium and magnesium concentrations, both expressed as calcium carbonate in milligrams per liter. Originally, water hardness was understood to be the capacity of water to precipitate soap. Hard water does not allow soap to form as much suds. Water high in hardness is detrimental to plumbing and will reduce the life of water heaters. Water softeners will typically reduce hardness to below 10 mg/L, however, they replace the calcium and magnesium metals with sodium which is undesirable for persons on low salt intake diets. Water softener companies often discuss hardness in terms of "Grains per Gallon", as opposed to the common units mg/L. To convert hardness from mg/L to grains per gallon, multiply mg/L by 17. Thus, 525 mg/L is equal to 31 gr/Gal.

pH - The intensity of the acidic or basic character of a solution is indicated by pH or hydrogen ion concentration. Natural waters usually have a pH value between 4.0 and 9.0, with 7.0 being neutral. Most natural waters are slightly above 7.0, due to the presence of carbonates and bicarbonates. Well waters indicating a sudden rise or lowering of pH could indicate outside polluting sources. One possibility would be a sudden lowering of pH due to the improper acidizing of an oil well in close proximity to a water source.

Calcium (Ca) - Calcium in well waters results from the passage of ground water through or over deposits of limestone, dolomite, gypsum, and gypsiferous shale. Concentrations may vary from zero to several hundred mg/L. High concentrations of calcium can clog plumbing and will shorten the life of water heaters. Water softeners will significantly decrease calcium levels, but will replace calcium ion with sodium ion. This is inadvisable treatment for drinking water for persons watching their sodium (salt) intake.

Magnesium (Mg) - Magnesium, like calcium, also precipitates when heated to form scale in water heaters. Concentrations greater than 125 mg/L can exert a cathartic and diuretic action when used as drinking water. However, it has been shown that human digestive systems can become tolerant to the effects of high magnesium content over a period of time. Concentrations may vary from zero to several hundred mg/L. In the Concho Valley, magnesium is generally due to the water passing over over dolomite formations and re-dissolving magnesium ion.

Sodium - Levels range from zero to several hundred mg/L. High concentrations are found in brine waters and waters softened by the ion exchange process. Soil permeability can be harmed by high sodium concentrations. Persons afflicted with certain heart diseases require water low in sodium.

Chloride - Chloride found in the form of Cl^- ion is one of the major inorganic anions present in water. In drinking water, the salty taste produced by chlorides is variable and dependent on the cations (Ca, Mg, Na) it is associated with. Chlorides, when associated primarily with sodium ion, produce a much saltier taste than when associated with calcium or magnesium ions. Levels above 1000 mg/L may cause problems when used for irrigation. The maximum limit recommended by the State of Texas for drinking water is 300 mg/L. Waters extremely high in chloride, when used for general household use, can have disruptive effects on septic tanks. The high chloride content causes damage to the septic tanks microbial flora, due to its effect on the osmotic pressure on microbial cell walls. This can often result when a water softener is used to condition water at a location using a septic tank. Backwash water should not be discharged into the septic tank.

High chlorides in well waters may be due to natural sources. However, if a sudden rise in chloride content is detected, the rise may be due to outside contaminating sources. Abandoned or improperly plugged oil wells, salt water injection wells, run-off from an oil drilling site, and industrial waste pollution are just a few possible polluting sources for chloride contamination.

Ammonia - Ammonia concentrations are generally low in groundwaters because it adsorbs to soil particles in clays and is not readily leached from soils. It is produced largely by the de-amination of organic nitrogen containing compounds and by the hydrolysis of urea. If significant amounts are found in wells, it can indicate the presence of pollutants in the water. One of the most common sources of pollution of a well is having a septic tank too close to the well or the wells cone of depression. Excess fertilization, or fertilizer run-off can contribute to high ammonia levels in wells if it occurs in close proximity to the well. Cattle or sheep feed yards, dairies, pig farms, stockyards, and similar areas which have high accumulations of animal waste are often found to pollute water tables and local wells. Detection of high ammonia levels is important in pollution investigation studies because it generally indicates the source is close by. Ammonia will oxidize fairly quickly to nitrate once in the environment and then is detected by the nitrate test.

Nitrate - Nitrate may be naturally occurring in groundwater or may come from a polluting source. After a short period of time, ammonia will be oxidized to nitrate through the nitrification process. In excessive amounts, nitrate contributes to the illness known as methemoglobinemia (commonly called "blue babies") in unborn children and infants. The nitrate ion decreases the oxygen carrying capacity of hemoglobin in the blood. A limit of 10 mg/L nitrate nitrogen NO_3-N has been imposed on drinking water to prevent this disorder. Pregnant women and parents with small infants or children should monitor the nitrate levels in their wells if this water is used for drinking water or the preparation of infant formula. Sources for nitrate pollution are generally the same as those indicated for ammonia. The Nitrate Nitrogen (NO_3-N) value can be converted to actual Nitrate (NO_3) by multiplying by 4.4. Thus, 10 mg/L NO_3-N is equivalent to 44 mg/L NO_3.

Sulfate - Sulfate is widely distributed in nature and may be present in natural waters in concentrations ranging from a few to several thousand mg/L. Sodium and magnesium sulfates exert a cathartic action when in excessive numbers. Drinking well water with high sulfate levels may produce symptoms similar to taking laxatives, especially when sodium and magnesium are present. Sodium containing chemicals are sometimes used in the treatment of oil wells and could contaminate drinking water sources if improperly used. The maximum limit recommended by the State of Texas for drinking waters is 300 mg/l.

Total Dissolved Solids (TDS) - The sum of the above minerals found in one liter of water, expressed as milligrams per liter. Low values indicate good water quality. High values indicate highly mineralized water. The maximum recommended by the State of Texas is 1000 mg/l for drinking water. Typical concentrations will range as follows:

Distilled Water	0 - 5 mg/L
Deionized Water	0 - 10 mg/L
Reverse-Osmosis Water	10 - 50 mg/L
High Quality Well Water	25 - 200 mg/L
Edwards Aquifer	50 - 450 mg/L
Concho River at San Angelo	700 - 1200 mg/L
O.H. Ivie Reservoir …………………………………	900 – 1500 mg/L
San Angelo Tap Water	800 - 1500 mg/L
Lake Spence Water	1600 - 3000 mg/L
Highly mineralized West Texas Wells …………….	2000 - 6000 mg/L

Conductivity – Conductivity, often termed specific conductance, is a measure of the ability of water to conduct an electrical current. In reality, it is a measure of the mineral content of water, very similar to Total Dissolved Solids (TDS) mentioned above. Depending on the chemistry of a water, conductivity usually runs about 1.4 to 1.7 times the TDS. Thus a water with a TDS of 1400 mg/L would probably have a conductivity around 2100 $\mu s/cm^2$. (1400 * 1.5 = 2100)

Note: The unit "mg/L" is equivalent to parts per million "ppm".