# Water Quality Analysis

Since the early 1920's, many different agencies have sampled and analyzed groundwater within the area now defined within Southwest Kansas Groundwater Management District No. 3. The number of samples taken and location of sampling sites varied throughout the years depending on the specific objectives and program of study for each agency. Likewise, the parameters analyzed varied; however, determining trends and identifying problem areas were common objectives for these agencies and their sampling programs.

The District implemented a Water Quality Program in 1988 with groundwater sampling and analysis being an integral part of that program. As seen with the other agencies, past endeavors by the District have been less than consistent. In order to establish greater validity and reliability with its water quality monitoring, the District in 2002, elected to hire private firms to help develop a "new approach" to these procedures. Ground Water Associates, Inc. and Servi-Tech Laboratories are currently involved with developing a new monitoring program. During this development period, Servi-Tech has continued to monitor the established sampling network by sampling 233 sites and performing the accompanying water quality laboratory analyses. Ground Water Associates is currently in the process of revamping the existing network and determining future sites within the District to sample.

When evaluating a groundwater source of supply, the two primary factors to consider are quantity and quality. If the quantity is sufficient, then a determination needs to be made whether or not the quality is satisfactory. Groundwater quality is determined by levels of chemicals and amount of "trash" contained within that water. In general, the District has groundwater suitable for most all uses with that suitability dependent on the type of use for which the water is to be used. Groundwater which meets quality standards for municipal use may be quite satisfactory for livestock; however, a well providing water for livestock may have an unacceptable quality for certain municipal purposes.

With groundwater being the only major source for water within the District, type of use is quite varied. Approximately 95% of all the District's groundwater is allocated for irrigation with all other uses comprising the difference. Considering these figures alone, it is easy to reason that irrigation water quality is very important to the District. Likewise, it is quite obvious that the quality of water for human and livestock consumption are important, although, having different water quality criteria or levels of suitability. In fact, groundwater quality is very important for all uses within the District giving credence to continued monitoring and management of groundwater sources within the District. Recommended standards have been identified describing acceptable concentrations or levels of the many different elements which are found in groundwater. These parameters may be man-made or occur naturally.

For example, Federal and state agencies have established drinking water standards (See Table: ) for safe consumption of water by humans. Water standards are available for recreational facilities such as public swimming pools which are required to maintain certain levels of water quality. Many manufacturers have their own set of standards identifying the specific quality needs in order to produce their goods. While providing services to their communities, municipalities may utilize several levels or standards of water quality depending on the specific use (drinking water, irrigation, recreation, fire protection, etc.) Likewise, the agriculture industry has different criteria for the many segments of that industry.

As mentioned above, predominant use of groundwater within the Southwest Kansas Groundwater Management District No. 3 is irrigation water for agriculture production. Standards for irrigation have been developed allowing producers to make management decisions based on quality of their irrigation water.

**In general, there are four basic criteria for the evaluation of irrigation water quality:**

**A. Total soluble salt content creating a salinity hazard which may result in physiological drought conditions, leaf burn, and/or possible problems with germination, emergence, and stages of growth.**

**B. The relative proportion of sodium cations ($Na^{+}$) to other cations creating a sodium hazard effecting soil permeability.**

**C. The carbonate ($CO_3^{=}$) anion and bicarbonate ($HCO_3^{-}$) anion concentration as related to calcium ($Ca^{++}$) cation plus magnesium ($Mg^{++}$) cation concentration resulting in a sodium hazard effecting soil permeability and possible leaf toxicities.**

D. **An excessive concentration of elements and compounds creating an ionic imbalance or toxicity in the crops.**

# CONSTITUENTS and LIMITS

## (AS SAMPLED BY: Servi-Tech Laboratories 2002)

| **COMMON WATER QUALITY STANDARDS (RECOMMENDED MAXIMUM LEVELS)** | | | |
|---|---|---|---|
| **Constituent** | **Drinking Water Limits** | **Stock Water Limits** | **Irrigation Water Limits** |
| Nitrogen: Nitrate ($NO_3$-N) | 10 mg/L | 100 mg/L | --- |
| Chloride (Cl) | 250 mg/L | 1500 mg/L | 70-350 mg/L |
| Sulfate ($SO_4$) | 250 mg/L | 500 mg/L | --- |
| Sulfate-Sulfur ($SO_4$-S) | --- | --- | --- |
| Carbonate ($CO_3$) | --- | --- | --- |
| Bicarbonate ($HCO_3$) | --- | --- | --- |
| Calcium (Ca) | 75-200 mg/L | 1000 mg/L | --- |
| Magnesium (Mg) | 50-150 mg/L | 90-250 mg/L | --- |
| Sodium (Na) | 100 mg/L | 150-800 mg/L | 500-700 mg/L |
| Potassium (K)<br>($K_2O$) Calc. | 100 mg/L<br>--- | 20 mg/L<br>--- | ---<br>--- |
| Boron (B) | 5 mg/L | 5 mg/L | .3-4 mg/L |
| Total Dissolved Solids Calc. | 500 mg/L | 5000-7000 mg/L | 525-1400 mg/L |
| Hardness ($CaCO_3$) Calc. | 400 mg/L | 2000 mg/L | --- |
| Hardness ($CaCO_3$) Calc. | 23 grains/gal. | 118 grains/gal. | --- |
| Alkalinity ($CaCO_3$) Calc. | 60-300 mg/L | 2000 mg/L | --- |
| Electrical Conductivity (EC) | .75 mmhos/cm | 8-11 mmhos/cm | .75-2.0 mmhos/cm |
| Sodium Adsorption Ratio (SAR); Adj. (SARa) | --- | --- | 6-9 |
| Sodium, % of Cations | --- | --- | 40-60 |
| Water pH; pHc | 6.5-8.5 | 5.5-8.3 | 4.5-9.0 |

The "Water Limits" above are adapted from established standards provided by the United States Environmental Protection Agency, National Academy of Sciences, Council for Agricultural Sciences and Technology, USDA Natural Resources Conservation Service and other such organizations. Individual tolerance to taste, odor, and/or color may be reason for published differences in "recommended maximum levels". Likewise, diet and physiological conditions of the animal species as well as seasonal and climatic differences play an important part in tolerance levels. Crops and animals may be more or less sensitive depending on their growth stage or age. Levels of tolerance may vary depending on the individual element itself, or when it is compounded with other elements. Sensitivity levels may also vary depending on the method of uptake and/or application of the element or compound.

## COMMON WATER QUALITY STANDARDS

**Nitrogen:**

**Nitrate ($NO_3$-N):**

Excessive nitrate/nitrite intake levels impair fetal development and may lead to methemoglobinemia, known in humans as "blue baby syndrome".

Among livestock, ruminants are most susceptible to toxic levels due to nitrate conversion by the bacteria in the rumen. Conversely, pigs are quite resistant to nitrate poisoning and can tolerate levels greater than 750 mg/L.

No recommended maximum level or standard exists for irrigation water; however, concentrations found higher than the local average may be due to pollution.

**Chloride (Cl):**

A salty taste to water may exist when chloride salts become higher than 100 mg/L. Also, water may become increasingly corrosive when chloride is combined with calcium and magnesium.

The weight of the animal and amount of water consumed daily determines the maximum intake levels of salts and ions. In general, the chloride ion found in stock water does not create problems.

Chloride tolerance varies considerably with some crops being quite sensitive (foliar toxicity), especially under sprinkler irrigation.

**Sulfate ($SO_4$):**

Sulfates may give an unpleasant taste to the water and may have a laxative effect. Higher levels (1000 mg/L) found in domestic water sources may be utilized for drinking after a period of adjustment.

Smaller animals such as weanling pigs may realize a greater effect with lower concentrations of sulfates when alkalinity levels reach 500 mg/L. Diarrhea and reduced milk production may occur in dairy cows consuming high (2000 mg/L) levels. Also, copper deficiencies in cattle can be caused by high sulfate in water.

Depending on the concentration, sulfate ions may have negative effects to the growth of certain sensitive crops, disrupting the cationic balance within the plant.

**Carbonate ($CO_3$) and Bicarbonate ($HCO_3$):**

They generally produce a mild alkalinity when in combination with calcium and/or magnesium. Bicarbonates may cause boilers and hot water heaters to form scale and release carbon dioxide gas.

See Alkalinity:

Irrigation waters high in bicarbonate tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) which will increase the relative proportion of sodium ions; thus, producing a sodium hazard level of the water greater than what is indicated by the SAR value. See SAR and $SAR_{adj}$.

**Calcium (Ca) and Magnesium (Mg):**

Causes hardness and the scale forming characteristics of water. See Hardness.

Levels found in water generally have little effect on water suitability for livestock and irrigation water. However, in the form of magnesium sulfate ($MgSO_4$), Epsom salts, is undesirable at higher levels due to its laxative effect.

**Sodium (Na):**

Sodium salts may cause "foaming" in boilers and high concentrations of sodium (Na), when combined with chloride (Cl), will give a salty taste to water.

Generally, low to moderate levels have little effect on water use.

High concentrations can cause diarrhea and a drop in milk production in dairy cows. Sodium sulfate ($NaSO_4$) is a recognized laxative. With sodium (Na) being a major component of salt (NaCl), high levels may be reason for adjustment to livestock rations. With levels greater than 400 mg/L in the water, salt may be reduced in swine diets.

Foliar applications of "salty water" can produce leaf burn and even defoliation in sensitive crops. High sodium (Na) concentrations effect spoil permeability and infiltration. See SAR.

**Potassium (K) and ($K_2O$) [Calc.]:**

Low to moderate concentrations of potassium (K) have little effect on the use of water, however, higher levels may give a "salty" taste when combined with chloride (Cl).

Potassium (K) has nutritional qualities for both plants and animals; however, high concentrations may introduce a magnesium deficiency and iron chlorosis in plants.

**Boron (B):**

Too high of a concentration in stock water may cause slow growth rates. Also, high levels may cause inflammation and edema in the legs of cattle.

Slightly higher levels can cause plant toxicity even though it is an essential nutrient for plant growth. The optimum concentration varies depending on plant type.

**Total Dissolved Solids (TDS):**

A measure of actual salt content which levels at 1000 mg/L or higher may have a mineral content which gives the water a distinctive taste. Levels at 2000 mg/L are generally too salty to drink.

Due to laxative effects, livestock may take some time to get use to these concentrations. Pregnant or lactating animals should not drink water with these levels. Reasonably safe.

Irrigation water at these concentrations may be used for non-sensitive crops, however, leaching may be necessary. Total dissolved solids (TDS) can be converted to electrical conductivity by dividing by 640. (ppm TDS / 640 = mmhos/cm EC) See Electrical Conductivity (EC):

**Hardness ($CaCO_3$) [Calc.]:**

Hardness has no effect on water safety, however, it will create "soap scum" and forms scale in boilers, hot water tanks, and pipes. 180 mg/L is considered very hard.

Livestock can tolerate very hard water, however, the clogging of pipes, etc. can have associated problems with water consumption.

In general, crops grow well in hard water. See Calcium (Ca) and Magnesium (Mg):

**Alkalinity ($CaCO_3$) [Calc.]:**

Concentrations above 500 mg/L may have a laxative effect. Levels lower than 500 mg/L may have the same effect if there are high sulfates ($SO_4$) in the water. Alkalinity indicates the relative amounts of carbonate ($CO_3$), bicarbonate ($HCO_3$), and hydroxide ions in the water. Most water sources have alkalinity levels less than 500 mg/L which are not usually harmful. See Carbonate ($CO_3$) and Bicarbonate ($HCO_3$).

**Electrical Conductivity (EC):**

Electrical conductivity (EC), is an estimated measurement of the total salt content of water based on the flow of electrical current through the water. The higher the concentration of salt the higher the electrical conductivity (EC). See Total Dissolved Solids (TDS).

**Sodium Adsorption ration (SAR):**

For irrigation purposes, high sodium concentrations in water have negative effects on soil permeability and water infiltration. The physical structure of soil is broken down when high levels of sodium (Na) replaces the calcium (Ca) and magnesium (Mg). The sodium adsorption ratio (SAR) is calculated from the ratio or proportion of sodium (Na) to calcium (Ca) plus magnesium (Mg) and is an estimate of the sodium hazard of irrigation water.

**Adj. Sodium Adsorption Ratio (SARa):**

The adjusted sodium adsorption ratio ($SAR_{adj}$)is often used when irrigation waters contain significant amounts of bicarbonate ($HCO_3$).

**Sodium, % Of Cations:**

Another measurement to evaluate a sodium hazard in irrigation water is the ratio of sodium (Na) to the total cation equivalents per million multiplied by 100. Water with a percent larger than 60 may result in levels of sodium (Na) that will cause breakdowns in the physical properties of soils.

**Water pH and pHc:**

The pH level of water is a measurement of the hydrogen (H) ion concentration or acidity. Various water treatments such as chlorination can be effected by changes in pH.

Acidosis and reduced intake of feed may occur in cattle when the pH of stock water is lower than 5.5

Irrigation waters with pH levels higher than 8.5 generally means that the water is high in soluble salts and will require additional management practices for irrigation.