SERVICE IN ACTION

COLORADO STATE UNIVERSITY EXTENSION SERVICE

Irrigation water quality criteria

R. H. Follett and P. N. Soltanpour[1]

no. .506

Quick Facts

Colorado irrigation water varies from excellent—water that can be used with confidence without special restriction, to very poor—water that should not be used.

The quality of Colorado water generally is limited by salinity hazard and sodium hazard.

There are four basic criteria for evaluating water quality for irrigation purposes:

1. Total soluble salt content (salinity hazard).
2. Relative proportion of sodium cations (Na^+) to other cations (sodium hazard).
3. Concentration of elements that may be toxic.
4. Bicarbonate anion ($HCO3^-$) concentration as related to calcium (Ca^{++}) plus magnesium (Mg^{++}) cations.

(An ion is an electrically charged atom or groups of atoms. Cations carry a positive charge, and anions have a negative charge.)

The first two criteria are of major concern in Colorado and are used by the Colorado State University Soil Testing Laboratory in determining irrigation water quality.

There also are many nonwater factors that must be considered in deciding the usefulness of water for a specific situation. These include soil texture and structure, drainage conditions, gypsum and lime content of the soil, salt and sodium tolerance of the crop and irrigation method and management.

Salinity Hazard

Excess salt increases the osmotic pressure of the soil solution which can result in a physiological drought condition. Even though the field appears to have plenty of moisture, the plants wilt because insufficient water is absorbed by the roots to replace that lost from transpiration.

The total soluble salt content of irrigation water is generally measured either by determining its electrical conductivity (EC), which is reported as micromhos per centimeter, or by determining the actual salt content in parts per million (ppm). Table 1 presents the basic guidelines for water use relative to its salt content. See Service in Action sheet .505 for crop tolerance to soluble salts.

Table 1: Salinity hazard of irrigation water.

Hazard	Dissolved salt content: ppm	Dissolved salt content: EC-micromhos/cm
Water for which no detrimental effects will usually be noticed.	500	750
Water that may have detrimental effects on sensitive crops.	500-1000	750-1500
Water that may have adverse effects on many crops and requiring careful management practices.	1000-2000	1500-3000
Water that can be used for salt-tolerant plants on permeable soils with careful management practices and only occasionally for more sensitive crops.	2000-5000	3000-7500

Sodium Hazard

The sodium hazard of irrigation water usually is expressed as the sodium adsorption ratio (SAR). This is the proportion of Na^+ to Ca^{++} plus Mg^{++} in the water. The following formula is used to calculate SAR:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

[1]*R. H. Follett and P. N. Soltanpour, CSU professors, both department of agronomy (revised 2/1/85)*

Ions in the equation are expressed in milliequivalents per liter.

Although sodium contributes directly to the total salinity and may be toxic to sensitive crops, such as fruit trees, the main problem with a high sodium concentration is its effect on soil physical properties.

The use of water with an SAR value greater than 10 should be avoided if it must be used as the only source of irrigation water for long periods. This is true even if the total salt content is relatively low.

If the soil contains an appreciable amount of gypsum, an SAR value of 10 may be exceeded somewhat. The gypsum content of the soil can be determined by the CSU Soil Testing Laboratory.

Continued use of water having a high SAR value leads to a breakdown in the physical structure of the soil caused by excessive amounts of colloidally absorbed sodium. This breakdown results in the dispersion of soil clay which causes the soil to become hard and compact when dry and increasingly impervious to water penetration due to dispersion and swelling when wet. Fine-textured soils, those high in clay, are especially subject to this action.

Toxic Elements

Direct toxicity to crops may result from some specific chemical element in irrigation water. The actual concentration of an element in water that will cause toxic symptoms varies depending on the crop.

When an element is added to the soil through irrigation, it may be inactivated by chemical reactions, or it may build up in the soil until it reaches a toxic level. An element at a given concentration in water may be immediately toxic to a crop or it may require a number of years to accumulate in the soil before it becomes toxic.

There is a long list of elements that can cause a toxic effect on crops, including boron, chlorine and others.

The following tables show the interpretation of boron and chlorine results:

Table 2: Boron (B).

Concentration	Effect on crops
Below 0.5 ppm	Satisfactory for all crops.
0.5-1.0 ppm	Satisfactory for most crops.
1.0-2.0 ppm	Satisfactory for semi-tolerant crops.
2.0-4.0 ppm	Satisfactory for tolerant crops only.

Table 3: Chlorine (Cl).

Concentration me/l	Concentration ppm	Effect on crops
Below 2	Below 70	Generally safe for all plants.
2-4	70-140	Sensitive plants show injury.
4-10	140-340	Moderately tolerant plants show injury.
Above 10	Above 350	Can cause severe problems.

Bicarbonate Concentration

Waters high in bicarbonate (HCO_3^-) will tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) when the soil solution concentrates through evapotranspiration. This means that the SAR value will increase—the relative proportion of sodium ions becoming greater. This, in turn, will increase the sodium hazard of the water to a level greater than indicated by the SAR value.

For More Information

United States Salinity Laboratory Staff. 1969. Diagnosis and Improvement of Saline and Alkali Soils. USDA Agricultural Handbook 60.