Irrigation Water Classification Systems

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Irrigation water quality refers to the kind and amount of salts present in the water and their effects on crop growth and development. Salts are present in variable concentrations in all waters, and the salt concentrations influence osmotic pressure of the soil solution: the higher the concentration, the greater the osmotic pressure.

Osmotic pressure in turn affects the ability of plants to absorb water through their roots. Plants can absorb water readily when osmotic pressure is low, but absorption becomes more difficult as the pressure increases. Even if the soil is thoroughly wet, plant roots have difficulty absorbing water when the osmotic pressure is high. When the pressure is unusually high, it may even be impossible for plants to absorb sufficient water for normal plant growth. Under these conditions, plants may actually wilt when the roots are in water.

Salts break down into ions when they go into solution. The various anions and cations produced when the salts are dissolved in water exert considerably different effects on plants.

PRINCIPAL CATIONS

Calcium

Calcium (Ca) is an essential plant nutrient found extensively in New Mexico soils. It occurs as limestone (calcium carbonate) and gypsum (calcium sulfate). Calcium carbonate is considered slightly soluble, while calcium sulfate is moderately soluble. Waters from areas where gypsum is prominent are almost always high in calcium sulfate. Examples of areas where this condition occurs are the Pecos Valley, the Tularosa Basin, and at locations in the Estancia Valley.

Waters high in calcium or magnesium are considered hard and are not desirable for domestic water supplies, but hard water is considered good for irrigation. Calcium helps keep soils in good physical condition, which favors good water penetration and easy tilling.

Magnesium

Magnesium (Mg) is another essential plant nutrient found in abundance in New Mexico well water. Chemical reactions of magnesium in the water are similar to those of calcium. Magnesium normally occurs at about half the concentration of calcium; however, in the Portales area some irrigation waters have a magnesium concentration equal to or higher than calcium.

Sodium

Sodium (Na), another cation, occurs in almost all irrigation waters in the state. Not generally considered an essential plant nutrient, it is the most injurious of the cations found in irrigation waters. Unlike calcium and magnesium waters, those high in sodium are considered “soft” and are generally undesirable for irrigation. Unfavorable conditions are likely to develop when the concentration of sodium exceeds that of calcium plus magnesium.

When clay particles adsorb the sodium, they tend to disperse and create “slick spots.” Sodium-affected soils take water slowly and form dry, hard clods that melt when wetted and tend to seal the soil surface, leaving a slick appearance. Sodium not only affects the soil structure, but also may have a toxic effect on plants.

Sodium-affected soils can be improved by exchanging the adsorbed sodium with calcium and leaching out the sodium salt. Materials used to improve sodium soils include gypsum, sulfuric acid, and sulfur.

Potassium

Potassium (K) is an essential plant nutrient commonly found in good supply in New Mexico soils. Although rocks and minerals containing potassium are common in New Mexico, potassium is a minor element in irrigation waters; consequently, potassium determination is no longer a routine part of irrigation water analysis.

PRINCIPAL ANIONS

Sulfate

The most dominant anion in most well waters in the state is the sulfate (SO_4) ion. The sulfate ion causes no particular harmful effects on soils or plants; however, it contributes to increased salinity in the soil solution.

Chloride

The next most common anion is the chloride (Cl) ion. Unlike sulfate, the chloride ion has a direct toxic effect on some plants, while also contributing to the salinity of the soil solution.

Carbonate and Bicarbonate

The carbonate (CO_3) and bicarbonate (HCO_3) ions are of minor importance in well waters except for the southwestern part of the state.

Other Ions

Other ions that are sometimes determined in water analyses are boron, nitrates, silicates, and fluorides. Boron and nitrates are the only ones of much importance for irrigation waters. Except for some waters in the Carlsbad area, almost all waters tested have been low in nitrates. Waters tested for boron indicate that New Mexico waters do not contain harmful amounts of boron.

WATER QUALITY

Irrigation water quality is determined several ways, including the degree of acidity or alkalinity (pH), electrical conductivity (EC), residual sodium carbonate (RSC), and sodium adsorption ratio (SAR).

pH

The hydrogen ion concentration (pH) of water is a measure of its acidity or alkalinity. A neutral pH, neither acid nor alkaline, is 7.0; waters with pH below 7 are acidic and above 7 are alkaline. A pH of 8.5 or higher is a good indication that the water is high in soluble salts. Using waters with high pH may require special cropping and irrigation practices.

Electrical Conductivity

The total concentration of salts in an irrigation water is measured by the electrical current conducted by the ions in solution. This measurement is expressed as electrical conductivity or EC x 10^6. EC is an estimate of the quantity of salts in solution and is normally expressed in parts per million (ppm). The higher the salt concentration, the higher the EC.

Residual Sodium Carbonate

Waters containing a carbonate plus bicarbonate concentration greater than the calcium plus magnesium concentration have what is termed "residual sodium carbonate" [RSC = (CO_3 + HCO_3) - (Ca + Mg)].

The potential for a sodium hazard is increased as RSC increases, and much of the calcium and sometimes the magnesium is precipitated out of solution when water is applied to the soil. Salts become concentrated when the soil dries out, as less soluble ions such as calcium and magnesium tend to precipitate out and are removed from the solution. The sodium percentage increases when calcium and magnesium are removed from the solution, increasing the rate of sodium adsorption on soil particles. Waters having high chlorides and sulfates do not cause as much change in the RSC, as chlorides and sulfates are more soluble than carbonates and bicarbonates.

Sodium Adsorption Ratio

The sodium adsorption ration (SAR) indicates the effect of relative cation concentration on sodium accumulation in the soil; thus, SAR is a more reliable method for determining this effect than sodium percentage. SAR is calculated using the following formula:

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

Ions are expressed as milliequivalents per liter (meq/L). The potential for a sodium hazard increases in waters with higher SAR values.

WATER QUALITY CLASSIFICATIONS

The Enviro-Ag Laboratory at NMSU uses two types of irrigation water classifications in their water analysis reports: U.S. Salinity Laboratory classifications and NMSU classifications.

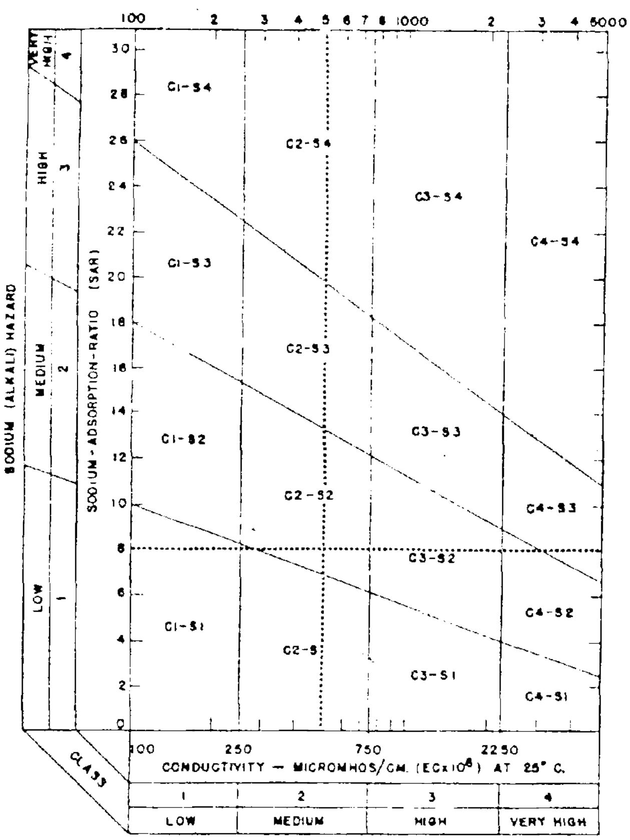
U.S. Salinity Laboratory Classification

This system uses SAR and EC x 10^6 values for classifying water. Figure 1 is a simplified diagram developed at that laboratory for use in classifying irrigation waters. EC x 10^6 values are shown across the bottom and top of the diagram; SAR values are shown along the left side.

Use this figure by finding the EC x 10^6 value on the irrigation water analysis report and locating it along the bottom and top margins of the figure. Draw a line from the EC value on the bottom margin straight up to the same value on the top margin. Next, find the SAR value on the analysis report and locate it on the left margin of the diagram. Draw a line from this point horizontally across the diagram to the right margin. The area in which the two lines meet is the classification of your irrigation water.

Example. Assume an EC x 10^6 value of 500 and an SAR value of 8. Drawing the lines at those points (dotted lines on diagram), we find the water is classified as C2-S2, or medium salinity–medium sodium.

Figure 1. Diagram for the classification of irrigation waters.



Source: Agriculture Handbook 60, U.S. Dept of Agriculture

Salinity Hazard:

- Low-salinity water (C1) can be used for irrigation on most crops in most soils with little likelihood that soil salinity will develop.
- Medium-salinity water (C2) can be used if a moderate amount of leaching occurs.
- High-salinity water (C3) cannot be used on soils with restricted drainage.
- Very high-salinity water (C4) is not suitable for irrigation under ordinary conditions, but it may be used occasionally under very special circumstances.

Sodium Hazard:

- Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium.
- Medium-sodium water (S2) may cause an alkalinity problem in fine-textured soils under low-leaching conditions. It can be used on coarse-textured soils with good permeability.
- High-sodium water (S3) may produce an alkalinity problem. This water requires special soil management such as good drainage, heavy leaching, and possibly the use of chemical amendments such as gypsum.
- Very high sodium water (S4) is usually unsatisfactory for irrigation purposes.

NMSU Classifications

In New Mexico, local soil conditions and crops play a major part in determining whether irrigation water can be used with ordinary precautions or whether it must be handled with great care. Accordingly, three classification systems are proposed for groups of groundwater areas in the state. Group I waters are those in the vicinity of Carlsbad, Artesia, and Roswell; in the Portales area; and in the Tularosa Basin. Group II waters are in the southwestern part of New Mexico, including Deming, Columbus, the Animas Valley, the Gila drainage, and nearby areas. Group III waters are in the Estancia Valley, Lea County, the House area, the Bluewater area, and the Rio Grande Valley and include most of the other smaller areas in the state where well water is used for irrigation.

The classifications used in this guide are based on three classes of water. Class 1 water is suitable for most crops under most conditions. Class 2 water can be used satisfactorily for most crops if care is taken to prevent the accumulation of soluble salts and sodium in the soil. Class 3 water is generally unsatisfactory for crop production. The less salty water in Class 3 may be used as a supplemental source of water if the regular water is of better quality.

Group I

Most of the waters in Group I contain moderate amounts of salt, but all of these areas have some water with excessive salt concentrations. SARs in a group of water samples taken several years ago averaged highest in the Roswell area and lowest in the Artesia area. Only one water had any RSC.

A classification system proposed for Group I waters is presented in table 1.

Table 1. Quality classes for irrigation well waters from group I areas.

Class	Electrical Conductivity EC X 10^6
1	0–1500
2	1500–4500
3	above 4500

Group II

The irrigated areas in Group II include the Mimbres groundwater basin, the Animas Valley, and scattered pump-irrigated lands in the vicinity of Lordsburg, the Playas Valley, the Hachita Valley, and the Rodeo area. The waters are generally low in salt, with moderate-to-high sodium percentages and moderate-to-high SARs. All of them contain RSC.

Sodium is the dominant cation, followed by calcium, and bicarbonate is often the dominant anion. Sodium percentage, sodium adsorption ratio, residual sodium carbonate, and the carbonate plus bicarbonate content increase as the EC increases. The main problem with soils in this group is the sodium hazard.

The classification system proposed for Group II waters is presented in table 2.

Table 2. Quality classes for irrigation well waters from Group II areas.

Class	Electrical Conductivity EC X 10^6	Residual Sodium Carbonate (meq./L)
1	0–750	0–1
2	750–2250	1–2.5
3	above 2250	above 2.5

Group III

The classification system proposed for Group III waters, which represent the remainder of the state's irrigation water, is presented in table 3. Generally, these waters have little or no sodium hazard.

Table 3. Quality classes for irrigation well waters from Group III area.

Class	Electrical Conductivity EC X 10^6
1	0–1000
2	1000–3000
3	above 3000

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