

Lecture No. 26

Quality of Irrigation Water

26.1 Introduction

All irrigation waters are not pure and may contain some soluble salts. In arid and semi-arid regions successful crop production without supplemental irrigation is not possible. Irrigation water is usually drawn from surface or ground water sources, which typically contain salts in the range of 200 to 2000 ppm (= 200 to 2000 g/m³). Irrigation water contains 10 – 100 times more salt than rain water. Thus, each irrigation event adds salts to the soil. Crop removes water from the soil to meet its water needs (ETc) leaving behind most of the salts to concentrate in the shrinking volume of soil water (Fig. 26.1). This is a continuous process. Application of saline water may hinder the crop growth directly and may also cause soil degradation. Beyond its effect on crop and soil, irrigation water of low quality can also affect environment by introducing potentially harmful substances in to surface and ground water sources. Therefore, a salt balance in the soil has to be maintained through proper water management practices for continuous and successful cultivation of crops.

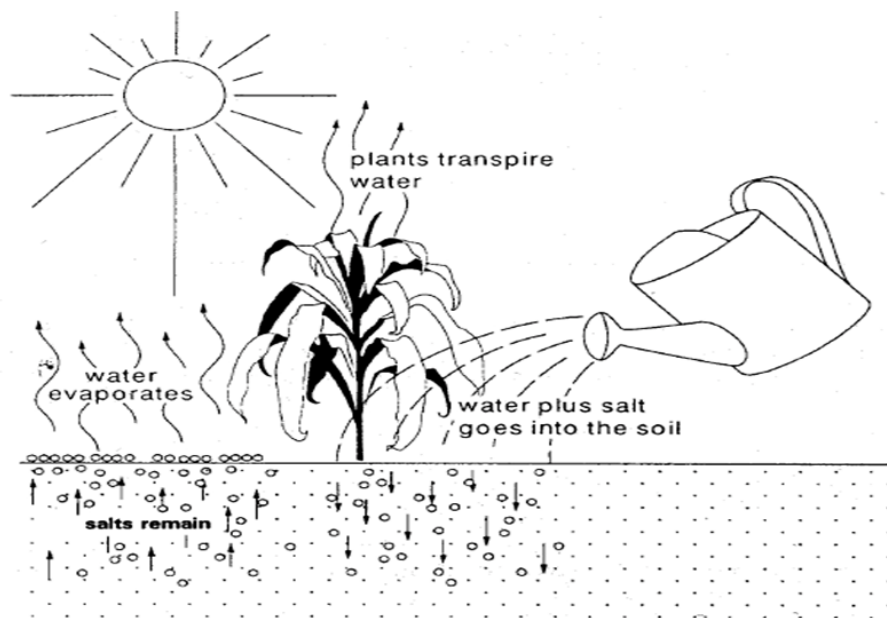


Fig. 26.1. Salinity buildup process in irrigated soils

26.2 Criteria to determine the quality of irrigation water

The criteria for judging the quality of irrigation water are: Total salt concentration as measured by electrical conductivity, relative proportion of sodium to other cations as expressed by sodium adsorption ratio, bicarbonate content, boron concentration and soluble sodium percentage.

26.2.1 Total soluble salts

Salinity of water refers to concentration of total soluble salts in it. It is the most important single criterion of irrigation water quality. The harmful effects increase with increase in total salt concentration. The concentration of soluble salts in water is indirectly measured by its electrical conductivity (EC_w). The quality of saline waters has been divided into five classes as per USDA classification given in Table 26.1.

Table 26.1. Salinity classes of irrigation water

Salinity class	Electrical conductivity	
	Micro mhos/cm	Milli mhos/cm
C₁ – Low	< 250	< 0.25
C₂ – Medium	25 – 750	0.25 – 0.75
C₃ – Medium to high	750 – 2250	0.75 – 2.25
C₄ – High	2250 – 5000	2.25 – 5.00
C₅ – Very high	> 5000	> 5.00

Adverse effects of saline water include salt accumulation, increase in osmotic potential, decreased water availability to plants, poor germination, patchy crop stand, stunted growth with smaller, thicker and dark green leaves, leaf necrosis & leaf drop, root death, wilting of plants, nutrient deficiency symptoms and poor crop yields.

26.2.2 Sodium Adsorption Ratio (SAR)

SAR of water indicates the relative proportion of sodium to other cations. It indicates sodium or alkali hazard.

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

The ion concentration is expressed as meq per litre. Increase in SAR of water increases the exchangeable sodium percentage (ESP) of soil. There is a linear relationship between SAR and ESP of the soil:

$$ESP = \frac{100 (0.23 + 0.0042SAR)}{1 + (0.23 + 0.0042SAR)}$$

As per USSSL, the sodicity classes of water are shown in Table 26.2.

Table 26.2. Sodicity classes of water

Sodium class	SAR value
S₁ – Low	< 10
S₂ – Moderate	10 – 18
S₃ – High	18 – 26
S₄ – Very high	> 26

Harmful effects of sodic water include destruction of soil structure, crust formation, poor seedling emergence, reduction in availability of N, Zn and Fe due to increased soil pH, Na toxicity and toxicity of B & Mo due to their excessive solubility.

26.2.3 Residual sodium carbonate

Bicarbonate is important primarily in its relation to Ca and Mg. There is a tendency for Ca to react with bicarbonates and precipitate as calcium carbonate. As Ca and Mg are lost from water, the proportion of sodium is increased leading to sodium hazard. This hazard is evaluated in terms of Residual Sodium Carbonate (RSC) as given below:

$$RSC \text{ (meq/litre)} = (CO_3^{--} + HCO_3^-) - (Ca^{++} + Mg^{++})$$

RSC is expressed in meq per litre. Water with RSC more than 2.5 meq/L is not suitable for irrigation. Water with 1.25 to 2.5 meq/L is marginally suitable and water with less than 1.25 meq/L is safe for use.

26.2.4 Boron content

Though boron is an essential micronutrient for plant growth, its presence in excess in irrigation water affects metabolic activities of the plant. For normal crop growth the safe limits of boron content are given in Table 26.3.

Table 26.3. Permissible limits of boron content in irrigation for crops

Boron (ppm)	Quality rating
< 3	Normal
3 - 4	Low
4 - 5	Medium
5 - 10	High
More than 10	Very high

26.3 Leaching requirement

Leaching requirement (LR) is that fraction of total crop water requirement which must be leached down below the crop root zone depth to control salts within the tolerance level (ECe) of the crop.

$$\text{Leaching Requirement (LR)} = \frac{EC_w}{5(EC_e) - EC_w}$$

Where:

EC_w = Salinity of applied water in dS/m

EC_e = Threshold level soil salinity of the crop in dS/m

26.4 Management practices for using poor quality water

Whenever, it is inevitable to use water of poor quality water for crop production appropriate management practices helps to obtain reasonable yield of crops. Some of the important management practices are as follows:

- a) **Application of gypsum:** Chemical amendments such as gypsum, when added to water will increase the calcium concentration in the water, thus reducing the sodium to calcium ratio and the SAR, thus improving the infiltration rate. Gypsum requirement is calculated based on relative concentration of Na, Mg & Ca ions in irrigation water and the solubility of gypsum. To add 1 meq/L of calcium, 860 kg of gypsum of 100% purity per ha m of water is necessary.
- b) **Alternate irrigation strategy:** Some crops are susceptible to salinity at germination & establishment stage, but tolerant at later stage. If susceptible stages are ensured with good quality water, subsequent tolerant stages can be irrigated with poor quality saline water.
- c) **Fertilizer application:** Fertilizers, manures, and soil amendments include many soluble salts in high concentrations. If placed too close to the germinating seedling or to the growing plant, the fertilizer may cause or aggravate a salinity or toxicity problem. Care, therefore, should be taken in placement as well as timing of fertilization. Application of fertilizers in small doses and frequently improve uptake and reduce damage to the crop plants. In addition, the lower the salt index of fertilizer, the less danger there is of salt burn and damage to seedlings or young plants.
- d) **Methods of irrigation:** The method of irrigation directly affects both the efficiency of water use and the way salts accumulate. Poor quality irrigation water is not suitable for use in sprinkler method of irrigation. Crops sprinkled with waters having excess quantities of specific ions such as Na and Cl cause leaf burn. High frequency irrigation in small amounts as in drip irrigation improves water availability and uptake due to microleaching effect in the wetted zone.
- e) **Crop tolerance:** The crops differ in their tolerance to poor quality waters. Growing tolerant crops when poor quality water is used for irrigation helps to obtain reasonable crops yields. Relative salt tolerance of crops is given in Table 26.4.
- f) **Method of sowing:** Salinity reduces or slows germination and it is often difficult to obtain a satisfactory stand. Suitable planting practices, bed shapes, and irrigation management can greatly enhance salt control during the critical germination period. Seeds have to be placed in the area where salt concentration is less. Salt accumulation is less on the slope of the ridge and bottom of the ridge. Therefore, placing the seed on the slope of the ridge, several cm below the crown, is recommended for successful crop establishment (Fig. 26.2).

Table 26.4. Relative salt tolerance of crops

Tolerant	Field crops: Cotton, Safflower, Sugarbeet & Barley Fruit crops: Date palm & Guava Vegetables: Turnip & Spinach Forage crops: Berseem & Rhodes grass
Semi tolerant	Field crops: Sorghum, Maize, Sunflower, Bajra, Mustard, Rice & Wheat Fruit crops: Fig, Grape & Mango Vegetables: Tomato, Cabbage, Cauliflower, Cucumber, Carrot & Potato Forage crops: Senji & Oats
Sensitive	Field crops: Chick pea, Linseed, Beans, Greengram & Blackgram Fruit crops: Apple, Orange, Almond, Peach, Strawberry, Lemon & Plum Vegetables: Radish, Peas & Lady's finger

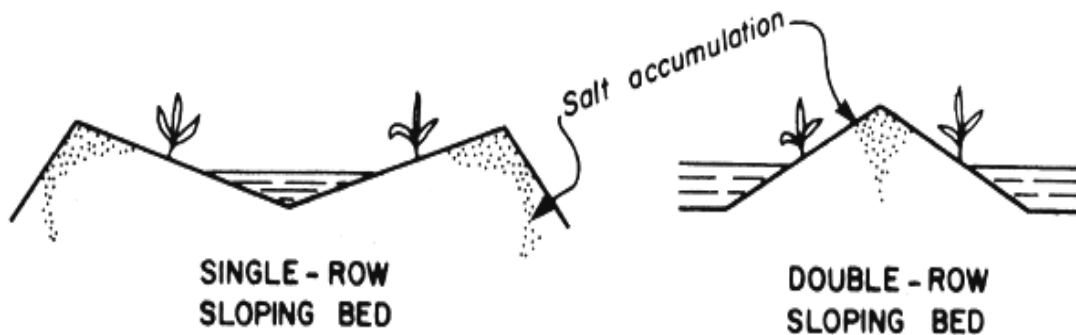


Fig. 26.2. Salinity control with sloping beds

g) Drainage: Provide adequate internal drainage. Meet the necessary leaching requirement depending on crop and EC of water. This is necessary to avoid build of salt in the soil solution to levels that will limit crop yields. Leaching requirement can be calculated from water test results and tolerance levels of specific crops.

h) Other management practices

- ◆ **Over aged seedlings in rice:** Transplanting of rice with over aged seedlings at a closer spacing results in better establishment in salt effected soils than normal aged seedlings. In case of other crops like finger millet, pearl millet etc., transplanting is better method than direct sowing of these crops for proper establishment.
- ◆ **Mulching:** Mulching with locally available plant material help in reducing salt problems by reducing evaporation and by increasing infiltration.
- ◆ **Soil management:** All soil management practices that improve infiltration rate and maintain favourable soil structure reduces salinity hazard.
- ◆ **Crop rotation:** Inclusion of crops such as rice in the rotation reduces salinity.