# CAI 334 IRRIGATION WATER QUALITY AND WASTE WATER MANAGEMENT

## UNIT II NOTES

## THE CHEMICAL QUALITY OF IRRIGATION WATER

### 1. Composition and concentration of soluble salts

Salinity is a common problem facing farmers who irrigate in arid climates. This is because all irrigation waters contain soluble salts. Whether derived from springs, diverted from streams, or pumped from wells, the waters contain appreciable quantities of chemical substances in solution. The composition of salts in water varies according to the source and properties of the constituent chemical compounds. These salts include substances such as gypsum (calcium sulphate, CaSO4.2H2O), table salt (sodium chloride NaCl) and baking soda (sodium bicarbonate NaHCO3). When dissolved in water, salts separate into ions; e.g. sodium chloride breaks down into sodium and chloride ions.

| Ions | Chemical symbol | Equivalent weight |
|---|---|---|
| ***Anions (acidic ions)*** | | |
| Chloride | $Cl^-$ | 35.5 |
| Sulphate | $SO_4^{--}$ | 48 |
| Carbonate | $CO_3^{--}$ | 30 |
| Bicarbonate | $HCO_3^-$ | 61 |
| Nitrate | $NO_3^-$ | 62 |
| ***Cations (basic ions)*** | | |
| Sodium | $Na+$ | 23 |
| Potassium | $K+$ | 39.1 |
| Calcium | $Ca++$ | 20 |
| Magnesium | $Mg++$ | 12.2 |

All ions are expressed in the form of milligrams per litre (mg/litre or ppm) and milliequivalents per litre (meq/litre). The latter unit is preferable because water quality criteria involve milliequivalents per litre calculations.

The conversion formula is:

$$meq/litre = \frac{mg/litre}{equivalentweight}$$

The common method for evaluating the total salts content in water is by measuring the electrical conductivity of water (ECw) at 25°C. Electrical conductivity is expressed in deciSiemens per metre.

The relationship between electrical conductivity and total dissolved salts (TDS) is:

ECw (dS/m) x 640 = TDS (mg/litre)

**Effect of soluble salts on plants**

The application of irrigation water to the soil introduces salts into the root zone. Plant roots take in water but absorb very little salt from the soil solution. Similarly, water evaporates from the soil surface but salts remain behind. Both processes result in the gradual accumulation of salts in the root zone, even with low salinity water. This situation may affect the plants in two ways: a) by creating salinity hazards and water deficiency; and b) by causing toxicity and other problems.

**2.sodium hazard (sodium adsorption ratio-SAR)**

Sodium hazard A soil permeability problem occurs with a high sodium content in the irrigation water. Sodium has a larger concentration than any other cation in saline water, its salts being very soluble. Positively charged, it is attracted by negatively charged soil particles, replacing the dominant calcium and magnesium cations. The replacement of the calcium ions with sodium ions causes the dispersion of the soil aggregates and the deterioration of its structure, thus rendering the soil impermeable to water and air. The increase in the concentration of exchangeable sodium may cause an increase in the soil pH to above 8.5 and reduce the availability of some micronutrients, e.g. iron and phosphorus.

The degree of absorption to the clay particles of the sodium depends on its concentration in the water and the concentration of the calcium and magnesium ions. This reaction is called cation exchange and it is a reversible process. The capacity of soil to adsorb and exchange cations is limited. The percentage of the capacity that sodium takes up is known as the exchangeable sodium percentage (ESP). Soils with ESP > 15 are seriously affected by adsorbed sodium. The sodium problem is reduced if the amount of calcium plus magnesium is high compared with the amount of sodium. This relation is called the sodium adsorption ratio (SAR) and it is a calculated value from the formula:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$ *(ions units meq/litre)*

**Residual sodium carbonate (RSC)**

This is defined as the difference in milliequivalents per litre between the bicarbonate ions and those of calcium and magnesium. Calcium and magnesium may react with bicarbonate and precipitate as carbonates. The relative sodium concentration in the exchangeable complex increases resulting in the dispersion of soil. When the RSC value is lower than 1.25 meq/litre, the water is considered good quality, while if the RSC value exceeds 2.5 meq/litre, the water is considered harmful.

**4.Ion toxicity**

Many fruit trees and other cultivations are susceptible to injury from salt toxicity. Chloride, sodium and boron are absorbed by the roots and transported to the leaves where they accumulate. In harmful amounts, they result in leaf burn and leaf necrosis. Moreover, direct contact during sprinkling of water drops with a high chloride content may cause leaf burn in high evaporation conditions. To some extent, bicarbonate is also toxic. Other symptoms of toxicity include premature leaf drop, reduced growth and reduced yield. In most cases, plants do not show clear toxicity problems until it is too late to remedy the situation. Chloride and sodium ions are both present in the solution. Thus, it is difficult to determine whether the damage caused is due to the one or to the other. Chloride ions in high concentrations are known to be harmful to citrus and many woody and leafy field crops.

A chloride content exceeding 10 meq/litre may cause severe problems to crops. The effect of sodium toxicity is not very clear. However, it has been found that it may cause some direct or indirect damage to many plants. Boron is an essential element to the plants. However, where present in excessive amounts, it is extremely toxic, even at relatively very low concentrations of 0.6 mg/litre. Toxicity occurs with the uptake of boron from the soil solution. The boron tends to accumulate in the leaves until it becomes toxic to the leaf tissue and results in the death of the plant. In arid regions, boron is considered the most harmful element in irrigation water.

**II.Safe limits**

TDS levels below 700 mg/L and SAR below 4 are considered safe; TDS levels between 700 and 1,750 mg/L and SAR levels between 4 and 9 are considered possibly safe, while levels above these are considered hazardous to any crop. When the RSC value is lower than 1.25 meq/litre, the water is considered good quality, while if the RSC value exceeds 2.5 meq/litre, the water is considered harmful.

| **Classesofwater** | **TDS** | **ElectricalConductivity** |
|---|---|---|
| | (mg/l) | (dS/m)* |
| Class1,Excellent | <1,000 | ≤0.25 |
| Class2,Good | | 0.25- 0.75 |
| Class3,Permissible[1] | 1,000–2,000 | 0.76- 2.00 |

| | | |
|---|---|---|
| Class4,Doubtful[2] | | 2.01- 3.00 |
| Class5,Unsuitable[2] | >2,000 | ≥3.00 |
| *dS/mat25ºC=mmhos/cm<br>[1]Leachingneededifused.<br>[2]Gooddrainageneededandsensitiveplantswillhavedifficultyobtainingstands. | | |