Chapter 40: Quality of Irrigation Water

Introduction

The quality of water used for irrigation is as important as its quantity. While the volume of water determines the extent of area that can be irrigated, the quality determines the long-term sustainability of soil fertility, crop yield, and environmental health. Poor-quality irrigation water may contain excess salts, toxic elements, or biological contaminants, which can affect plant growth, deteriorate soil structure, and reduce agricultural productivity over time.

This chapter explores the parameters used to assess irrigation water quality, its sources of degradation, methods for testing, interpretation of results, and management practices for maintaining soil and crop health.

40.1 Sources of Irrigation Water

Irrigation water can be sourced from:

- **Surface water** (rivers, canals, reservoirs)
- **Groundwater** (dug wells, tube wells)
- **Treated wastewater** (urban reuse)
- **Rainwater harvesting systems**

Each source varies in quality based on local geology, pollution levels, and human activity. Groundwater, in particular, is more prone to salinity and high mineral content.

40.2 Criteria for Assessing Irrigation Water Quality

The suitability of water for irrigation is determined by the following key criteria:

40.2.1 Salinity Hazard (Total Dissolved Solids - TDS or EC)

- **Electrical Conductivity (EC)** is a measure of water's salinity and its ability to conduct electricity due to the presence of dissolved salts.

- High EC affects osmotic balance, making it harder for plants to absorb water.
- **Acceptable EC Values**:
    - < 0.7 dS/m – Excellent
    - 0.7 – 3.0 dS/m – Moderate
    - 3.0 dS/m – Unsuitable for many crops

40.2.2 Sodium Hazard (Sodium Adsorption Ratio - SAR)

- SAR indicates the sodium content relative to calcium and magnesium.
- High SAR leads to soil dispersion and poor permeability.
- **SAR formula**:

$$\text{SAR} = ¿¿$$

- SAR < 10 – Safe for most soils
- SAR 10–18 – Moderate hazard
- SAR > 18 – Unsuitable without treatment

40.2.3 Residual Sodium Carbonate (RSC)

- RSC assesses the risk of sodium build-up due to carbonate and bicarbonate ions.

$$\text{RSC} = \left(C O_3^{2^-} + H C O_3^-\right) - ¿$$

- RSC < 1.25 meq/L – Safe
- 1.25–2.5 meq/L – Marginal
- 2.5 meq/L – Unsuitable

40.2.4 Magnesium Ratio (MR)

- High magnesium reduces soil aggregation and affects soil structure.

$$\text{MR} = M \frac{g^{2+¿}}{C a^{2+¿ + M g^{2+¿}} \times 100 ¿ ¿}$$

- MR > 50% is generally considered harmful.

40.2.5 Boron Toxicity

- Boron is essential in trace amounts but toxic at higher concentrations.
- Sensitive crops show toxicity symptoms at > 1.0 ppm.
- Acceptable boron levels:
    - < 0.5 ppm – Safe
    - 0.5–2.0 ppm – Moderate
    - 2.0 ppm – Toxic

40.2.6 Chloride and Sulphate Content

- Chloride > 10 meq/L can cause leaf burn and crop yield reduction.
- Sulphate concentrations are less toxic but contribute to total salinity.

40.3 Classification of Irrigation Water Quality

Based on **US Salinity Laboratory Classification (1954)**:

- **Salinity Classes (C1 to C4):**
    - C1: Low salinity (EC < 0.25 dS/m)
    - C2: Medium (EC 0.25–0.75)
    - C3: High (EC 0.75–2.25)
    - C4: Very high (EC > 2.25)
- **Sodium Hazard Classes (S1 to S4):**
    - S1: Low sodium (SAR < 10)
    - S2: Medium (SAR 10–18)
    - S3: High (SAR 18–26)
    - S4: Very high (SAR > 26)

A combination like **C2–S1** indicates medium salinity and low sodium – generally acceptable for most crops and soils.

40.4 Effects of Poor Quality Irrigation Water

40.4.1 On Soil

- Salinization
- Alkalinity and reduced permeability
- Crusting and compaction
- Degradation of soil structure

40.4.2 On Crops

- Osmotic stress
- Nutrient imbalance
- Leaf burn, stunted growth
- Yield reduction or crop failure

40.4.3 On Environment

- Groundwater contamination
- Salt accumulation in downstream areas
- Reduced biodiversity

40.5 Crop Tolerance to Salinity

Different crops have varying tolerance to salinity:

- **Highly tolerant**: Barley, cotton, sugar beet
- **Moderately tolerant**: Wheat, maize, sorghum
- **Sensitive**: Beans, carrot, citrus

Threshold EC levels for yield reduction are determined experimentally and vary by crop species and soil type.

40.6 Methods of Testing Irrigation Water Quality

40.6.1 Field Tests

- EC meter
- pH meter
- Portable test kits for Cl^-, NO_3^-, etc.

40.6.2 Laboratory Analysis

- Titration methods (for carbonates and bicarbonates)
- Atomic Absorption Spectrometry (for trace elements)
- Ion chromatography

Samples should be collected carefully and analyzed promptly for accurate results.

40.7 Management Practices for Using Marginal Quality Water

40.7.1 Blending Water

- Mixing poor quality water with good quality water to dilute harmful concentrations.

40.7.2 Leaching

- Periodic application of excess water to flush salts below the root zone.

40.7.3 Soil Amendments

- Gypsum application to counter high sodium levels and improve soil structure.

40.7.4 Crop Management

- Selection of salt-tolerant crops.
- Use of organic mulches to reduce evaporation and salt build-up.

40.7.5 Improved Irrigation Techniques

- Drip irrigation to minimize salt contact with foliage.
- Alternate furrow irrigation for salinity control.

40.8 Guidelines and Standards

BIS (Bureau of Indian Standards) Guidelines – IS: 11624 (1986)

- Specifies water quality norms for irrigation.
- Includes permissible limits for EC, SAR, RSC, and individual ions.

FAO Guidelines (Ayers and Westcot, 1985)

- Widely used international standard.
- Provides classification and management recommendations for various crops and soils.

40.9 Reuse of Wastewater for Irrigation

- Increasing interest due to water scarcity.
- Needs proper treatment to remove pathogens and toxic elements.
- Risk management through restricted irrigation (non-food crops), timing, and methods.

40.10 Case Studies and Regional Examples

- **Punjab and Haryana** – Over-extraction of groundwater leading to high salinity.
- **Coastal areas** – Saline intrusion into aquifers.
- **Urban fringe zones** – Use of untreated sewage leading to heavy metal contamination.
