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Water Quality Standards for Irrigation

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INTRODUCTION

Most of human activities including agriculture need ample quantities of water. Increasing demands of food grain by ever increasing population has resulted in the over utilization of water resources. Irrigation water quality refers to the kind and amount of salts present in the water and their effects on crop growth and development. High salt concentrations influence osmotic pressure of the soil solution and affect the ability of plants to absorb water through their roots. However, an appropriate evaluation of the water quality prior to its use in irrigation will help in arresting any harmful effect on plant productivity and ground water recharge.

The suitability of water for irrigation is determined in several ways including the degree of acidity or alkalinity (pH), EC, Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Permeability Index (PI) and Total Hardness (TH) along with the effects of specific ions. The assessment of water quality criteria for irrigation is based on the consideration of the related aspects like the possible effects on the physico-chemical properties of the soil and the impact on crop yield.

Various criteria are considered in evaluating the standards of irrigation water.

- Salinity hazard - total soluble salt content
- Sodium hazard - relative proportion of sodium to calcium and magnesium ions
- pH - acid or basic
- Alkalinity - carbonate and bicarbonate
- Specific ions: chloride, sulfate, boron, and nitrate.

1. Electrical conductivity

The total soluble salt content of irrigation water is measured either by determining its Electrical Conductivity (EC), reported as microseimens per centimeter or by determining the actual salt content in parts per million (ppm). According to US Salinity laboratory classification, the irrigation water classified into the following classes.

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Table 1. Electrical conductivity of irrigation water classes

S.No.	Water Classes	EC dSm^{-1}	Quality	Remarks
1	C1 Low saline	< 0.25	Good	Can be used for irrigation
2	C2 Medium saline	0.25 to 0.75	Fair	Can be used with moderate leaching
3	C3 High saline	0.75 to 2.25	Poor	Can be used for irrigation purposes with some management practices
4	C4 Very high saline	2.25-5.00	Very poor	Cannot be used for irrigation purposes

The higher the EC, the less water is available to plants, even though the soil may appear wet. Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as EC increases.

2. Potential salinity

It can be express by using the formula Cl + 1/2 SO_4^{2-} where ions are expressed in me L^{-1}.

Table 2. Potential salinity of irrigation water classes

S.No.	Potential salinity (me L^{-1})	Remarks
1	3-15	Can be recommended for medium permeability soils
2	3-7	Recommended for soils of low permeability

3. Salt Index (SI): salt index is given by Puri This explains the relationship between sodium and calcium concentration in waters.

PSI = (Total Na^+ - 24.5) - { (Total Ca^{2+} - Ca in $CaCO_3$) x 4.85}

If negative : Good quality water.

Positive : Poor quality water.

4. Sodicity hazard

High concentrations of sodium are undesirable in water because sodium adsorbs on soil cation exchange sites, causing soil aggregates to break down (deflocculating), sealing the pores of the soil and making it impermeable to water flow. The sodicity hazard of irrigation water is usually evaluated by: Sodium Adsorption Ratio (SAR), Adjusted SAR and Sodium to calcium activity ratio (SCAR).

4.1 Sodium Adsorption Ratio (SAR)

Irrigation water containing large amounts of sodium is of special concern due to sodium's effects on the soil and poses a sodium hazard. Sodium hazard is usually expressed in terms of SAR or the sodium adsorption ratio. SAR is calculated from the ratio of sodium to calcium and magnesium. The latter two ions are important since they tend to counter the effects of sodium. For waters containing significant amounts of bicarbonate, the adjusted sodium adsorption ratio (SARadj) is sometimes used.

$$SAR = \frac{[Na^+]}{\sqrt{\frac{([Ca^{2+}]+[Mg^{2+}])}{2}}}$$

where [ ] represents the concentration of cation in cmol(+)/L

note halving sum of $[Ca^{2+}]$ and $[Mg^{2+}]$ before taking square root

United States Salinity Laboratory (USSL) staff introduced the concept of sodium adsorption ratio (SAR) to predict sodium hazard. Sodicity hazard also classified as the following classes.

Table 3. Sodium Adsorption Ratio of different irrigation water classes

S.No.	Classes	SAR value (me L^{-1})	Quality	Remarks
1	S1	<10	low sodium hazard	Little or no hazard
2	S2	10-18	medium sodium hazard	Appreciable hazard but can be used with appropriate management
3	S3	18-26	High sodium hazard	Unsatisfactory for most of the crops
4	S4	>26	Very high sodium hazard	Unsatisfactory for most of the crops

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4.2 Soluble sodium percentage

Soluble sodium per cent (SSP) is also used to evaluate sodium hazard. SSP is defined as the ration of sodium in equivalents per million to the total cation equivalents per million multiplied by 100. A water with a SSP greater than 60 per cent may result in sodium accumulations that will cause a breakdown in the soil's physical properties.

$$SSP = \frac{Na}{Ca + Mg + K + Na}$$

5. Alkalinity hazard

Residual Sodium Carbonate (RSC), Residual Sodium Bicarbonate (RSBC) and Bicarbonates (HCO_3-) occur in low salinity water and its concentration usually decreases with an increase in EC. The proportion of bicarbonate ion is higher than calcium ions are considered undesirable, because after evaporation of irrigation water bicarbonate ions tend to precipitate calcium ions. Hence, the effect of bicarbonate together with carbonates evaluated through RSC.

$$RSC = (CO3^{-} + HCO3^{-}) - (Ca2^{+} + Mg2^{+}), \text{ all ions expressed as me } L^{-1}$$

5.1 Residual sodium carbonate (RSC)

The residual sodium carbonate is a quick test to determine if irrigation water can reduce free in the free calcium and magnesium in the sediment. RSC is calculated by subtracting the water's calcium and magnesium forms its carbonate and bicarbonate.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca2^{+} + Mg^{2+})$$

Where all ionic concentrations are expressed in mill equivalents per liter.

Table 4. Residual sodium carbonate of different irrigation water classes

S.No.	RSC value (mel^{-1})	Water quality
1	<1.25	Water can be used safely
2	1.25 – 2.5	Water can be used with certain management
3	>2.5	Unsuitable for irrigation purpose

6. Permeability Index

This refers to proportion of sodium and bicarbonate in relation to cations in water.

$$\text{Permeability Index(PI)} = \frac{Na + HCO_3}{Ca + Mg + Na} \times 100$$

PI <60 per cent – good quality water and suitable for irrigation

PI >60 per cent – poor quality water and unsuitable for irrigation

Besides above parameter, concentration of specific ion if exceeds certain limits in water then that water may not be suitable for irrigation. Excess of any ion (B, Cl, SO4, No-3, Fl) including heavy metal like Nickel, lead cadmium etc is injurious to plants. Boron is excessively available is some locations which makes the water quality poor.

7. Boron concentration

It is evident that boron is essential for the normal growth of plant, but the amount required in small amount the permissible limts of boron in irrigation water is given below.

Table 5. Boron concentration of different irrigation water classes

S. No.	Concentration of boron	Quality	Remarks
1	0.5	Low B	waters can be used for irrigation
2	0.5 to 1	Medium B waters	Water can be used with certain management
3	1.0 to 2	High B waters	Resistant crops can be grown
4	2.0 to 4	Very high B waters	unsuitable
5	4.0	Excessive B waters	unsuitable

8. Chloride:

The occurrence of chloride ions in irrigation water increases with increase in EC and sodium ions. Therefore, these ions are most dominant in very high salinity water. Unlike sodium ions, the chloride ions neither affect on the physical properties of the soil, nor are absorbed by the soil.

$$\text{Chloride concentration (me L}^{-1}\text{)} = \frac{Cl^-}{CO_3^{2-} + HCO_3^- + SO_4^{2-} + Cl^- + NO_2^{-3}}$$

Table 6. Chloride concentration of different water classes and their quality

S. No.	**Chloride concentration (me L^{-1})**	**Water quality**
1	< 4	Excellent water
2	4-7	Moderately good water
3	7-12	Slightly usable
4	12-20	Not suitable for irrigation
5	>20	Not suitable for irrigation

9. Sulphate:

Sulphate salts are less harmful when compared to chlorides. This is because when both the ions occur in this concentration, only half of the sulphate ions contribute to salinity due to the fact that approximately half of the sulphates gets precipitated as $CaSO_4$ while the other half remains in soluble form as Na-$MgSO_4$ in the soil.

Table 7. Sulphate concentration of different water classes and their quality

S. No.	**Sulphate concentration (me L^{-1})**	**Water quality**
1	< 4	Excellent water
2	4-12	Good to injurious
3	>12	Injurious to unsatisfactory

10. Fluorine:

fluorides are only sparingly soluble and are in only small amounts. The concentration of fluoride ranges from traces to more than 10 mg L^{-1} in natural water, and surface water do not exceed 0.3 mg L^{-1} unless they are polluted. Irrigation with fluoride saline water (upto 25 mg L^{-1}) has not been found to affect yield of wheat. Therefore, it is doubtful if fluoride requires any monitoring in India. At present, the average concentration of fluoride has not been observed to be very high (10 mg l^{-1}).

11. Nitrate:

Very frequently ground water contain high amount of nitrate. When such type of irrigation water is applied on soils continuously, various properties of soils are affected. NO3 me l-1 < 5 No problem 5-30 Intensity of problem is moderate > 30 Intensity of problem is severe.

12. Lithium :

Lithium is a trace element may be found in most of saline ground water and irrigated soils. It has been found that 0.05-0.1 ppm of lithium in water produce toxic effects on growth of citrus. It has

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also been reported that saline soils of varying degrees found in India contain lithium upto 2.5 ppm. Fortunately, the germination of majority of crops is not affected with this level of lithium content.

Management practices for using poor quality water

- Application of gypsum
- Alternate irrigation strategy
- Fertilizer application
- Methods of irrigation
- Crop tolerance:
- Method of sowing:
- Drainage Saline waters

Dealing with salinity in irrigation water:

1. Irrigate only well-drained soils.
2. Irrigate more frequently and determine leaching requirement. (See references 3,4 for explanation of of LR).
3. Minimize contact with plant leaves.
4. Plant salt-tolerant crops 5. avoid irrigation to seedlings and young plants.

