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Sridevy S
Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Sivakumar K
Krishi Vigyan Kendra, Papparapatty, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Parameswari E
Nammazhvar Organic Farming Research Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Davamani V
Directorate of NRM, TNAU, Coimbatore, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Thangadurai R
Krishi Vigyan Kendra, Papparapatty, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Vennila MA
Krishi Vigyan Kendra, Papparapatty, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Kumaresan P
Centre for Water and Geospatial Studies, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Sridevy S
Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Quality of irrigation water: An elixir for crop production

Sridevy S, Sivakumar K, Parameswari E, Davamani V, Thangadurai R, Vennila MA and Kumaresan P

Abstract
Irrigation water quality is an important criteria in deciding the crop production of an area. The parameters like pH, Electrical conductivity (EC), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Sulphate (SO_4^{2-}), Chloride (Cl^-), Boron (B). Fluorine (F), Sodium (Na) and Potassium (K) content are essential for the determination of irrigation water quality. The irrigation water may be saline (or) sodic based on the electrical conductivity values (dSm^{-1}). The other quality indices like Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC). Residual Sodium Bi-Carbonate (RSBC), Puri's Salt Index (PSI) will also help in identifying the suitability of irrigation water to a crop. The sensitivity of the crops to irrigation water will differ based on its salinity. Normally pulse crops are highly sensitive to salinity of irrigation water. Criteria have been fixed by Central Soil Salinity Research Institute (CSSRI), Karnal for the suitability of the irrigation water. Saline tolerant varieties like TRY 1, 2, 3 and CO 43 in paddy have been evolved in the soil salinity Research Centre located at Trichy. Similarly many saline tolerant varieties have been released for other crops also to manage the salinity and sodicity hazards. Recently many modern tools have also come to enlighten the farmers and scientists to understand the ground water quality and potential. Remote sensing and GIS is one of the emerging tool which helps in assessment and mapping of ground water.

Keywords: Quality of irrigation water, salinity, sodicity, remote sensing and GIS

Introduction
The quality of irrigation waters differs in various regions, countries and locations based on how the groundwater has been extracted and used, the rainfall intensity and subsequent aquifer recharge. The use of groundwater for agriculture in hot arid countries where rainfall is scarce leads to increase groundwater salinity and limits the selection of crops for cultivation. It is therefore important to determine the irrigation water quality. The concentration and composition of soluble salts in water determines its quality for irrigation. Four basic criteria for evaluating water quality for irrigation purposes are described, including water salinity (EC), sodium hazard (sodium adsorption ratio-SAR), residual sodium carbonates (RSC) and ion toxicity. Toxicities of boron and chlorides to plants are described. More specifically the relative tolerance levels of plants to boron is tabulated for easy understanding. The most important part of this chapter is the modification of water quality diagram of US Salinity Laboratory Staff published in the year 1954, this diagram does not present EC over 2250 µS cm^{-1}, however, most of the irrigation waters present salinity levels higher than 2250 µS cm^{-1}. Therefore, to accommodate higher water salinity levels the water classification diagram is extended to water salinity of 30,000 µS cm^{-1} allowing the users of the diagram to place EC values above 2250 µS cm^{-1}. The salinity and sodicity classes are included in this chapter to provide information for crop selection and develop salinity and sodicity management options. The procedures for water salinity reduction through blending of different waters and management of water sodicity using gypsum are described by giving examples.

Materials and Methods
A study was conducted in the ICAR - Krishi Vigyan Kendra farm located in Papparapatty of Dharmapuri district. The irrigation water samples were collected from four sources *viz*., one open well and three bore wells. The collected water samples were analysed for different water quality parameters *viz*., pH, EC, sodium, potassium, calcium, Magnesium, carbonate, bicarbonate and chloride.

The irrigation water was assessed for the following quality standards

1. pH – pH of water sample was recorded using glass electrode (Richards, 1968) [4]
2. Soluble salts- salinity (Ec) - Electrical Conductivity of water sample was measured using conductivity bridge and expressed in dSm^{-1} (Jackson, 1973) [2].

Cation

a. Calcium and Magnesium - Complexometric titration using Ethylene Diamine Tetra Acetic acid (EDTA) is followed for the estimation of calcium and magnesium (Tandon, 1995) [5].

b. Sodium and Potassium – Sodium and Potassium were determined using flame photometer (Richards, 1968) [4].

Anions

a. Chloride - Sample is titrated with $AgNO_3$in the presence of potassium chromate as indicator (Mohr's titration) for the estimation of chloride. Carbonates and bicarbonates, if present, were destroyed before performing the titration.

b. Carbonates and Bicarbonates - Carbonates and bicarbonates were determined by titrating against standard sulphuric acid using phenolphthalein and methyl orange as indicators. Addition of phenolphthalein gives pink colour in the presence of carbonates and titration with H_2SO_4 converts CO_3into HCO_3 decolourises the pink colour. Methyl orange is added which gives yellow colour. Further titration neutralises all the HCO_3 into water and CO_2. The end point is the color change from yellow to rosy red (Tandon, 1995) [5].

Classification of irrigation water

Irrigation waters were classified based on EC, RSC and SAR. EC classes were grouped into low saline (C1), medium saline (C2), high saline (C3) and very high saline (C4). Based on RSC the irrigation waters were classified into safe (< 1.25 mmol L^{-1}), marginally suitable (1.25 – 2.5 mmol L^{-1}) and unsuitable (> 2.5 mmol L^{-1}) (Eaton, 1950). Based on SAR and EC values sodium hazard classes were grouped into S1, S2, S3 and S4 representing low sodium, medium sodium, high sodium and very high sodium waters respectively.

The following are the irrigation water quality parameters with their ratings

1. Alkalinity (Based on pH)
2. Soluble salts- salinity (EC) (dSm^{-1})
3. Sodicity (SAR)
4. Alkalinity (RSC/RSBC)
5. EC and SAR
6. SAR and RSC

Table 1: Alkalinity (Based on pH)

pH	Classification	Interpretation
6.0 – 8.0	Normal	Can be used for all soils
8.1 – 8.5	Medium	Can be used in soils with good drainage and in the presence of enough organic matter
8.6 and above	Alkaline	In addition to all the criteria needed for the use of medium alkaline water certain special measures like application of gypsum, should be taken up.

Table 2: Soluble salts- salinity (EC) (dSm^{-1})

EC (dSm^{-1})	Quality
0 – 0.2	Non saline water
0.2 – 1.5	Normal water
1.5 – 3.0	Low salinity water
3.0 – 5.0	Medium salinity water
5.0 – 10.0	High salinity water
> 10.0	Very high salinity water

Table 3: Sodicity (SAR)

SAR	Quality
0 – 5	Non sodic water
5 – 10	Normal water
10 – 20	Low sodicity water
20 – 30	Medium sodicity water
30 – 40	High sodicity water
> 40	Very high sodicity water

Table 4: Alkalinity (RSC/RSBC)

RSC (meq L^{-1})	Quality
-ve	Non alkaline water
0	Normal water
0 – 2.5	Low alkalinity water
2.5 – 5.0	Medium alkalinity water
5.0 – 10	High alkalinity water
> 10	Very high alkalinity water

Table 5: EC and SAR

Salinity hazard	EC (dSm^{-1})	Sodicity hazard	SAR
Low	0.10 – 0.25	Low	< 10
Medium	0.25 – 0.75	Medium	10 - 18
High	0.75 – 2.25	High	18 – 26
Very high	2.25 – 5.00	Very high	26 - 31

Results and Discussion

The results of the analysis of irrigation water samples of KVK, Papparapatty showed that the pH of the water samples were normal as all the samples had pH values between 7.0 and 8,0.hence can be used for all soils. Based on the EC values it can be inferred that samples 1, 2 and 3 were of medium salinity (C2) they need moderate leaching to reduce the leaching and sample 4 alone was of low salinity (C1) and is safe with no likelihood of any salinity problem.

Table 6: Results of Irrigation water quality analysis of KVK, Papparapatty

Particulars	Sample			
	1	2	3	4
pH	7.13	7.26	7.29	7.40
EC (dSm^{-1})	0.68	0.65	0.56	0.06
Na (meq/l)	5.57	5.26	5.05	4.70
K (meq/l)	0.18	0.18	0.17	0.09
Ca (meq/l)	1.97	1.97	1.97	1.97
Mg (meq/l)	1.74	1.28	1.85	1.23
CO_3 (meq/l)	1.0	1.0	1.0	1.0
HCO_3 (meq/l)	3.0	3.2	2.9	3.1
Cl (meq/l)	8.0	8.0	9.0	5.0

Table 7: SAR values calculated based on the irrigation water quality analysis of KVK, Papparapatty

Particulars	Sample			
	1	2	3	4
SAR	4.09	4.13	3.66	3,73
Rating	Low	Low	Low	Low

The quality parameter Sodium Adsoption Ratio (SAR) is calculated by the formula,
$SAR = Na/\sqrt{(Ca + Mg)/2}$

The quality parameter Residual Sodium Carbonate (RSC) is calculated by the formula
$RSC = (CO_3 + HCO_3) – (Ca + Mg)$

Table 8: RSC values based on Irrigation water quality analysis of KVK, Papparapatty

Particulars	Sample			
	1	2	3	4
RSC (meq/l)	0.29	0.95	0.08	0.90
Rating	Good	Good	Good	Good

The quality parameter soluble sodium percentage (SSP) is given by the formula
SSP = (Na/ Ca + Mg + Na + K) * 100

Table 9: SSP values calculated based on Irrigation water quality analysis of KVK, Papparapatty

Particulars	Sample			
	1	2	3	4
SSP	59	57	56	59
Rating	Suitable			

From the results of the irrigation water samples analysed for quality parameters it can be inferred that all the water samples were grouped under low alkalinity hazard (S1) (< 10) based on SAR and were good (< 1.25 meq/l) based on the RSC values. The quality parameter SSP also showed that all the irrigation water samples were suitable as they were < 60 percent.
Based on the chloride content the samples were good as all the samples had the chloride content ranging between 5.0 and 10.0 meq/l.

Amelioration of the poor quality of irrigation water

1. Tillage - Deep ploughing - improve physical condition of soil.
2. Mulching with rice husk in the surface of sodic soil increase the infiltration rate.
3. Pre-sowing irrigation - Leach out the surface salts and improve germination and early growth.
4. If salinity is the problem, planting seeds in raised beds. Higher seed rate and closer spacing increase the yield.
5. Dilution of salt water with good quality water decrease the salt concentration.
6. Irrigation water treated with gypsum, FYM, press mud and basic slag reduce sodium hazard.
7. Passage of irrigation water through ion exchange material (charcoal).
8. Soaking of the seeds in NaCl (or) $CaCl_2$ solution have beneficial effect at salt tolerance.
9. Gypsum is the most effective amendment in reducing the concentration of bicarbonate.
10. Gypsum + FYM + press mud improves the effectiveness of gypsum and improve the water quality.
11. Wheat, Barley, Cowpea and Pearlmillet crops are highly susceptible to salinity.

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