**Irrigation water quality testing and advisory**

Water is a vital resource for agriculture like land, and it is a finite resource that has to be shared amongst a growing population. It has been estimated that in Asia per capita water availability has fallen by around 80 per cent during last five decades. Given that much of Asia's crop production is dependent on irrigation. This decline in water availability has potentially severe implications for food severity. This is exacerbated by growing demand for water from urban and industrial sectors that compete with demand for water from agricultural sector.

Irrigation water always contains some soluble salts irrespective of its source. The suitability of waters for a specific purpose depends on the types and amounts of dissolved salts. Some of the dissolved salts or other constituents may be useful for crops. However, the quality or suitability of waters for irrigation purposes is assessed in terms of the presence of undesirable constituents, and only in limited situations is irrigation water assessed as a source of plant nutrients. Some of the dissolved ions, such as NO3, are useful for crops.

**Parameters for water quality assessment**

Water quality is determined according to the purpose for which it will be used. The continuous use of irrigation water of varying quality in terms of its higher salt content (Saline), high EC and SAR (Saline-sodic) (or) high RSC affect the physical and chemical properties of soil over a long period of time. Ultimately the soils become unfit for any agricultural operation. Hence, it is essential to assess the quality of irrigation water before using them.

The important characteristics of irrigation water that have been used in determining its quality are: (1) Salinity hazard (2) Sodicity hazard

(3) Carbonate hazard (4) Permeability hazard (5) Concentration of Boron and other specific ion toxicity.

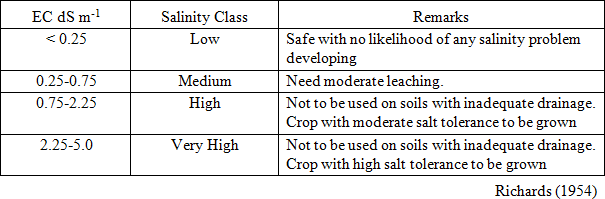
* 1. Salinity hazard

Accumulation of soluble salts in the soil is directly related to the salt content of the irrigation water (Table 5) . A salinity problem due to irrigation water occurs if the total quality of salts is high enough that the salts accumulate in the crop root zone.

The effect of salt on crop growth is largely of an osmotic nature, restricting the availability of soil water to plants. The concentration of soluble salts in irrigation water can be determined in terms of electrical conductivity and is expressed as dS m-1 at 25C. For solutions of very low EC, units can be μS cm-1. The total salt concentration can also be measured as TDS (Total Dissolved Salts) by the following equation:

TDS (ppm) = EC in dsm-1 x 640.

# Table 5. Classification of irrigation water based on Electrical conductivity



1. Sodicity hazard

Irrigation waters containing higher proportion and sodium to other cations lead to the problem of sodicity. The sodicity hazard of irrigation water is usually evaluated by sodium Adsorption ratio (SAR). Sodium Adsorption Ratio (SAR): It is expressed as the relative proportion of sodium to other cations viz., Ca and Mg in water and is calculated by using

the following formula, where the concentration of ions is expressed in me L-1

SAR = Na+ / ( (Ca++ + Mg++) / 2 ) ½

Irrigation water is under low sodicity class (SAR < 20) can be used for crops which are semi-tolerant to tolerant (Table 6). Moderate sodic waters can be used only for tolerant crops.

1. Carbonate hazard

Carbonates and bicarbonate ions are important because they are having the tendency to precipitate Ca and Mg in soil solution (Table 6). The effect of bicarbonate and carbonate ions on water quality is expressed in terms of Residual sodium carbonate (RSC) concept, where the concentration of ions is expressed in me L-1.

RSC = (CO 2- + HCO -) - (Ca2+ + Mg2+)

3 3

# Table 6. Classification of irrigation water based on SAR

|  |  |  |
| --- | --- | --- |
| Class | Classification | Remarks |
| **Water suitability** | | |
| < 10 | Safe | |
| 10 - 20 | Moderate | |
| >20 | Unsafe | |
| *Crop Suitability* | | |
| < 5 | Non-sodic | All soils and crops |
| 5-10 | Normal water | All soils and crops except sodium sensitive crops |
| 10-20 | Low sodic water | Semi – tolerant to tolerant crops |
| 20-30 | Medium sodic water | Tolerant crops |
| 30-40 | High sodic water | Not suitable |
| > 40 | Very high sodic water | Not suitable |

Ayers and Westcot (1976)

# Table 7. Classification of irrigation water based on RSC (me L-1)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Class | | Classification | | Remarks | | |
| *Water suitability* | | | | | | |
| < 1.25 | | Safe | | | | |
| 1.25 - 2.50 | | Moderate | | | | |
| >2.50 | | Unsafe | | | | |
| *Crop Suitability* | | | | | | |
| A0 | -ve | Non water | alkaline | For all soils and crops | | |
| A1 | 0 | Normal water | | For all soils and crops (even crops sensitive to carbonate and bicarbonate) | | |
| A2 | 0-0.25 | Low alkalinity | | Semi – tolerant to tolerant crops | | |
| A3 | 2.5-5.00 | Medium alkalinity | | Tolerant crops management | with | little |
| A4 | 5.0-10.0 | High alkalinity | | Can be used in soils with good drainage | | |
| A5 | > 10.0 | Very alkalinity | high | Not suitable | | |

(Ayers and Westcot, 1976)

Irrigation water containing high concentration of carbonate and bicarbonate ions, have a tendency to precipitate Ca, and to lesser extent Mg, in the form of carbonates as solution becomes more concentrated. This leads to an increase in SAR of soil solution and consequently to an increase in ESP of the soil.

# Permeability hazard

Permeability hazard occurs when the rate of water infiltration into and through the soil is reduced by the effect of specific salts. High sodium in irrigation water results in severe soil permeability problem. Permeability in also affected by to carbonate and bicarbonate content in irrigation water. Permeability Index can be calculated by using the following formula, where the ionic concentrations are expressed in me L-1.

Permeability Index (PI) = Na (HCO3) / (Ca + Mg + Na) x 100

# Specific ion toxicity

Ground waters having toxic ions such as B, Cl, F, No3, Se etc. also become problematic for irrigating crops and have consequence of entering human food chain (Table 8). Apart from boron and fluorine, there are some trace elements present in irrigation waters may also cause toxic effect. The permissible maximum concentrations of these toxicants in irrigation waters are based on the limitations of soils for crop production (Table 9).

|  |  |  |  |
| --- | --- | --- | --- |
| Specification | Degree of problem | | |
| No problem | Increasing problem | Severe problem |
| Sodium (adj-SAR) | <3 | 3.0-9.0 | >9.0 |
| Chloride (mg L-1) | < 4 | 4.0-10.0 | >10.0 |
| Boron (mg L-1) | < 0.75 | 0.75-2.0 | >2.0 |
| NO3 – N (mg L-1) | < 5.0 | 5.0-30.0 | >30.0 |
| HCO3-N (mg L-1) | < 1.5 | 1.5-8.5 | >8.5 |
| Fluoride (mg L-1) | < 1.0 | 1.0-15.0 | >15.0 |

Somani (1991)

# Table 9. Permissible concentration of trace elements in irrigation waters (ppm)

|  |  |  |
| --- | --- | --- |
| **Element** | **For waters used continuously on all soils (mg l-1) / ppm** | **For use upto 20 years on fine textured soils of pH 6.0 to 8.5 (mg l-1)** |
| ***Aluminium*** Arsenic Beryllium Boron Cadmium Chromium Cobalt Copper Fluorine Iron  Lead Lithium Manganese Molybdenum Nickel Selenium Vanadium  Zinc | 5.0  0.1  0.1  0.75  0.1  0.10  0.25  0.20  1.00  5.00  2.50  5.00  0.20  0.01  0.20  0.02  0.10  2.00 | 20.0  2.0  0.5  2.0  0.05  1.0  5.0  5.0  15.0  20.0  10.0  2.5  10.0  0.05  2.0  0.02  1.0  10.0 |

(Ayers and Westcot, 1976)

# Management of poor quality water

Irrigation is essential for good crop production, where large area fall under arid and semi-arid regions and when rainfall is seasonal and erratic. Due to scarcity of fresh water for irrigation in theses areas, the under ground water becomes major source of irrigation which are commonly saline/ sodic. It necessitates the use of poor quality water for irrigation. However, poor quality irrigation water can be utilized by adopting proper management.

# Irrigation management

Conjunctive use of good quality water: Wherever feasible, the saline or sodic waters can be applied to the land in conjunction with good quality water (rain water/ canal water and river water) to reduce the harmful effect of poor quality water. The cyclic / alternate use of poor quality water (or) blending methods can be employed. Good drainage must be provided to get lower water table thereby salt accumulation in upper surface (or) near root zone can be avoided. Poor quality irrigation water is not suitable for sprinkler irrigation. However drip irrigation is a potential means of utilizing poor quality water. As it wets the soil surface around the crop continuously there is hardly little chance for accumulation of salt on the surface.

For high SAR water the dilution can be decided by a dilution factor with the quality of water available for dilution

|  |  |
| --- | --- |
| Dilution factor = | (SAR of problem water) 2 |
| (SAR of desired water) 2 |

# Crop Management

Salt tolerant crops are to be grown to the soils affected by salinity and sodicity. Crops such as wheat, barley, cowpea etc totally fail to grow under highly saline conditions. Oilseed crops, which require less water can tolerate high EC levels where as most of the pulses, are very sensitive to salts (Table 10).

Pre soaking of seeds with the 0.1 per cent NaCl 0.5 per cent KH2PO4

will improve salt tolerance of crops. Germination of seeds decreases with increasing salinity. Seeds have to be placed in the area where the salt concentration is less. With furrow irrigation the salts tend to concentrate mainly in the centre of the ridge between furrows and in a thin layer along the top of the ridge. The salt concentration is less on the slope of the ridge and the bottom of the ridge. Seeds have to be placed on the slope of the ridge several centimeters below the crown of the ridge. By this method satisfactory germination is possible even when the EC of soil is 30 – 40 dS m-1.

Crops suitable to the dominant ion composition in irrigation may be selected for cultivation.

Following are the crops preferring a dominant ion for luxuriant growth

|  |  |  |  |
| --- | --- | --- | --- |
| Magnesium loving crops (MgCl2 MgCO3 – rich  water) | | : | Banana, Sugarcane, Chillies, Tapioca, Cotton, Vegetables (except tomato) and  flowering crops |
| Chloride loving crops  (Na, Ca, Mg rich water) | | : | Coconut, Chillies, Brinjal, Sunflower and  Jasmine |
| Calcium loving crops  (Chloride rich water) | : | | Cotton, Millets and Curry leaf |
| Bicarbonate loving crops | : | | Millets, Rice Chillies, Sugarcane, Cotton, Sunflower and Fruit crops (except Mango,  Citrus and Grapes) |

# Table 10. Relative tolerance of crop plants to salt

|  |  |  |
| --- | --- | --- |
| **Tolerant** | **Moderately tolerant** | **Sensitive** |
| Field crops | | |
| Finger millet | Rice | Black gram |
| Sugar beet | Wheat | Green gram |
| Cotton | Sunflower | Bengal gram |
|  | Groundnut |  |
|  | Sorghum |  |
|  | Castor |  |
|  | Soybean |  |
|  | Sesame |  |
| Vegetables | | |
| Asparagus | Brinjal | Carrot |
| Spinach | Cabbage | Radish |
| Amaranthus | Onion | Coriander |
|  | Potato | Mint |
|  | Chillies  Garlic | Cumin |
| Forage crops | | |
| Bermuda grass | Rye grass | Red clover |
| Rhodes grass | Sudan grass | Meadow foxtail |
| Birds root | Alfalfa |  |
| Barley (Hay) | Wheat |  |
| Fruits | | |
| Date palm | Pomegranate | Pear |
|  | Guava | Apple |
|  | Grape | Orange |
|  | Fig | Peach |
|  | Ber | Mango |

**Use of chemical amendments**

Gypsum and iron pyrites are the chemical amendments used frequently to reclaim the soil, which is affected by salts. Gypsum application is necessary for reducing damage due to excessive sodium in irrigation water. The soil solution at the root zone must not contain more than 70 percent of sodium out of total cations.

For saline water the gypsum requirement can be calculated as follows:

|  |  |
| --- | --- |
| Gypsum requirement  (lb acre ft-1) | = {[(Na X 0.43) – (Ca + Mg)] + [(CO3 HCO3 X 0.7] + 0.7} X 234 |

For sodic water, gypsum requirement can be calculated based on residual sodium carbonate as 1 me of RSC = 1 me of CaSO4

Nutrient management

Organic matter addition has distinct impact in improving soil when using saline / sodic water. Liberal application of farmyard manure

or compost will be much beneficial. Use of nitrate and sulphate rich fertilizers is suitable to reduce chloride accumulation in plants. Use of ammonium and chloride rich fertilizers will help to counteract effect of excess sulphate. Applying superphosphate is essential with high magnesium water irrigation. Further, with this water, sulphate rich fertilizers must be avoided and liberal use of potassium fertilizer is necessary to overcome Mg-K antagonism. Alkali soils have acute deficiency of zinc. Hence, basal dressing of ZnSO4 is necessary particularly to rice.

Generally saline, and alkaline soils irrigated with poor quality waters are low in their fertility status, especially with reference to nitrogen and sometimes to phosphorus. Green manuring of *Sesbania* before rice is beneficial. Alternatively, pressmud, water hyacinth Farmyard manure or any other potential source of nutrients may be utilized to supplement fertilizer N in alkali soil for sustainable crop production with simultaneous improvement in soil, which may be increased upto 50% of recommended dose. Use of organics also brings down the soil pH and ESP.

# Soil Management

Deep ploughing with disc plough helps to turn down salts accumulated on surface and facilitates fast leaching. Chisel ploughing of field during summer season is to be adopted for soils having hardpan. Chiseling is to be done at 0.5 intervals in crisscross direction at 0.5 depths once in two years. Chisel plough is essential for improving yield of crops especially under dry farming. It shatters compacted subsoil layers and aids in better infiltration of water in the crop root zone.