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# Utilization of Saline Water in Agriculture

Dr. Arunabha Pal



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# Introduction

- ❑ About 70% of our Earth's surface is covered by water, out of these About 97.3% of water on earth is salty, leaving only 2.7% as fresh water. Less than 1% of the world's fresh water (0.007% of all water on earth) is accessible for direct human uses.
- ❑ The fresh water is also considered as good quality water, while sodic water, saline water, municipal/city waste water, industrial effluents, sewage and sludge - all are considered as poor quality water of varying degree.
- ❑ In India about **50%** of ground waters are marginal and poor in quality whereas in **Rajasthan** their extant is still elevated to **84%**. The present distribution of poor quality of water in India indicates about **37%** water are **sodic** and **20%** are **saline** in nature.



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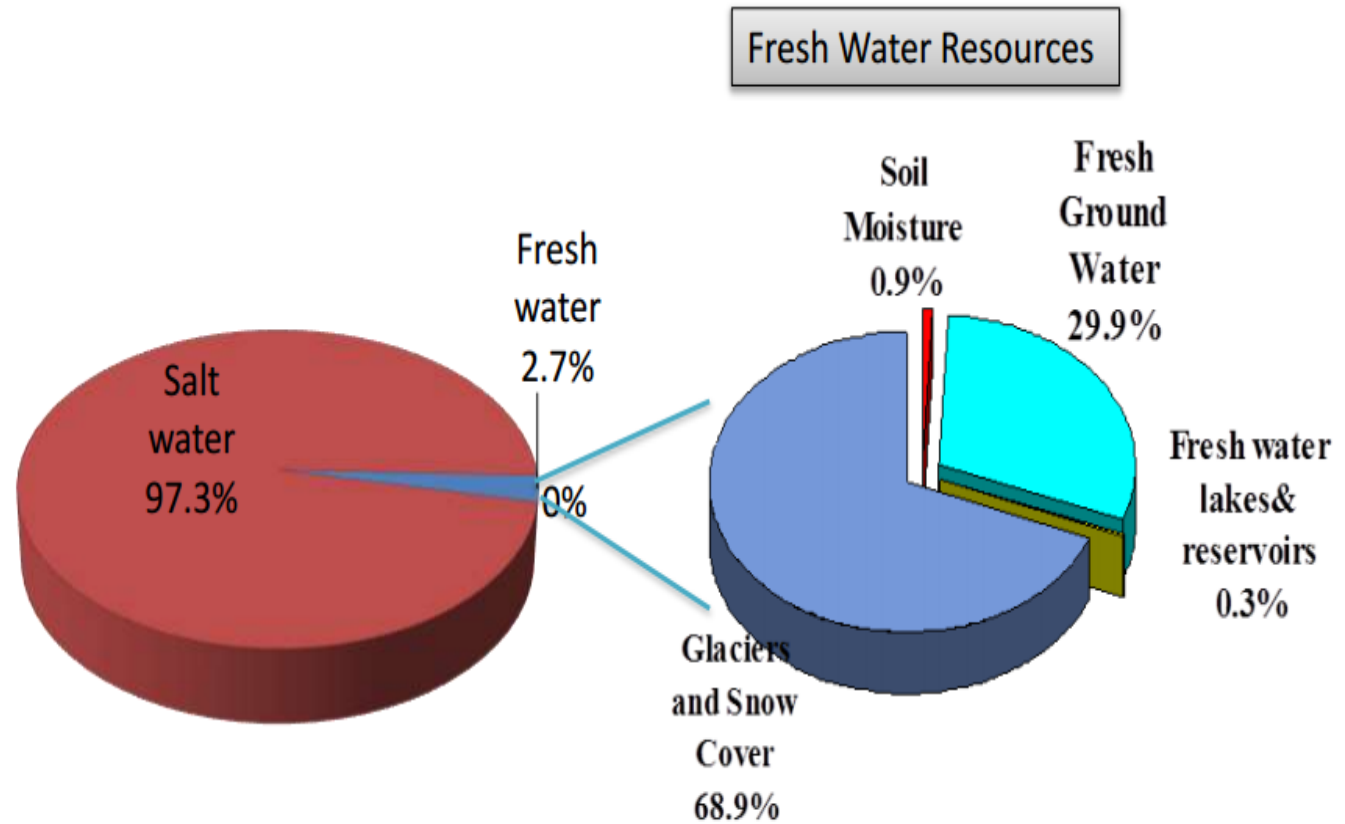
- The municipal waste has been reported to be a good source of irrigation (Chhabra, 1988) and nutrients (Prasad, 1999).
  
- Sodic water contains higher residual sodium carbonates and saline water contains greater salts and hence both are considered unfit as sources of direct irrigation.
  
  
- Keeping the above facts in mind, our objective is to see the feasibility of using poor quality water for agricultural crop production.



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# Fig 1: Global Water Availability



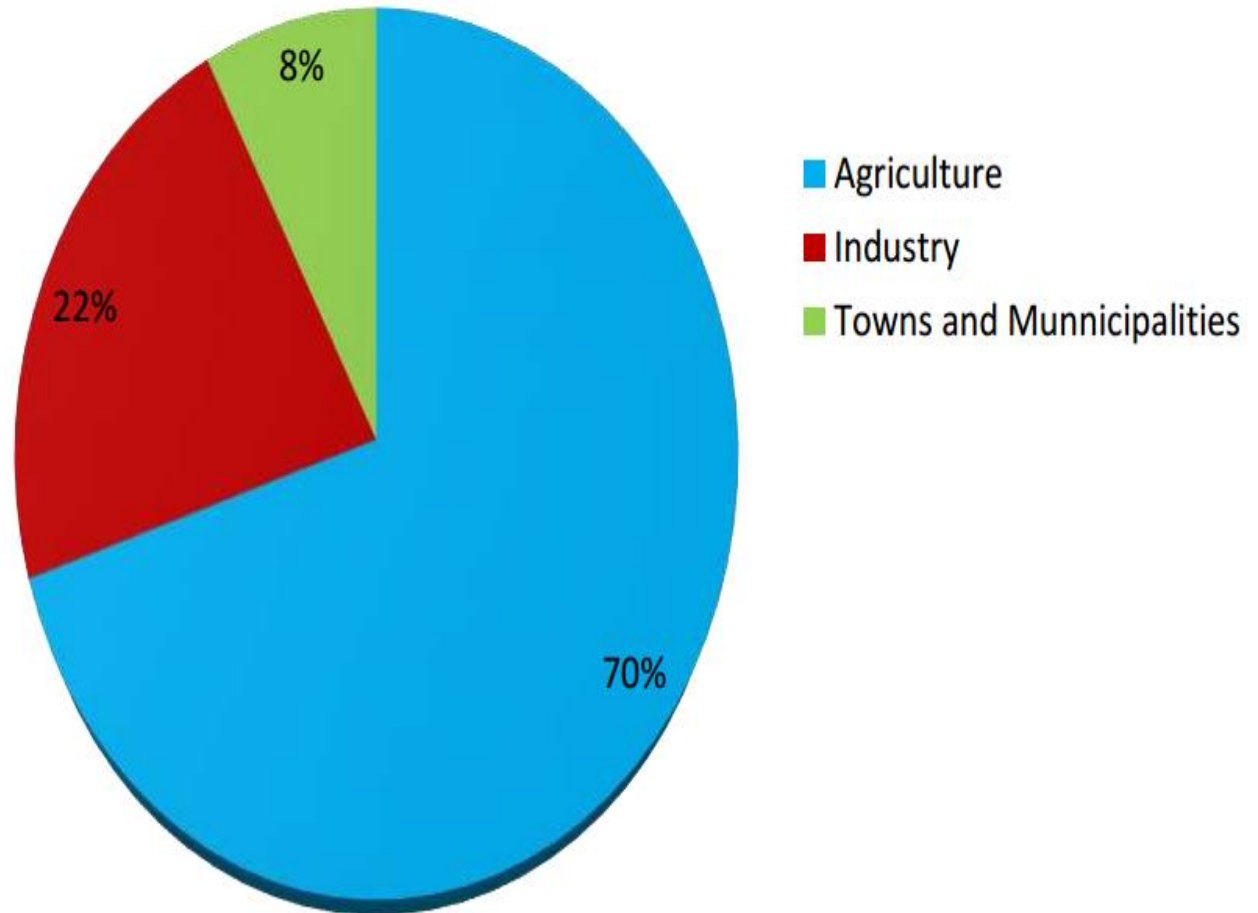
< 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human uses.



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## Fig 2: World Water Use



Source: World Bank, World Development Indicators, 2012



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# Groundwater quality status in selected states of India

| State            | Utilizable ground water resource (M ha-m yr <sup>-1</sup> ) | Use of poor quality waters (M ha-m yr <sup>-1</sup> ) | Area underlain by saline GW (EC > 4 dS m <sup>-1</sup> ) (km <sup>2</sup> ) |
|------------------|---|---|---|
| Punjab           | 1.47  | 0.68  | 3,058   |
| Haryana          | 0.86  | 0.47  | 11,438  |
| UP               | 6.31  | 1.42  | 1,362   |
| <b>Rajasthan</b> | <b>0.95</b>   | <b>0.65</b>   | <b>1,41,036</b>   |
| Gujarat          | 1.56  | 0.26  | 24,300  |
| Karnataka        | 1.24  | 0.17  | 8,804   |
| Tamilnadu        | 2.02  | NA  | 3,300   |
| <b>All India</b> | <b>32.63</b>  | <b>NA</b>   | <b>1,93,438</b>   |

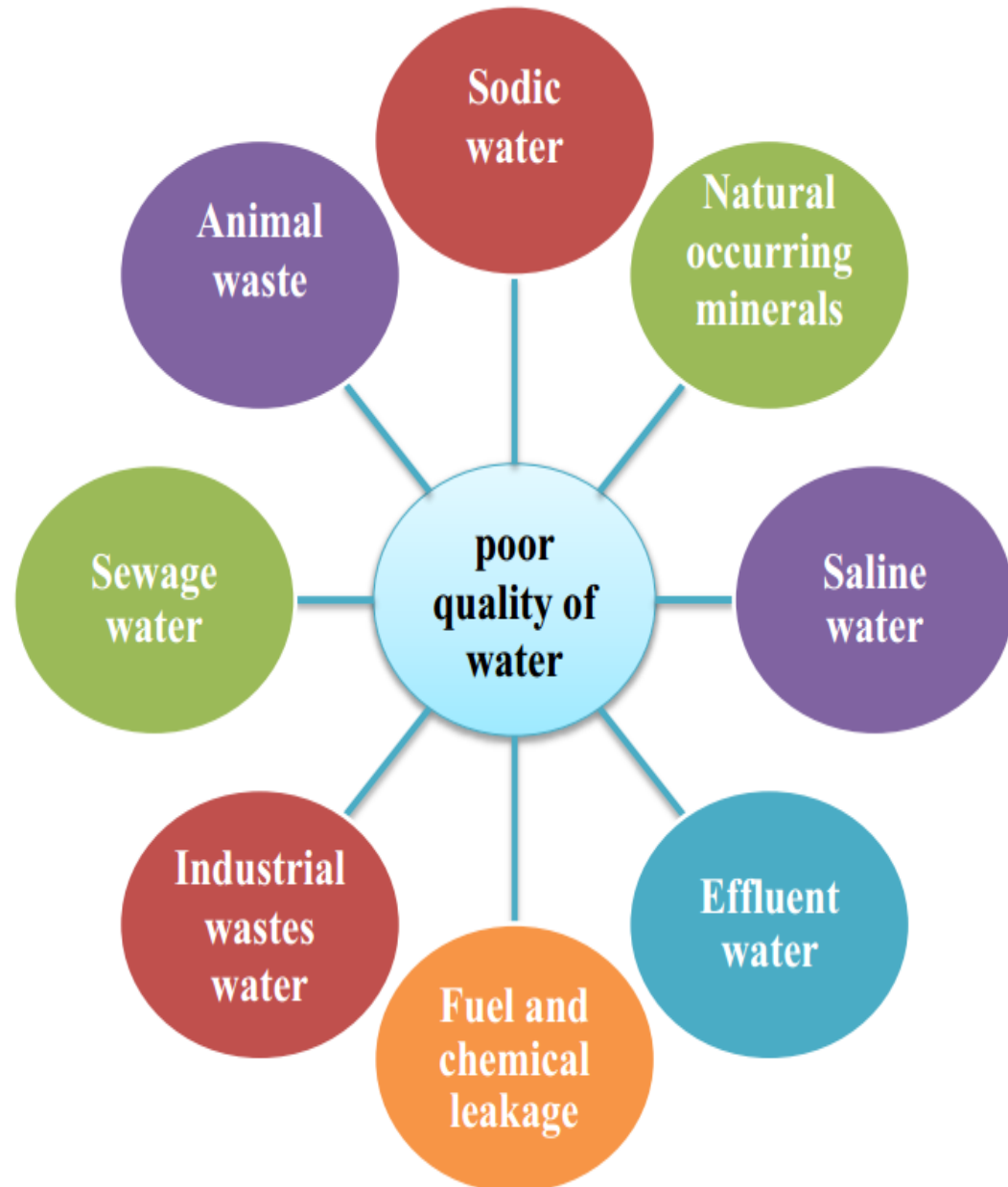
Source : CSSRI, Karnal (2012)



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## Different sources of poor quality water







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# Poor quality of water

- 1.Sewage water:** Sewage water are basically very rich in organic matter and their fertility is very high. It is quietly suitable for irrigation
- 2.Sodic water or alkali water:** Sodic water containing higher residual sodium carbonate and sodium adsorption ratio, unfit for irrigation.
- 3.Saline water:** saline water is that water which is usually contains high amount of soluble salts (Chloride and sulfate type).
- 4.Industrial wastes water :** The direct use of industrial effluent water in agriculture may raise problem like salinity, alkalinity and /or toxicity in the soil as a result of long-term irrigation with such waste water.

Ex: **a. Sugar factory effluent**

**b. Paper mill effluent**

**c. Distillery effluent**

**d. Chemical effluent**

**e. Refinery effluent**



**fig: Industrial waste waster**



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## POOR QUALITY WATER -RELATED CONSTRAINTS IN IRRIGATED AGRICULTURE

### **SALINITY**

- Irrigation water contain high amount of  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$  of Na Ca and Mg . Cause accumulation of salt in crop root zone.
- Than Osmotic effect and specific ion toxicity can seen in plants

### **SODICITY**

- Irrigation water contain high amount of carbonates and bicarbonates of sodium. Cause sodicity hazards
- sodicity hazards responsible for poor physical condition of soil and nutritional imbalance in plants

### **SPECIFIC ION TOXICITY**

Certain ions (sodium, chloride, boron ,other cations like , Mn ,Zn ,Cu, Ni, Cr , Cd Pb etc) from soil or water and accumulate in a crop to high concentrations, enough to cause crop damage and reduce yields.



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# Measuring the quality parameters for suitability of irrigation water

- ❖ Electrical conductivity (EC)
- ❖ pH
- ❖ Sodium adsorption ratio or sodium hazard (SAR)
- ❖ RSC (Residual sodium carbonate)
- ❖ Boron concentration
- ❖ Chloride concentration
- ❖ Heavy metal concentration



## Classification of poor quality ground water

| Water quality          | Eciw (dS m <sup>-1</sup> ) | SAR (meq l <sup>-1</sup> ) | RSC (meq l <sup>-1</sup> ) |
|------------------------|----------------------------|----------------------------|----------------------------|
| <b>A. Good</b>         | <2                         | <10                        | <2.5                       |
| <b>B. Saline</b>       |                            |                            |                            |
| i. Marginally saline   | 2-4                        | < 10                       | <2.5                       |
| ii. Saline             | > 4                        | < 10                       | <2.5                       |
| iii. High-SAR saline   | > 4                        | > 10                       | < 2.5                      |
| <b>C. Alkali water</b> |                            |                            |                            |
| i. Marginal alkali     | <4                         | <10                        | 2.5-4.0                    |
| Alkali                 | <4                         | <10                        | >4.0                       |
| iii. Highly alkali     | variable                   | >10                        | >4.0                       |



# Classification of irrigation water based on salinity and sodium hazards

## Salinity hazards

| Class | Salinity  | EC (micromhos/cm) | Preference                    |
|-------|-----------|-------------------|-------------------------------|
| C1    | Low       | <250              | Used safely                   |
| C2    | Medium    | 250-750           | Moderate salt tolerance crops |
| C3    | High      | 750-2250          | Only tolerance crops          |
| C4    | Very high | >2250             | Not suitable for irrigation   |

## Sodium hazards

| Class | Sodium hazards | SAR(me/ l) | Preference                                |
|-------|----------------|------------|---|
| S1    | Low            | 0-10       | Little or low hazards                     |
| S2    | Medium         | 10-18      | Appreciable hazards, used by proper mang. |
| S3    | High           | 18-26      | Appreciable hazards, used by proper mang. |
| S4    | Very high      | >26        | Not suitable for irrigation               |



## Based on chloride concentration

| Chloride concentration ( $\text{me}^{-1}$ ) | Water quality                       |
|---|-------------------------------------|
| < 4   | Excellent water                     |
| 4 – 7                                       | Moderately good water               |
| 7 – 12                                      | Slightly usable                     |
| 12 – 20                                     | Not suitable for irrigation purpose |
| > 20  | Not suitable for irrigation purpose |



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## Based on boron concentration

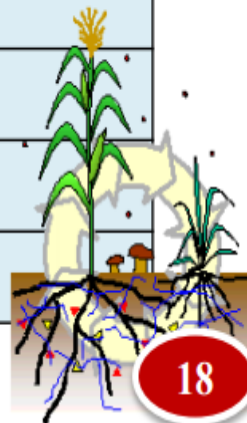
| Class        | Boron (ppm) | Remarks                     |
|--------------|-------------|-----------------------------|
| B1<br>Low    | <1          | Used safely                 |
| B2<br>Medium | 1 – 3       | Can be used with management |
| B3<br>High   | >3          | Unsuitable                  |



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## Relative tolerance of crops to boron

| Tolerant<br>(>3 ppm) | Semi-tolerant<br>(1-3 ppm) | Sensitive<br>(0.3-1.0 ppm) |
|----------------------|----------------------------|----------------------------|
| Date palm            | Sunflower                  | Apple                      |
| Sugar beet           | Potato                     | Grape                      |
| Berseem              | Cotton                     | Citrus                     |
| Onion                | Tomato                     | lemon                      |
| Cabbage              | Radish                     |                            |
| Carrot               | Barley                     |                            |
|                      | Wheat                      |                            |
|                      | Maize                      |                            |
|                      | sorghum                    |                            |







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## Permissible limit of heavy metals in irrigation water

| Element | Recommended maximum conc. (mg L <sup>-1</sup> ) | Remarks  |
|---------|---|--|
| Al      | 5.0   | Can cause non productive to acid soil                |
| As      | 0.10  | Toxicities to plant very widely                      |
| Cd      | 0.01  | For potential to accumulation in plant               |
| Cu      | 0.20  | Toxic at 0.1 to 1.0 mg L <sup>-1</sup>               |
| Mn      | 0.20  | Toxic to no. of crops.                               |
| Pb      | 5.0   | Inhibit plant cell growth at very high concentration |
| Se      | 0.02  | Toxic at low level conc. 0.025 mg L <sup>-1</sup>    |
| Zn      | 2.0   | Toxic to many plant at widely varying                |

**CSSRI (Haryana)**

**Yadav (2004)**



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## Effect of saline water irrigation on yield and quality of tomato

| Treatment<br>EC (dSm <sup>-1</sup> ) | Yield<br>(t ha <sup>-1</sup> ) | Yield<br>reduction<br>(%) | pH of<br>juice | TSS  | Acidity<br>(%) | Lycopene<br>mg/100g |
|--------------------------------------|--------------------------------|---------------------------|----------------|------|----------------|---------------------|
| SW0 (0)                              | 39.33                          | --                        | 5.52           | 4.20 | 0.51           | 1.65                |
| SW1(1.5)                             | 38.10                          | 3.13                      | 5.49           | 4.25 | 0.55           | 1.80                |
| SW2 (2.5)                            | 35.25                          | 10.37                     | 5.25           | 4.32 | 0.59           | 1.85                |
| SW3 (5)                              | 34.21                          | 12.60                     | 5.05           | 4.92 | 0.63           | 2.10                |
| SW4 (7.5)                            | 32.04                          | 16.07                     | 5.08           | 5.10 | 0.67           | 2.24                |
| SW5 (10)                             | 29.90                          | 24.00                     | 5.00           | 5.22 | 0.69           | 2.47                |
| S.Em±                                | 0.30                           | --                        | 0.014          | 0.06 | 0.016          | 0.042               |
| CD at 5(%)                           | 1.40                           | --                        | 0.043          | 0.18 | 0.183          | 0.123               |

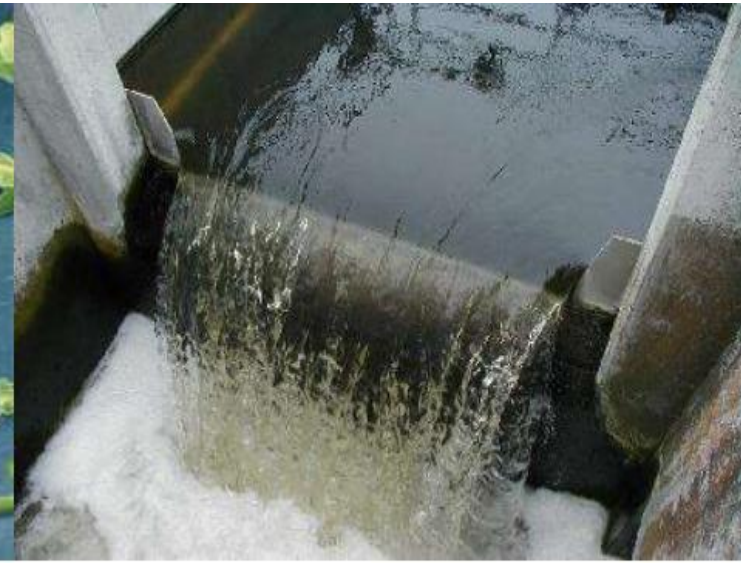
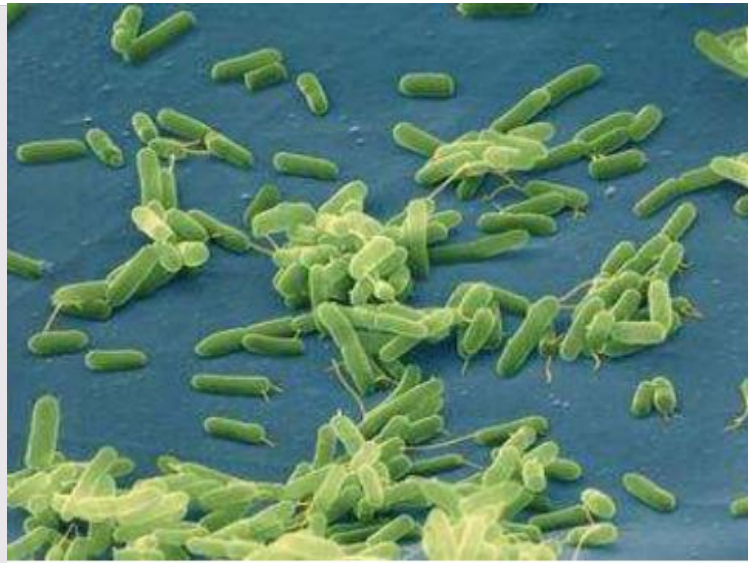
**Agra (U.P.)**

**Kadam and Patel (2008)**



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# Management Options for Saline Water Use



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## Crop Management - Selection of Crops

- For successful utilization of saline water, crops which are semi-tolerant to tolerant such as Barley, Cotton, Sugar beet, mustards and wheat as well as those with low water requirement are recommended
- Crops such as rice, sugarcane and berseem, which require liberal water use, should be avoided In low rainfall areas (<40 cm/annum)
- mono-cropping is recommended for maintaining salt balances
- All crops do not tolerate salinity equally well at different stages of their growth. For example, germination and early seedling establishment are the most critical stages followed by the phase changes from vegetative to reproductive i.e. heading and flowering to fruit setting.



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# Relative tolerance of crops to salinity

| <b>Sensitive</b><br>1.5 – 3 dS/m | <b>Moderately sensitive</b><br>3– 5 dS/m | <b>Moderately tolerant</b><br>5 – 7 dS/m | <b>Tolerant</b><br>7– 10 dS/m |
|----------------------------------|--|--|-------------------------------|
| Apple                            | Cabbage                                  | Safflower                                | Barley                        |
| Carrot                           | Corn                                     | Soybean                                  | Cotton                        |
| Lemon                            | Cowpea                                   | Wheat                                    | Sugar beet                    |
| Onion                            | Grape                                    | Oat                                      | Date palm                     |
| Pulses                           | Groundnut                                | Dhaicha                                  | Cluster bean                  |
| Beans                            | Potato                                   |  | Pearl millet                  |
|                                  | Rice                                     |  | Mustard                       |
|                                  | Sugarcane                                |  |                               |
|                                  | Tomato                                   |  |                               |
|                                  | Radish                                   |  |                               |
|                                  | Sorghum                                  |  |                               |





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## Salinity limits of irrigation water for Agricultural crops

| Crops        | ECiw (dS/m) for yield 90% | ECiw (dS/m) for yield 75% |
|--------------|---------------------------|---------------------------|
| Wheat        | 6.6                       | 10.4                      |
| Barley       | 7.2                       | 11.3                      |
| Pearl millet | 5.4                       | 9.0                       |
| Cluster bean | 3.2                       | 5.4                       |
| Mustard      | 6.6                       | 8.8                       |
| Groundnut    | 1.8                       | 3.1                       |
| Cowpea       | 8.2                       | 11.3                      |
| Sorghum      | 7.0                       | 11.2                      |
| Tomato       | 2.4                       | 4.1                       |



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# Crop cultivars

- ❖ crop cultivar also vary in their tolerance to salinity. Such cultivars have been identified on their rating for high yield potential.
- ❖ salt tolerance and stability under saline environments are included in next slide



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## Crop varieties tolerant to saline water irrigation

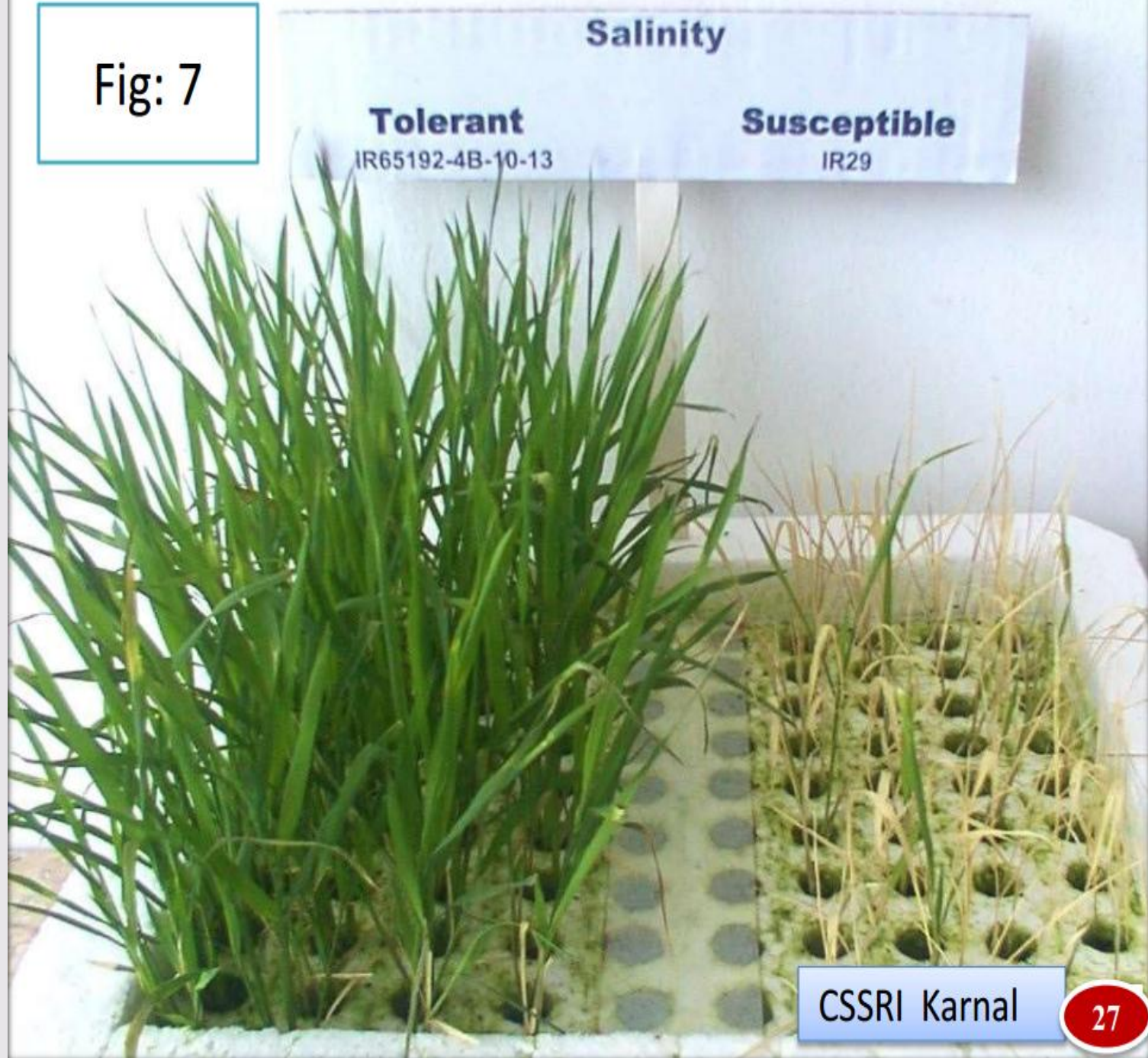
| Crop                | Varieties  |
|---------------------|--|
| <b>Wheat</b>        | KRL-10,WH 383,PBW 134, WL 2328, Raj 2560, HD 2374      |
| <b>Barley</b>       | CS-137, DL-157, Ratna, RL345, RD103, 137, K169         |
| <b>Mustard</b>      | DYS-1, PUSA Kalyani, CS-52                             |
| <b>Cotton</b>       | Sangam, DHY 286, CPD 404, G 17060                      |
| <b>Rice</b>         | CSR- 10, 30,43,36 , Lunishree, Dandi, GNR-2, SLR 51214 |
| <b>Sugarcane</b>    | CON-4131   |
| <b>Pearl millet</b> | MH269, 331, 427, HHB-60                                |
| <b>Sunflower</b>    | Ramson record , EC 10145, EC 68413                     |
| <b>Ragi</b>         | HR -911, 10181, 10541 and Indaf - 9                    |
| <b>Sorghum</b>      | DSH 1, K6  |
| <b>Green gram</b>   | LGG- 127   |





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**Fig: 7**





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## Water Management Irrigation and Leaching Management

- a. Arid areas would need 15 to 20 percent more water to be applied as irrigation for meeting out the leaching requirements. To maximize the benefit from enhanced quantity of irrigation saline irrigation should be applied more frequently
- b. In the years of sub-normal rainfall, a heavy pre-sowing irrigation with saline water should be applied so that the salts accumulated during the preceding rabi season are pushed beyond the root-zone.
- c. The distribution of water and salts in soils vary with the method of irrigation. micro-irrigation systems such as **drip and sprinklers**, where a better control on salt and water distributions can be achieved
- d. In the case of saline water logged soils provided with **sub-surface drainage**, the system can be beneficially employed to induce crop water use from shallow water table through controlled drainage in rabi crops and thus reduce the requirement of irrigation

water



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## Conjunctive Use of Saline and Canal Water

- ❖ Application of the two waters separately, if available on demand, can be done so that the higher salinity water is avoided at sensitive growth stages of the crops
- ❖ Better quality water should be utilized for pre sowing irrigation, germination and seedling establishment stage and early stages of crop growth.
- ❖ The seasonal cyclic use, non-saline water is used for salt sensitive crops or in the initial stages of tolerant crops to leach out the accumulated salts from irrigation with salty water to previously grown tolerant crops.

Cyclic uses i.e. irrigating with water of different qualities separately offers both operational and performance advantages over mixing.

# Nutrient Management



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## Fertilizers

- a. Application of fertilizers is important for obtaining good yields with saline irrigation.
- b. Response to applied nitrogen is rather reduced under saline irrigation. Thus, additional doses of nitrogenous fertilizers are recommended to compensate for volatilization losses.
- c. Soils irrigated with chloride rich water respond to higher phosphate application, because the chloride ions reduce availability of soil phosphorus to plants
- d. For micro-nutrients such as zinc, the recommended doses based on soil test values should applied



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# Farm yard Manure

- 1.FYM and other organic manures not only have the nutritive value, they also play an important role in structural improvements.
- 2.This further influences leaching of salts and reduce their accumulation in the root zone. The other advantage of FYM in saline water irrigated soils are in terms of reducing the volatilization losses and enhancing the nitrogen-use efficiency.
- 3.Retention of nutrients in organic forms for longer periods also guards against leaching and other losses.



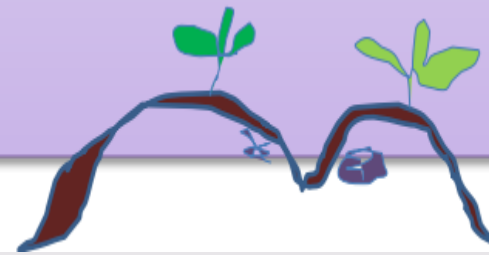
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## Cultural practices

- ❖ Using higher seed rate.
- ❖ Heavy application of good quality water at pre sowing stage wherever possible.
- ❖ Dry seeding and post sowing irrigation.
- ❖ Double row, flat topped bed technique.
- ❖ Slopping bed are best for saline condition.
- ❖ For large seeded crop seed can be planted in

furrow





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## Tree Species and Medicinal Plants


In cases where it is neither feasible nor economical to use saline water for crop production, such water can be used to raise tree species especially on lands those are already degraded. The preferred choice of species should be *Azadirachta indica*, *Acacia nilotica*, *Cassia siamea*, *Eucalyptus tereteerms*, *Feronia limonia*, Tamarix etc.

Some medicinal plant such as Isabgol (*Plantag oovata*), Aloe and Kalmeg have also been found promising under saline irrigation conditions as an alternative to arable crops.



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# Management Options for Use of Alkali Water





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# Crop Selection

In low annual rainfall areas ( $< 400$  mm) if the good quality canal water is not available, it is advisable to keep the fields fallow during kharif season. During rabi, only tolerant and semi-tolerant crops such as barley, wheat and mustard should be grown.

For areas having rainfall  $>400$  mm per annum, jowar-wheat, guar-wheat, bajra wheat and cotton-wheat rotations can be practiced, provided it is ensured that sowing, particularly of kharif crops is done with rain water or good quality canal water.

For areas having annual rainfall  $>600$  mm in the rice-wheat belt of alluvial plains, rice-wheat, rice-mustard, sorghum-mustard, and dhainacha (green maure)- wheat rotations can be practiced with gypsum application.



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## Relative tolerance of different crops to sodicity of soils

| ESP range (%) | crops   |
|---------------|---|
| 10-15         | Safflower, peas, lentil, pigeon pea, urdbean, banana                              |
| 16-20         | Bengal gram, soybean, papaya, maize, citrus                                       |
| 20-25         | Groundnut, cowpeas, onion, pearl-millet, guava, beal, grapes                      |
| 25-30         | Linseed, garlic, guar, palma rosa, lemon grass, sorghum, cotton                   |
| 30-50         | Mustard, wheat, sunflower, ber, karonda, phalsa, vetiver, sorghum, berseem, senji |
| 50-60         | Barley, sesbania, paragrass, Rhoades grass  |
| 60-71         | Rice, sugarbeat, karnal grass   |



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## Use of Amendments - Gypsum

- ❖ Sodic water can be safely and economically used after treating them with calcium bearing amendment such as gypsum. The agricultural grade gypsum can either be added to soil or applied in water through specially designed gypsum beds.
- ❖ The quantity of gypsum for neutralization of each  $\text{meq l}^{-1}$  of RSC is  $86 \text{ kg ha}^{-1}$  for 10 cm depth of irrigation.
- ❖ Application at the rate of 25 - 100% Gypsum Requirement (GR) of water has been reported to boost crop yields (Manchanda, *et. al.* 1985). Yadav *et al.* (1991) in another study has reported that addition of gypsum at the rate of 50% gypsum requirement of a loamy sand soil was found sufficient to grow even the sensitive *kharif* crops like pearl millet, moongbean, urdbean, cowpea and cluster bean in the presence of 600 mm rainfall.



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# Method and time of gypsum application in soil

- ❖ Gypsum are normally applied by broadcasting and then incorporated with the soil by disking or ploughing. gypsum mixed with the surface 15 cm was more effective in the removal of exchangeable sodium, than gypsum applied on the soil surface.
- ❖ The best time for application of gypsum is after the harvest of *rabi* crops, preferably in the month of May or June, if some rain has occurred. Gypsum can be applied in the standing water also. The soil should be subsequently ploughed upon attaining proper soil moisture condition
- ❖ Gypsum applied after the harvest of a *rabi* crop will also help in considerable improvement of the soil prior to the on set of *kharif* season.



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## Influence of alkali water irrigation along with varying quantum of gypsum on yield of rice - wheat cropping sequence.

| Treatment (% GR) | Gypsum applied (t/ha) | Crop yield(t/ha) |             |
|------------------|-----------------------|------------------|-------------|
|                  |                       | Rice             | Wheat       |
| 0                | 0                     | 4.01             | 3.55        |
| 12.5             | 1.25                  | 4.22             | 3.75        |
| 25.0             | 2.50                  | 4.13             | 3.68        |
| 50.0             | 5.00                  | <b>4.26</b>      | <b>3.82</b> |
| 75.0             | 7.50                  | <b>4.26</b>      | <b>3.83</b> |
| 100.0            | 10.00                 | <b>4.48</b>      | <b>3.94</b> |
| Canal water      | Nil                   | 4.46             | 3.85        |
| LSD (P=0.05)     |                       | 0.24             | 0.16        |

CSSRI ( Karnal)

Sharma and Minhas (2005)



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# Irrigation Management

- Conventional irrigation practices such as basin irrigation could be adopted to manage alkali water.
- The 'alkali hazard' is reduced considerably, if the water is used alternatively or mixed with canal water.
- conjunctive use of alkali and canal water also helps in bringing more area under protective irrigation and also in controlling rise in ground water table and associated problems.
- Canal water should preferably be applied during initial stages including pre-sowing irrigation to boost establishment of crops



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## Effect of cyclic use of sodic and canal water on soil properties and crop yield

| Water quality/mode | pH   | ESP(%) | Average yield (Mg/ha) |       |
|--------------------|------|--------|-----------------------|-------|
|                    |      |        | Rice                  | Wheat |
| Canal water (CW)   | 8.2  | 4      | 6.78                  | 5.43  |
| Sodic water (SW)   | 9.7  | 46     | 4.17                  | 3.08  |
| 2 CW-1SW           | 8.8  | 13     | 6.67                  | 5.22  |
| 1CW-1SW            | 12.8 | 18     | 6.30                  | 5.72  |
| 1 CW-2SW           | 18.5 | 22     | 5.72                  | 4.85  |

\*

Source : Bajwa and Josan (1989)



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## Nutrient Management - Fertilizer Application

- a. Since sodic water cause a rise in soil pH that leads to greater nitrogen losses through volatilization and denitrification, extra nitrogen may have to be added to meet the requirement of the crops
- b. Application of 25% extra nitrogen is needed as compared to the normal conditions.
- c. Zinc sulphate @ 25 kg per ha should be added, particularly for the rabi crops.
- d. Phosphorus, potassium and other limiting nutrients may also be applied on the basis of soil test values.





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# Addition of Organic Materials

- a. Addition of organic materials improve sodic soils through mobilization of inherent  $\text{Ca}^{2+}$  from  $\text{CaCO}_3$  (Calcium Carbonate) and other minerals by organic acids and increased  $\text{pCO}_2$  in soils. The solubilized  $\text{Ca}^{2+}$  in soil replaces  $\text{Na}^+$  from the exchange complex.
- b. Positive role of FYM towards improving soil properties and crop yields. The response of organic sources also varies with the nature of organic matter added.
- c. The mobilization of  $\text{Ca}^{2+}$  during decomposition of organic materials, the quantity of gypsum required for controlling the harmful effects of sodic water irrigation can be considerably decreased.

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Effect of Sodic water along with gypsum and organic amendments on grain yield of wheat crop (t/ha) .

| Irrigation treatment   | Organic amendments                        |             |             |             |             |
|--|---|-------------|-------------|-------------|-------------|
|  | Control                                   | FYM         | GM          | WS          | Mean        |
| <b>CW</b>  | 5.78                                      | 6.45        | 5.94        | 5.89        | 6.02        |
| <b>SW</b>  | 4.75                                      | 5.99        | 5.70        | 5.69        | 5.53        |
| <b>SW+12.5%GR</b>  | 5.58                                      | 6.07        | 5.81        | 5.82        | 5.82        |
| <b>SW+25%GR</b>  | 5.62                                      | 6.08        | 5.89        | 5.75        | 5.83        |
| <b>SW+50%GR</b>  | <b>5.65</b>                               | <b>6.20</b> | <b>6.02</b> | <b>5.89</b> | <b>5.94</b> |
| <b>Mean</b>  | 5.47                                      | 6.16        | 5.87        | 5.81        |             |
| <b>LSD(P=0.05)</b>   | irrigation treatments = 0.40              |             |             |             |             |
|  | Amendments = 0.32                         |             |             |             |             |
|  | Irrigation treatments X Amendments = 0.64 |             |             |             |             |
| CW=Canal water , SW= sodic water GR=Gypsum requirement ,GM=Green manure ;WS=Wheat straw. |   |             |             |             |             |



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# Water Quality Guidelines



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## These guidelines identify special consideration for saline water such as

- a. Use gypsum when saline water (having SAR > 20 and/or Mg/Ca ratio > 3 & rich in silica) induces water stagnation during rainy season and crops grown are sensitive to it.
- b. Fallowing during rainy season is helpful when SAR > 20 and water of higher salinity are used in low rainfall areas.
- c. Additional phosphatic fertilization is beneficial, especially when C1/SO<sub>4</sub> ratio in water is > 2.0.
- d. Canal water preferably is used at early growth stages including pre-sowing irrigation for conjunctive use with saline water.
- e. Putting 20% extra seed rate and a quick post-sowing irrigation (within 2-3 days) will help better germination.



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# Policy Guidelines



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- To implement various technological options for enhancing the use of saline sodic water under real world field situations, the management strategies must be backed by strong policies on water management

**1. Water Quality Monitoring Network** : systematic database must be generated on water quality through network of stations in the basin or irrigation commands by strengthening the existing central and state level agencies.

**2. Modifications in Surface Water Delivery Schedules** : Policy interventions are required to ensure canal water supplies at sowing time of crops in saline irrigated areas. This would encourage farmers to bring more area under cultivation leading to enhanced productivity



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- a. **Ground Water Pumping Pricing** : providing substantial public subsidies in terms of free electricity is not only costing the exchequer but also leading to huge withdrawal of ground water in areas underlain with better quality water. a careful assessment of costs, public information, and education on costs of water services and consequences of subsidies are important for rational pricing strategies.
- b. **Subsidies on Amendments** : The farmers in areas underlain with alkali water further have to incur additional recurring costs on the amendments such as gypsum for sustaining crop productivity
- c. **Promoting Conjunctive Use** : Technically sound and economically viable technologies are available for conjunctive use of surface and poor quality ground water that not only promote the latter's use but also can help maintain overall salt and water balances in the basin
- d. **Further Subsidies on Micro-irrigation System** : Development of micro-irrigation systems including the use of drips, which of course are more capital intensive is considered to be the major innovation to enhance the use of low quality water. Though subsidies are given for promoting these techniques, further incentives are required for installation of such water saving irrigation systems



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# Conclusion



- a. Poor quality water directly and indirectly effect the soil physical, chemical, an biological properties and reduce crop growth and yield on economic level.
- b. Selection of crops, cropping patterns and crop varieties that produce satisfactory yields, the existing appropriate irrigation scheduling and conjunctive use options with canal water; rain water management and leaching strategies to maintain crop yield
- c. The optimal use of chemical amendments including time and mode of their application with judicious use of organic materials and chemical fertilizers
- d. Some of the policy guidelines such as establishing water quality monitoring networks, modifications in canal water delivery schedules, groundwater pumping pricing, subsidies on amendments etc are useful for utilization of poor quality water.