Management of Salt Affected Soils and Water

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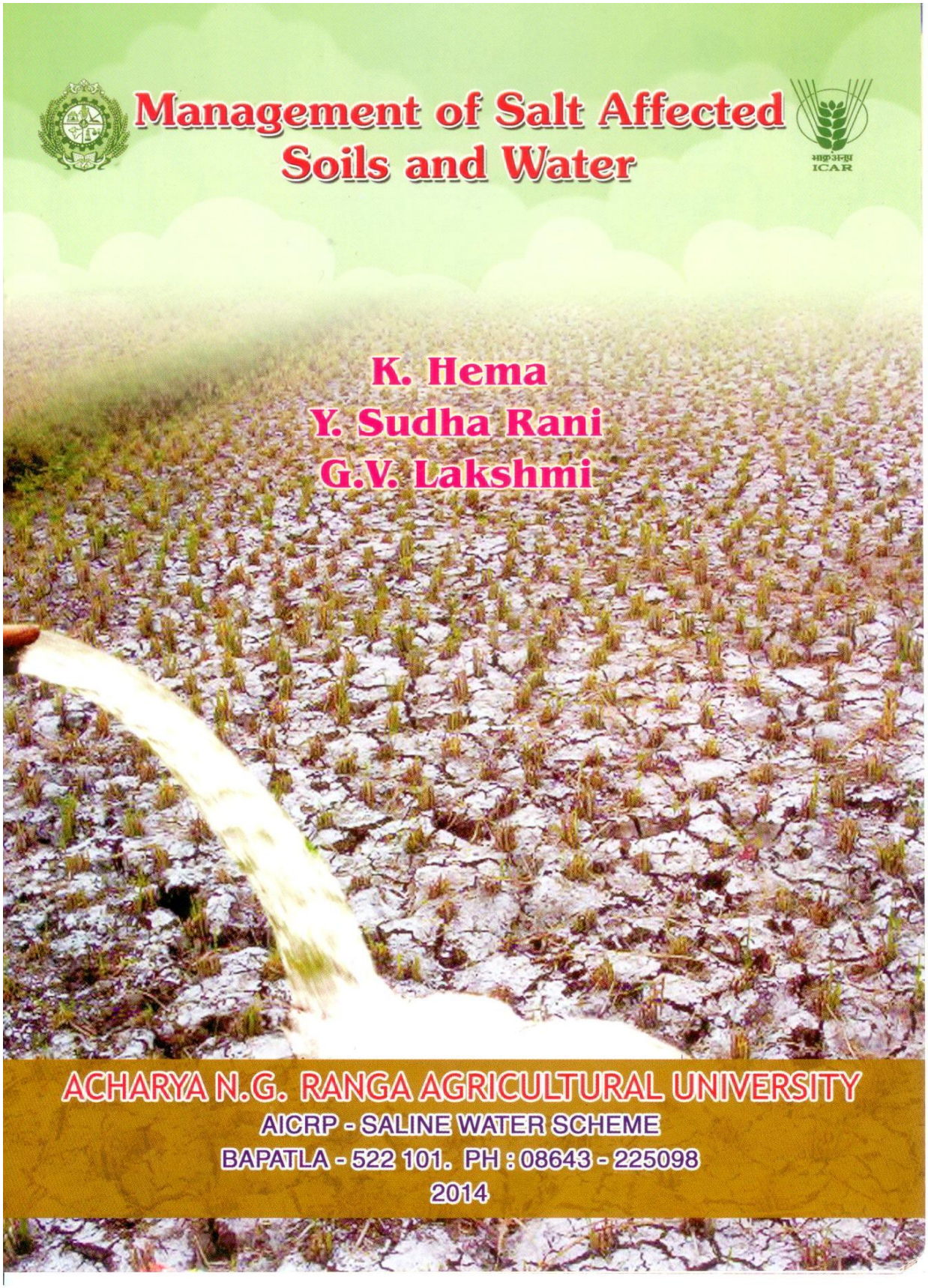

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SOIL

Introduction

In India, the problem of salinity and alkalinity increases every year as a result of secondary salinization. In India about 8.6 mha of land area is affected by soil salinity and sodicity and the area may increase up to 11.7 m ha by 2025. In Andhra Pradesh, saline and alkali soils occupied 8.10 lakh ha and waterlogged soils spread in 3.45 lakh ha.

Classification of salt affected soils

Class	pH	ECe ($dS\ m^{-1}$)	ESP (%)	Indian Local Names
Saline soils	< 8.5	> 4	< 15	Uppu, thur, Lona, Shora, Soula, Pokhali, Khar and Kari
Saline-Alkali soils	> 8.5	> 4	>15	Choudu, Usar, Chopra, Bari, Rels
Alkali soils	>8.5	< 4	> 15	Rakkar, Usar, Bara, Chopan, Kari

Saline soils :

Salinity is measured in terms of electrical conductivity (EC), which is the ability of salt solution to conduct electricity. It is expressed in terms of deci Siemens per metre ($dS\ m^{-1}$).

Characteristics of saline soils

1. White curst of salt on the soil surface
2. pHs (pH of saturation paste of soil) is less than 8.5.
3. Dominant anions are chloride and sulphate
4. The cations present are sodium, magnesium and calcium
5. Specific toxicities of anions and cations

Reclamation technologies for saline soils

- Scratch the soil surface with spade to remove salt flakes.
- Leaching: Divide the field into no. of small plots based on slope. Each plot should be provided with an inlet for filling of good quality water and an outlet for draining of the water with soluble salts. The water should be kept standing for 3-4 days for best results. Repeat the same till optimum soil EC is attained.
- Growing of salt tolerant varieties.
- Application of P to saline soil is necessary to maintain soil fertility status and to reduce the Chloride toxicity for plants.
- Application of organic manure is essential. Best results may be achieved by using optimum combination of organic manure, bio-fertilizer and chemical fertilizer.
- Application of 25% extra nitrogen fertilizers than the recommended.
- Increasing the density of plant population.

- Avoid application of acid forming fertilizers like ammonium sulphate, ammonium chloride etc.
- In ridge and furrow system, the plants are to be planted on the sloping side of the ridge.

Alkali soils :

The chief characteristic of sodic soils from the agricultural stand point is that they contain sufficient exchangeable sodium, which adversely affect the growth of most crop plants. Sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15. Excess exchangeable sodium has an adverse effect on the physical and nutritional properties of the soil, with consequent reduction in crop growth, significantly or entirely.

It is expressed in terms of ESP, which is the degree of saturation of exchangeable complex with sodium; and sodium adsorption ratio (SAR) which is a comparative ratio of Ca^{2+}, Mg^{2+} and Na^{+}.

$$ESP = \frac{\text{Exchangeable Na [c mol (p+) kg}^{-1}\text{)]}}{\text{CEC [c mol (p+) kg}^{-1}\text{)]}} \times 100$$

Characteristics of alkali soils :

- High exchangeable Na+ (>15 per cent) ESP (> 15) and high pH (pHs> 8.5), poor physical properties
- Highly dispersed clay
- The salts are dominated by carbonate and bicarbonate of sodium
- Due to low infiltration rate the soil often becomes waterlogged
- Plants may suffer due to toxicity of sodium carbonate and bicarbonate
- Show poor biomass production

Table: Exchangeable Sodium Percentage (ESP) and Sodicity hazard

Approx. ESP	Sodicity hazard	Remarks
< 15	None to slight	The adverse effect of exchangeable sodium on the growth and yield of crops in various classes occurs according to the relative crop tolerance to excess sodicity. Growth and yield of sensitive crops are affected at ESP levels below 15 and extremely tolerant native grasses grow at ESP above 70 to80.
15 - 30	Light to moderate	
30 - 50	Moderate to high	
50 - 70	High to very high	
> 70	Extremely high	

Reclamation technologies in alkali soils :

In these soils, the reclamation practices include removal of sodium on the exchange complex and decreasing of soil pH. The amendments such as gypsum and pyrites are best suitable for these soils due to the presence of higher quantities of calcium and sulphur.

- Level the land and divide the field in to small compartments with slope of 0.1% to remove drain water
- Inlet and outlet should be separate
- Grow dhaincha crop upto 50% flowering stage and incorporate into field which reduce the ESP over a period of time.
- Planting of old aged seedlings and increasing the density of planting
- FYM application should be accompanied by the gypsum application. To mitigate the adverse affect of alkalinity, application of FYM without gypsum will not have much use.

- Gypsum should be applied @ 500 Kg ha^{-1} for each crop especially where RSC waters are used for irrigation. It varies with the type of soil.
- Application of 25 percent extra nitrogen is needed as compared to the normal condition.
- Zinc sulphate @ 25 Kg ha^{-1} should be added particularly to the rabi crops grown with alkali water.

The quantity of an amendment necessary to reclaim sodic soil depends on the total quantity of sodium that must be replaced. This, in turn, depends on such factors as the soil texture and mineralogical make up of the clay, extent of soil deterioration as measured by ESP and the crops intended to be grown. If it is desired to replace greater quantities of adsorbed sodium, the quantity of gypsum can be accordingly increased. Amendments such as gypsum are normally applied broadcast and then incorporated with the soil by ploughing. Gypsum mixed with the surface 15 cm soil was more effective in the removal of exchangeable sodium than gypsum applied by broadcasting.

WATER

Introduction

The coastal region of India stretching over a coast line of 8219 km long with 10.78 million hectares. Lack of good quality irrigation water, high soil salinity, influence of tidal waves and periodical inundation of soils by tidal water and shallow ground water table enriched with salts are the characters of the ecosystem.

The most important criterion for evaluating given water is its total salt concentration, Sodium Adsorption Ratio (SAR) & Residual Sodium Carbonate (RSC)

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

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

In these equations concentrations are expressed in meq L^{-1}

Table. Grouping of poor quality ground waters for irrigation

Water quality	ECiw (dSm^{-1})	SARiw (m mol L^{-1})	RSC (meq L^{-1})
A. Good water	<2	<10	<2.5
B. Saline water			
i. Marginally saline	2-4	<10	<2.5
ii. Saline	>4	<10	<2.5
iii. High-SAR saline	>4	>10	<2.5
C. Alkali waters			
i. Marginally alkali	<4	<10	2.5-4.0
ii. Alkali	<4	<10	>4.0
iii. Highly alkali	Variable	>10	>4.0

All India Coordinated Research Project on Management of Salt Affected Soils and Use of Saline Water in Agriculture, Bapatla prepared state and districts maps for ground water quality and distributed to the extension agencies. The package of practices to be adopted both for saline and alkaline water along with technological options are presented in the booklet.

Saline Water

Waters with ECiw more than 4 dS m^{-1}, SAR less than 10(m mole L^{-1}) ½ and RSC more than 4 meq L^{-1} called saline water. They are divided in to three types viz., marginally saline, saline and high SAR saline. Saline water is prominent in the following districts...

S.No.	Name of the District	No. of samples	Good	Saline	Alkali	Salinity +Alkalinity
1	Krishna	491	69.2	19.60	11.20	30.80
2	Guntur	805	66.5	22.30	11.20	33.50
3	Prakasam	246	80.5	17.10	2.40	19.50
4	East Godavari	129	83.7	15.50	0.80	16.30
5	West Godavari	784	82.0	12.30	5.70	18.00

Management

- Selection of salt tolerant crops and varieties.
- Marginally saline water can be used for irrigation in light textured soils without any problem either on crop yield or on soil properties.
- Marginally saline water can also be used in heavy textured soils with precautions such as selection of crops which needs less number of irrigations and avoid summer irrigation.
- Application of organic manures like FYM @ 5-10 t ha^{-1} will mitigate the adverse effect of marginally saline/saline water irrigation.
- Proper irrigation and leaching practices can prevent excessive accumulation of salts in the root zone. A shift towards micro-irrigation systems such as drip and sprinklers, where a better control on salt and water distributions.
- Application of amendment like gypsum @ 1-2 t ha^{-1} is recommended for saline water having Mg:Ca > 3.
- Split application of nitrogen to prevent N losses through volatilization and denitrification. Correction of nutrient deficiencies by foliar application of nutrients.
- Addition of 50 percent more phosphotic fertilisers than recommended dose if irrigated water is rich in chlorides and the soils having low available phosphorous.
- For sulphate rich waters, no additional application of phosphate fertilisers is required and the dose recommended under normal conditions may be applied.
- Dilution and cyclic use of good and saline waters.

Alkali water

Waters with ECiw less than 4 dS m^{-1}, SAR more than 10 (m mole $L^{-1})^{½}$ and RSC less than 4 meq L^{-1} are called alkali water. Alkali waters are present in higher levels in the following districts. The RSC is the major problem in these waters. Continuous use of such high RSC waters will rise the soil pH and ESP which in turn decreases permeability. Due to high sodium and high pH, micronutrients (Zn, Fe etc.) deficiencies may occur.

S.No.	Name of the District	No. of samples	Good	Saline	Alkali	Salinity +Alkalinity
1	Warangal	607	54.4	7.80	37.80	45.60
2	Mahabubnagar	1128	56.1	3.20	40.70	43.90
3	Nalgonda	815	52.4	5.40	42.20	47.60
4	Kadapa	501	58.48	9.98	31.54	41.52
5	Nellore	929	39.0	9.20	51.80	61.00

Management

- Selection of crop varieties tolerant to sodicity / alkalinity.
- In low rainfall areas (average annual rainfall < 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 should be grown.
- For areas having rainfall > 400 mm/annum, it is ensured that sowing, particularly of *kharif* crops is done with rain water or good quality canal water. Besides, not more than 2 to 3 irrigations should be applied with alkali waters in the *kharif*.
- Alkali waters should not be used for growing summer crops in the month of April to June.
- Application of dhaincha @ 25 kg ha^{-1} and incorporate at 50% flowering as insitu
- Application of 25 per cent extra nitrogen is needed as compared to the normal conditions to avoid the nitrogen losses through volatilisation and denitrification.
- Zinc sulphate @ 50 kg ha^{-1} is recommended particularly to rice due to precipitation of zinc as hydroxides and carbonates .
- Phosphorus, potassium and other limiting nutrients may also be applied on the basis of soil test values.
- Some alkali waters may be rich in nutrients like nitrogen, potassium and sulphur. Such waters should be analysed and the fertiliser dose of concerned nutrient reduced accordingly.
- Soil application of calcium bearing and amendments like Gypsum, sulphuric acid, pyrites, Passing water through gypsum beds etc., among all gypsum is the cheapest source, low cost and easy handling.

- Gypsum requirement to neutralise residual alkalinity of water: The quantity of agricultural grade gypsum (70% purity) for neutralization of each meq L^{-1} of RSC is 100 kg ha^{-1} per irrigation. The quantity of gypsum is thus determined by the quality of water (RSC to be neutralised) and the quantity of water required for irrigation during a growing season.
- Gypsum application is recommended when high RSC waters are used for irrigation taking into consideration number of meq L^{-1} of RSC over and above the safe limit of 4 meq L^{-1}, soil texture and number of irrigations.

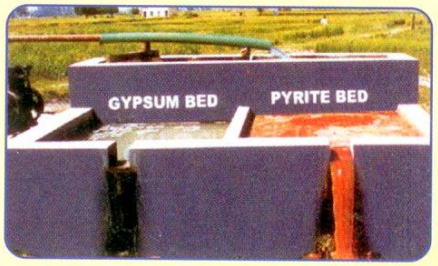
Gypsum to be applied Kg ha^{-1}

No. of irrigations	RSC of water (meq L^{-1})	RSC to be neutralized	Heavy textured soils	Light textured soils	Sandy loams	Sandy soils
5	5	5-4=1	300	200	100	Occasional gypsum application is sufficient to improve crop yield.
	6	6-4=2	600	400	200	
	7	7-4=3	900	600	300	
	8	8-4=4	1200	800	400	

(a) RSC less than 2.5 meq L^{-1} safe limit

(b) RSC between 2.5 - 4.0 meq L^{-1} occasional gypsum application will improve the crop yield.

(c) Gypsum application in splits along with each irrigation is better than single application.



- Time of application and method of application of gypsum is more important. Best method of application is through broadcast method and preferably applied at the end of the *rabi* crop / in the month of May or June.

Saline- Alkali water

Waters with ECiw more than 4 dS m^{-1}, SAR more than 10(m mole L^{-1}) ^{½} and RSC more than 4 meq L^{-1} called saline- alkali water.

Table: Percent distribution of Salinity + Alkalinity irrigation water

S.No.	Name of the District	No. of samples	Good	Saline	Alkali	Salinity +Alkalinity
1	Srikakulam	602	81.0	8.50	10.50	19.00
2	Karimnagar	643	83.83	8.09	8.09	16.18
3	Nizambad	658	83.43	2.28	14.29	16.57
4	Adilabad	661	87.29	1.81	10.89	12.70
5	Anantapur	797	88.3	10.60	1.10	11.70
6	Vizianagaram	600	80.0	2.00	18.00	20.00
7	Khammam	554	78.3	1.50	20.20	21.70
8	Rangareddy (+HYD)	514	72.8	6.90	20.40	27.30
9	Kurnool	622	69.0	9.80	21.20	31.00
10	Medak	622	71.2	2.60	26.20	28.80
11	Chittoor	712	71.3	10.60	18.10	28.70
12	Visakhapatnam	596	61.0	10.00	29.00	39.00

Management

- Selection of salt tolerant / sodicity tolerant crops and varieties.
- Proper irrigation and leaching practices can prevent excessive accumulation of salts in the root zone.
- Soil application of calcium bearing and amendments like gypsum, sulphuric acid, pyrites, passing water through gypsum beds etc.
- 25% extra seed rate required compared to normal seed rate.
- Application of organic manures like FYM @ 5-10 t ha^{-1} or application of dhaincha @ 25 kg ha^{-1} and incorporate at 50% flowering as insitu will mitigate the adverse effect of bad quality water irrigation.
- Application of 25 per cent extra nitrogen is needed as compared to the normal conditions to avoid the nitrogen losses through volatilisation and denitrification and 50 percent more phosphotic fertilisers than recommended dose if irrigated water is rich in chlorides and the soils having low available phosphorous
- Application of Zn @ 50 kg $ZnSO_4$ ha^{-1} counteracts the negative effect of higher salinity and sodicity.
- Dilution and cyclic use of good and saline alkali waters. When good quality water is limited, it can be used as follows :
  - Presowing and first irrigation should be with good quality water. Later saline water can be used.
  - Poor quality water can be mixed with good water.
  - Drip or pitcher irrigation is found suitable.
- Use of mulches and intercultural operations reduce water requirement of crops, thus with saline water salinity develops at a relatively lesser intensity.