RESEARCH ARTICLE Agricultural Scinece Digest, Volume 39 Issue 4: 286-290 (October-December 2019)

# Reclaimation of Sodic Bore Well Water for Irrigation through Gypsum Treatment at Anbil Dharmalingam Agricultural College and Research Institute, Trichirapalli District, Tamil Nadu

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10.18805/ag.D-4961

## ABSTRACT

It is necessary to ascertain the quality of irrigation water at Anbil Dharmalingam Agricultural College and Research Institute farm in order to monitor the possible effects of the sodic irrigation water on the soil. Irrigation with sodic water enhances soil sodicity built up in soils of experimental farm which leads to adverse effects on soil physical, chemical and biological properties, not fitted for farming. In areas where ground water is sodic and where good quality surface water supplies are either inadequate or not available at all and the farmers are left with no option but to use sodic ground water for irrigation purposes, which pose grave risks for soil health and environment. The quality of sodic water can be improved by treating with gypsum. Due to gypsum dissolution calcium and sulphate ions come in soluble form in irrigation water. Research conducted at Anbil Dharmalingam Agricultural College and Research Institute Trichy for reclamation of sodic bore well water revealed that the sodic bore water samples collected from bore well 1 (AMP shed) having initial Residual Sodium Carbonate (RSC) of 8.0 meq /lit and bore well 6 (Boys hostel) having initial RSC of 6.2 meq /lit indicated the decrease in RSC upto - 0.6 meq / l and 1.2 meq / l respectively due to gypsum treatment with 0.1 per cent (12.50 tons/ha) and 0.35 per cent (43.75 tons /ha) at the retention time of 1 hour to irrigate 1 ha paddy field throughout crop establishment stage. It was concluded that for lowest retention time higher doses of gypsum was required for sodic water reclamation. As we increased the retention time, the required gypsum quantity was also minimized as observed for bore well 1 (AMP shed 8 meq/l) sodic water samples with gypsum dose of 0.15 per cent (18.75 tons /ha) with the retention time of 4 hours. These findings were very much helpful for the farmers of Manikandam block, Tiruchirappallii district having secondary sodicity built up in soils due to sodic water irrigation during summer.

**Key words:** Characterization, Gypsum, Reclamation, Sodic water irrigation.

## INTRODUCTION

Water is one of the basic requirements for crop production. Rainfall is quite insufficient and erratic and is unable to meet the crop water requirements. Surface water supplies are also not sufficient to meet out the requirements of intensive cropping. Hence, use of poor quality underground water for crop production is increasing with the passage of time to meet the ever increasing demand for food and fiber. The suitability of water for crop production is judged from their long term effect on the soil productivity. Irrigation with poor quality water deteriorates the soil properties and creates conditions unfavorable for the economic growth of crops with normal farming practices. The nature of crop growth hindrance is determined by the amount and kind of salt present in the irrigation water. These problems may at times operate simultaneously or in combination. The general crop responses and the potential hazards of using poor quality waters are determined by a number of factors such as soil, crop and agro-climatic factors which require careful understanding for their better management (Joachim *et al*., 2010). Agricultural scientists have developed, perfected and tested technologies for safe use of brackish (sodic) water to sustain high level of agricultural production. There is need to disseminate the technology among the actual users, farmers, extension workers, administrators and development agencies etc (Flanary *et al.*, 2011). The sodic hazards of the water need to be mitigated for exploiting their irrigation potential. The common practice is the field mixing of powdered gypsum in a leveled field and then flooding it with good quality water. The powdering, bagging and proper storage of gypsum, the pre requisite for direct application to field, normally accounts for about 50 per cent of the total cost of sodic water reclamation. For best results, good amount of fresh water is required, which is generally lacking in the arid and semi-arid regions. Further, field application needs to be done well before sowing of crops and it may not be uniform leading to improper mixing with the soil. In this case soil gets affected first and reclamation is done afterwards. A relatively more economical and efficient method is the use of agriculturally grade gypsum mixed with irrigation water in a tank which minimizes the need for leveled field and fresh water. In this method the sodic water is reclaimed before its application in the field without affecting soil and crops. Moreover, the amount of gypsum required to reclaim sodic water will be much less as compared to direct application in the field. Considering the encouraging results, this technology was tested at ADAC&RI Farm, Trichy by collecting bore well water samples around 7 numbers and were characterized for their

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**How to cite this article:** K. Pradeepa, G. Lavanya, S. Inbarasan, T. Sherene and P. Balasubramaniam. (2019). Reclaimation of Sodic Bore Well Water for Irrigation through Gypsum Treatment at Anbil Dharmalingam Agricultural College and Research Institute, Trichirapalli District, Tamil Nadu. Agricultural Science Digest. 39(4): 286-290.

**Source of support:** Nil

**Conflict of interest:** None

**Submitted:** 06-06-2019 **Accepted:** 31-08-2019 **Published:** 06-12-2019

suitability to irrigation. Agriculturally grade gypsum was used for reclamation of sodic water and was analysed for total Ca and Mg content. Gypsum required for RSC optimization was computed. The research aimed at developing irrigation potential to farmers for reclaiming sodic ground water with gypsum treatment.

## Materials and Methods

### Collection of Bore well water samples

Around seven number of bore wells are available at ADAC&RI, farm Trichy (Fig 1). In order to check the suitability of water samples for irrigation, water samples were collected from seven bore well during January 2019 (Table1). Water samples were collected in clean glass bottle having a well-fitted glass stopper. The bottles were rinsed thoroughly at least three times with the water sample before the sample was finally drawn. Stoppard the bottle tightly and labeled it properly stating the source of water, date and time of collection of sample. At the time of analysis, filter the sample through a dry filter paper, to eliminate suspended impurities and carry out the chemical analysis on suitable aliquots for the analysis of anions and cations.

### Characterization of Sodic water for their suitability to irrigation

The water quality parameters *viz*., Hydrogen ion concentration (pH), Electrical conductivity (EC) Bicarbonate, Carbonate, Calcium, Magnesium, Sodium, Residual Sodium Carbonate (RSC) and Sodium Adsorption Ratio (SAR) are important to know ground water quality and are determined in the water for irrigation purposes as per standard procedures.

### Computation of RSC

The RSC exist in irrigation water when the carbonates plus bicarbonates content exceeds the calcium plus magnesium content of water. If high RSC water is used for irrigation accumulation of sodium occurs in soil. The formula for RSC as follows:-

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

| Class (meq/l) | Remarks |
|---|---|
| <1.25 | Good |
| 1.25-2.5 | Fair |
| >2.5 | Unsuitable |

### Computation of SAR

United States Salinity Laboratory (USSL) staff introduced the concept of sodium adsorption ratio to predict the sodium hazard. It is calculated as,

$$\mathbf{SAR = Na^{+}/\sqrt{Ca^{2+} + Mg^{2+}/2}} \quad \text{meq / l}$$

The sodium hazard of irrigation water expressed through SAR does not take into account the effect of anionic composition. Sodicity hazard also classified as $S_1$, $S_2$, $S_3$ and $S_4$ .

| Water class | SAR | Remarks |
|---|---|---|
| $S_1$-Low Sodium hazard | 0-10 | Little or no hazard |
| $S_2$-Medium Sodium hazard | 10-18 | Appreciable hazard but can be used with appropriate management techniques |
| $S_3$-High Sodium hazard | 18-26 | Unsatisfactory for most of the crops |
| $S_4$-Very high Sodium hazard | >26 | Not suitable |

### Characterization of Agricultural grade gypsum for their Ca & Mg contents

Gypsum, which is readily available from mines of Bhopal (M/s.Bhopal Mining Corportaion) in the form of powder, has a purity of 85%. The total Ca (28%) and Mg (21%) content of Gypsum were analysed as per FCO, (1985) protocol.

### Laboratory studies for RSC optimization in Sodic water

Among the seven sodic bore well water samples collected from ADAC&RI farm, only two samples (bore well 1- AMP shed & bore well 6 - Boys hostel) were used in RSC optimization experiment since the initial RSC of sodic water samples of bore well 1 and bore well 6 were 8.0 m.eq /lit and 6.2 m.eq/lit respectively . The following treatments were imposed with sodic water of bore well 1 & bore well 6 based on the solubility of gypsum i.e 2.5 g /lit. The experiment was designed in Completely Randomized Design and the treatments were triplicated. At every one hour interval, the samples were taken from the respective treatments, and were analysed for RSC of bore well water samples till it became less than 2.5 m.eq/lit which is a safe limit for sodic water to be irrigated.

### Treatment structure

| Treatments | Gypsum added (%) |
|---|---|
| $T_1$ | 0.05 |
| $T_2$ | 0. 1 |
| $T_3$ | 0.15 |
| $T_4$ | 0.20 |
| $T_5$ | 0.25 |
| $T_6$ | 0.30 |
| $T_7$ | 0.35 |
| $T_8$ | 0.40 |
| $T_9$ | 0.45 |
| $T_{10}$ | 0.50 |

**Table 1:** Bore well sampling locations of ADAC&RI, Trichy.

| Bore well No. | Particulars | Bore well location | |
|---|---|---|---|
| | | Latitude | Longitude |
| 1. | AMP shed, ADAC&RI, Trichy | 10°4′59″N | 78°36′4″E |
| 2. | Office, ADAC&RI, Trichy | 10°45′0″N | 78°35′55″E |
| 3. | F. No. $A_2$B, ADAC&RI, Trichy | 10°45′17″N | 78°36′12″E |
| 4. | F. No. $A_4$C, ADAC&RI, Trichy | 10°45′17″N | 78°36′12″E |
| 5. | F. No. $D_2$B, ADAC&RI, Trichy | 10°45′0″N | 78°35′55″E |
| 6. | Boys hostel, ADAC&RI, Trichy | 10°45′55″N | 78°35′58″E |
| 7. | Staff quarters, ADAC&RI, Trichy | 10°45′17″N | 78°36′12″E |

## Results and Discussion

### Characterization of sodic water of ADAC& RI, Farm

The bore well water samples of ADAC&RI farm were characterized based on pH, EC, SAR and RSC as per CSSRI, Karnal classification (Table 2). Among the seven bore wells, only three bore wells were meant for good quality irrigation water (bore well 2 – Office, bore well 3 – Field no.$A_2B$, and bore well 4 – Field No. $A_4C$), remaining four (bore well 1 - AMP shed, bore well 5- field no.$D_2B$, bore well 6 - Boys hostel, , bore well 7 - Quarters) bore wells were found to be in RSC range of 5.6 -8.0 meq / l reported to be sodic water. Among the four sodic bore well water samples, bore well 1 (AMP shed) and bore well 2 (Boys hostel) water samples were taken for RSC optimization studies .The underground sodic water used for treating with gypsum had pH in the range of 7.80 to 8.02, EC of 2.66 to 3.57 dS/m, Residual sodium Carbonate of 2.2 to 8 meq/l. As per classification such type of underground water comes under sodic water quality (Table 3). When these types of water are used for irrigation it increases pH, EC and ESP as a result physical properties such as aeration and permeability are adversely affected. Inspite of poor quality water is being used for irrigation as there are no other alternatives, use of such ground water with organic (Farm yard manure, green manure ,biogas slurry, pressmud etc) and inorganic amendments like gypsum may help the farmer in getting a satisfactory crop yield without deteriorating the soil fertility as reported by (Singh, 2013).

**Table 2:** Grouping of water quality for irrigation in India quality of water.

| | EC (ds/m) | SAR (mmol/l) | RSC (me/l) |
|---|---|---|---|
| A. Good | <2 | <10 | <2.5 |
| B. Saline | | | |
| i. Marginally saline | 2 – 4 | <10 | <2.5 |
| ii. Saline | >4 | <10 | <2.5 |
| iii. High SAR saline | >4 | >10 | <2.5 |
| C. Alkali water | | | |
| i. Marginally alkali | <4 | <10 | 2.5-4 |
| ii. Alkali | >4 | <10 | >4 |
| iii. High alkali | <4> | >10 | >4 |

(CSSRI, Karrnal,1978)

### Improvement of water quality

The result of sodic water treated with gypsum was given in Table 4 and 5. Results indicated that the decrease in RSC upto -0.6 meq / l and 1.2 meq /l due to increased gypsum dissolution with 0.1 per cent and 0.35 per cent gypsum in the borewell water sample of Boys hostel and AMP shed respectively at the retention time of 1 hour. Due to gypsum dissolution calcium and sulphate ions come in soluble form in irrigation water. The increased concentration of calcium in gypsum treated sodic irrigation water helps in neutralizing the RSC (Archana Singh *et al*., 2014).

Results indicated that upon usage of higher doses of gypsum for RSC neutralization, required minimum retention time of 1 hour. For lower doses of gypsum required more retention time to bring RSC values less than 2.5 meq/l which is a safe limit. In case of sodic water of AMP shed (bore well 1), we concluded that for lowest retention time higher doses of gypsum required. As we increased the retention time, the required gypsum quantity was also minimized (Table 6). These finding might be helpful to the farmers in saving the cost incurred towards gypsum for sodic irrigation water reclamation (Fig 2). Among various parameters recorded

**Table 3:** Characterization of sodic water of ADAC&RI, Farm, (Jan-2019) for its suitability to irrigation.

| Particulars | pH | EC | $CO_3^{2-}$ | $HCO_3^-$ | $Ca^{2+}$ | $Mg^{2+}$ | RSC | Remarks |
|---|---|---|---|---|---|---|---|---|
| AMP shed, ADAC&RI, Trichy | 8.01 | 3.57 | 2.8 | 10.2 | 1.0 | 4.0 | 8.0 | Alkali/Sodic |
| Office, ADAC&RI, Trichy | 7.80 | 3.0 | 1.0 | 11.2 | 1.00 | 7.0 | 4.2 | Alkai/Sodic |
| $A_2B$, ADAC&RI, Trichy | 7.97 | 2.81 | 2.0 | 2.8 | 2.0 | 5.2 | - 2.4 | Normal |
| $A_4C$, ADAC&RI, Trichy | 8.03 | 3.52 | 1.2 | 5.0 | 1.2 | 2.8 | 2.2 | Normal |
| $D_2B$, ADAC&RI, Trichy | 8.03 | 2.66 | 0.6 | 7.6 | 0.6 | 3.2 | 4.4 | Alkai/Sodic |
| Boys hostel, ADAC&RI, Trichy | 8.02 | 2.68 | 2.8 | 9.6 | 2.0 | 4.2 | 6.2 | Alkai/Sodic |
| Quarters ADAC&RI, Trichy, | 7.86 | 3.49 | 1.0 | 7.4 | 1.0 | 1.6 | 5.8 | Alkai/Sodic |

**Table 4:** RSC (m.eq./lit) neutralization of Sodic water at gypsum retention time of 1hour (Mean of three replication values) AMP SHED.

| Treatments | Calcium (meq/l) | Magnesium (meq/l) | Carbonate (meq/l) | Bicarbonate (meq/l) | RSC (meq/l) | SAR |
|---|---|---|---|---|---|---|
| $T_1$ | 3.4 | 5.6 | 2.0 | 14.4 | 7.4 | 4.18 |
| $T_2$ | 5 | 4.8 | 3.2 | 13.2 | 6.6 | 4.11 |
| $T_3$ | 5.2 | 6.8 | 2.0 | 14.0 | 4.0 | 3.42 |
| $T_4$ | 5.8 | 5.6 | 0.8 | 17.0 | 3.2 | 2.95 |
| $T_5$ | 8.6 | 4.8 | 3.2 | 13.0 | 3.8 | 4.09 |
| $T_6$ | 8.4 | 6.8 | 1.6 | 14.8 | 2.0 | 3.35 |
| $T_7$ | 9.6 | 6.2 | 2.0 | 15.0 | 1.2 | 3.22 |
| $T_8$ | 11 | 5.4 | 2.8 | 13.2 | 0.4 | 3.30 |
| $T_9$ | 11.6 | 4.6 | 2.8 | 13.8 | 0.4 | 3.51 |
| $T_{10}$ | 10.8 | 7.2 | 2.8 | 11.4 | -3.8 | 2.80 |

such as pH, EC, RSC and gypsum requirement, it is concluded that the amount of gypsum required for sodic water reclamation depend on the RSC values. The advantages of sodic water reclamation with gypsum treatment were found to be cheaper, economically viable and practically feasible for the farmers. Relatively less gypsum is required to reclaim as dissolution of gypsum is maximum in water. Flooding with good quality water is not necessary. No possibility of non-uniform application of gypsum in the field as the sodic water is reclaimed in the tank itself before reaching the field. No micro leveling off the field is essential. Saving in cost and energy for powdering and bagging of gypsum. The disadvantages are in case where a farmer uses sprinkler set for irrigation, an additional booster needs to be installed for lifting the reclaimed water from the storage tank.

**Model calculation**

**Working out gypsum requirement of sodic bore water of bore well 1 (AMP shed), ADAC&RI, Trichy for I ha of paddy crop irrigation**

**Table 4a:** RSC (m.eq./lit) neutralization pattern of sodic water (AMP shed) at different time interval.

| Treatments | 1 hour | 2 hour | 3 hour | 4 hour |
|---|---|---|---|---|
| $T_1$ | 7.4 | 6.9 | 5.1 | 4.5 |
| $T_2$ | 6.6 | 5.8 | 4.1 | 3.3 |
| $T_3$ | 4.0 | 3.1 | 2.5 | 2.2 |
| $T_4$ | 3.2 | 2.2 | 1.5 | 1.1 |
| $T_5$ | 3.8 | 2.3 | 1.3 | 0.3 |
| $T_6$ | 2.0 | 1.2 | 0.8 | -0.5 |
| $T_7$ | 1.2 | 0.5 | -0.9 | -0.1 |
| $T_8$ | 0.4 | -1.1 | -1.2 | -0.9 |
| $T_9$ | 0.4 | -0.9 | -0.2 | -0.02 |
| $T_{10}$ | -3.8 | -1.8 | -1.1 | -0.05 |




**Fig 1:** Farm layout representing borewell location of ADAC & RI, Trichy.

**Table 5:** RSC (m.eq./lit) neutralization of Sodic water when gypsum retention time after 1hour (Mean of three replication values) Boys Hostel.

| Treatments | Calcium (meq/l) | Magnesium (meq/l) | Carbonate (meq/l) | Bicarbonate (meq/l) | RSC (meq/l) | SAR |
|---|---|---|---|---|---|---|
| $T_1$ | 3.0 | 9.2 | 2.4 | 12.8 | 3.0 | 3.67 |
| $T_2$ | 4.4 | 10.6 | 2.8 | 11.6 | -0.6 | 2.53 |
| $T_3$ | 5.8 | 10.6 | 3.2 | 11.4 | -0.1 | 3.04 |
| $T_4$ | 6.8 | 9.6 | 4.0 | 10.0 | -2.4 | 3.18 |
| $T_5$ | 8.2 | 11.4 | 2.8 | 9.8 | -7.0 | 2.75 |
| $T_6$ | 8.2 | 11.4 | 4.0 | 9.6 | -6.0 | 2.74 |
| $T_7$ | 9.2 | 8.8 | 3.6 | 9.2 | -5.2 | 3.14 |
| $T_8$ | 8.2 | 10.0 | 2.4 | 11.2 | -4.6 | 2.82 |
| $T_9$ | 10.8 | 7.6 | 2.8 | 13.6 | -2.0 | 3.19 |
| $T_{10}$ | 12.4 | 5.4 | 3.6 | 14.2 | 0 | 3.62 |

**Table 6:** Reclamation of Sodic water of ADAC&RI, Farm, Trichy to irrigate 1 ha paddy field.

| Bore well location | RSC (m.eq/lit) | | Gypsum | Gypsum | Retention |
|---|---|---|---|---|---|
| | Initial | Final | requirement (%) | requirement (T) | Time |
| Boys Hostel | 6.2 | -0.6 | 0.1 | 12.50 | 1 Hr |
| AMP SHED | 8 | 1.1 | 0.35 | 43.75 | 1 Hr |
| AMP SHED | 8 | 2.2 | 0.15 | 18.75 | 4Hr |

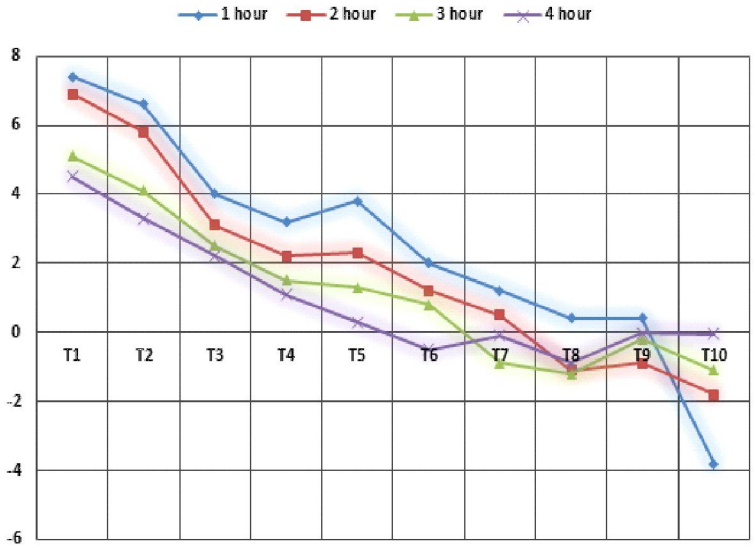



**Fig 2:** RSC (m.eq./lit) neutralization of sodic bore well water (AMP shed) at various time intervals with Gypsum addition.

Water requirement of paddy for one hectare land 1ha) =1250 mm /125 cm (Crop Production Guide, 2012)

1 cm irrigation water = 1 lakh litre $ha^{-1}$

Water requirement of 1 ha paddy = 125 cm $ha^{-1}$

Volume of water required in $cm^3$ =125 lakh litres

**1.** Quantity of gypsum required for RSC neutralization from 8.0 to 1.2 with 1 hr retention = 0.35 % gypsum

Gypsum requirement in Kg for paddy crop of 1 ha
= 125 ×100000×3.5/1000
**= 43,750 Kg gypsum or 43.75 tonns**

**2.** Quantity of gypsum required for RSC neutralization of sodic bore water from 8.0 to 2.2 for 4 hr retention time = 0.15 % gypsum

Gypsum requirement in kg for paddy crop of 1 ha
= 125 ×100000×1.5/1000
**= 18,750 Kg gypsum or 18.75 tonns**

**3.** Quantity of gypsum required for RSC neutralization of sodic bore water from 6.2 to -0.6 0.10 %

Gypsum requirement in kg for paddy crop of 1 ha
= 125 ×100000×1.0/1000
**= 12,500 Kg gypsum or 12.50 tonns**

## Conclusion

Sodicity built up in soil through sodic water irrigation is a major problem in ADAC&RI, farm. Quantity of gypsum required for RSC neutralization from 8.0 to 1.2 in 1 hour retention time was 0.35 % gypsum. Quantity of gypsum required for RSC neutralization from 8.0 to 2.2 in 4 hour retention time was 0.15 % gypsum. Quantity of gypsum required for RSC neutralization from 6.2 to -0.6 with the reaction time of 1 hour is 0.10 % gypsum. Presently there is no subsidy on lump/clod gypsum, whereas, the powdered gypsum is supplied at a highly subsidized rate to the farmers. State Government may provide subsidy for gypsum clods/ lump on par with powdered gypsum, it will encourage the farmers to use sodic water treated with gypsum, which reclaims the sodic groundwater to be used for irrigation and other domestic consumption. Further this study needs field level implication to validate the test results.

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ISSN: 0976-0547 (Online), 0253-150X (Print), Naas Rating: 4.21