Annals of Arid Zone 32(3) 145 – 150 1993

# Geo-electrical Investigation on Sub-surface Configuration and Groundwater Salinity in Indira Gandhi Canal Command, Western Rajasthan

**K S Sundara Sarma, H Chandrasekharan, D Datta*, P Mookerji and D K Das**
*Division of Agricultural Physics, NRL, Indian Agricultureal Research Institute, New Delhi – 110 012 India*

**Abstract** Knowledge of sub-surface configuration and studies on perched water salinity are important for efficient water management decisions in Indira Gandhi Canal Command, western Rajasthan. Results of geo-electrical investigations carried out at the Lunkaransar State Agricultural Farm in the IG Canal Command, indicated that gypsiferous layer is responsible for the occurrence of perched water varied from 2 to 26 m in thickness. Highly saline water is encountered beneath it in confined conditions. Salinity levels of the perched water was found to be governed partly by the nature of soils and partly by the subsurface flow of excess irrigation water.

**Key words** Geo-electrical, Resistivity, Subsurface configuration Gypsiferous layer, Salinity

To formulate a sound management policy for judicious use of water in irrigation command area, it is necessary to have a comprehensive knowledge of various hydrological parameters of the command and the type of hydrological processes involved, both paleo and present. Water management in the Indira Gandhi Canal Command, western Rajasthan, is beset with many complex problems such as presence of gypsiferous layer at shallow depths, water logging and salinity, thick blanket of wind blown sand, etc. It is often seen that geo-electical method can provide precise information of the subsurface configuration of any area in a given hydrogeological setup. The objectives of the present study was, therefore, aimed at finding out the subsurface configuration and possible mechanism of salinization of perched water through geo-electrical investigation carried out along a traverse in the Lunkaransar State Agricultural Farm.

## Materials and Methods

*Experimental area* : Situated in the Indira Gandhi Nahar Command, western Rajasthan, Lunkaransar Agricultural Farm with an area of about 75ha has been divided into 54 plots (Fig.1). These plots are provided with irrigation facilities through three main water channels drawn from the Lunkaransar lift canal, a branch from the Indira Gandhi Nahar. The topography of the farm is slightly uneven throughout and slopes downwards to plot numbers from 42 to 54. The main soil types are given in Table 1. The soil texture vary from sandy loam to loamy sand with an average sand content of 81%. The maximum temperature during summer months is around 45$^0$C, while the minimum temperature in winter reads below 5$^0$C. In view of the extreme aridity in the experimental area, the rainfall contribution to the subsurface flow is negligible.

*Investigations* : Considering the topography and the possible direction of surface water movement, it was felt that a traverse (AB) in the NE-SW direction across the farm could be more informative (Fig 1). Accordingly eight vertical electrical soundings (schlemberger configuration) at an interval of about 150 m between successive soundings and with a maximum electrode seperation of 200 m was conducted. The field resistivity data were interpretted by curve matching methods (Rijikswaterstaat 1969). The Longitudinal Unit Conductance, S, (Maillet 1947) for a given depth 'd' is calculated using the relation

$$S_d = \frac{\Sigma}{i} (h_i / \rho_i)$$

where, $h_i$ is the thickness of i th geo-electric layer, and

$\rho_i$, the corresponding resistivity value.

The parameter S, gives the overall conductivity value of the soil-water-rock matrix upto the depth designated and it has been reported that the electrical conductivity of groundwater available at the

* RRSSC, Jodhpur – 342 003

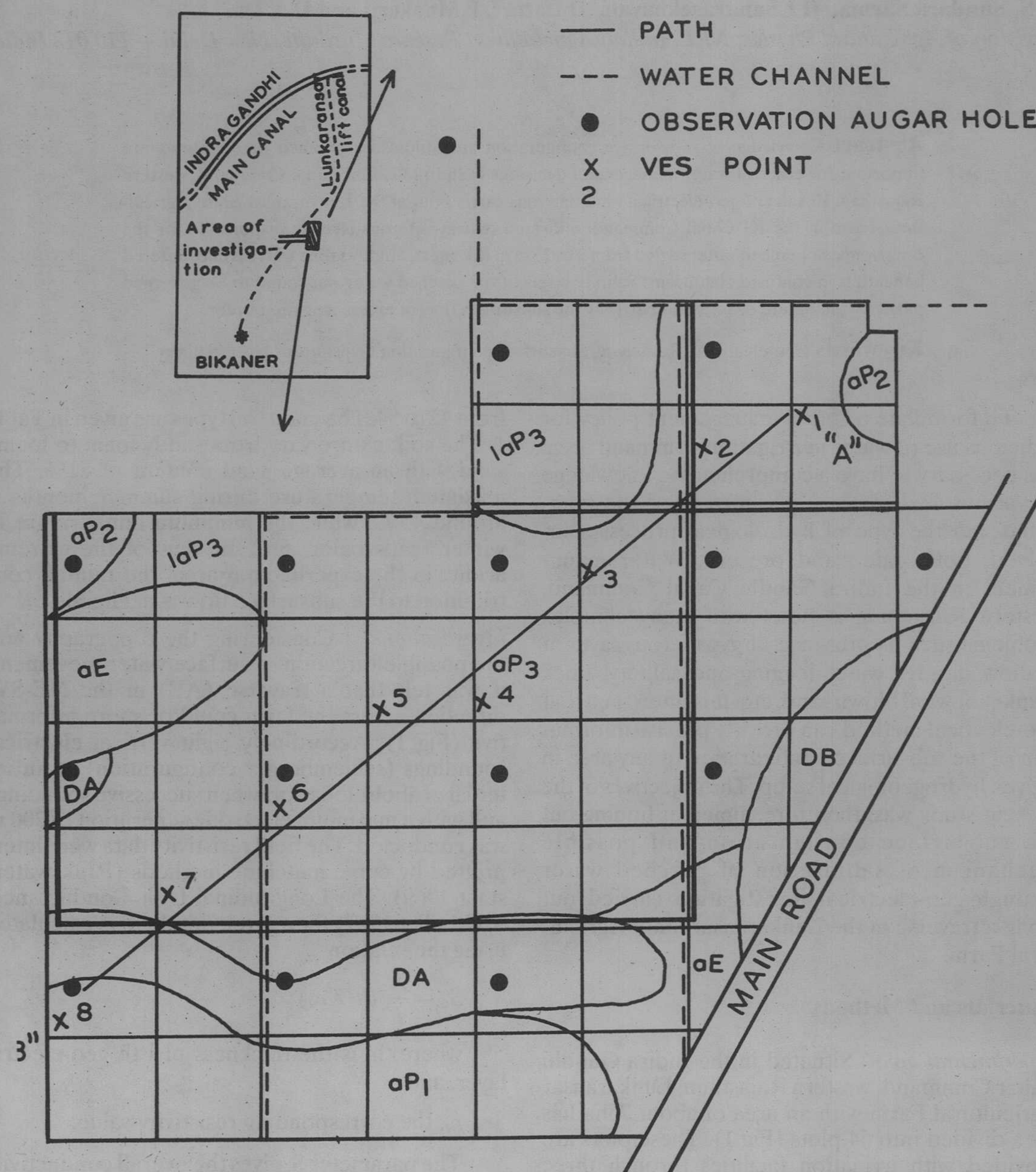


**Fig 1** Agricultural Research Farm, Lunkaransar (Rajasthan) 334 603

**Table 1** *Description of dominant soil types*

| Mapping Unit | Description | Relief | Drainage | Present land use |
|---|---|---|---|---|
| aE | Very deep, yellowish brown (10 YR 6/4), fine sand to loamy fine sand, droughty calcareous | Generally undulating and hummocky | No established pattern for surface drainage, subsoil drainage is excessive | *Kharif* cultivation : (groundnut, guar, arhar) *Rabi* : Mustard Barley |
| $aP_1$ | Moderately deep, dominantly loamy fine sands over *kankar* or rocky sub-strata with in 50 to 100 cm. (10 YR 6/4 dry) or dark brown (10 YR 4/5, moist), calcareous, high susceptibility to wind erosion | Slopping and hummocky | Sub-soil drainage excessive, but under-lying massive *kankar* or sandstone, imperme-able | same as above |
| $aP_2$ | Similar to $aP_1$ but are deep and *kankar* or rocky sub-strata within 100 to 150 cm | same as above | Sub-soil drainage excessive but underly-ing massive *kankar* sub-strata do not app-ear to be permeable | same as above |
| $aP_3$ | Similar to $aP_1$ and $aP_2$ but deeper and *kankar* or rocky sub-strata beyond 150 cm | same as above | – | – |
| DA | Undifferentiated shifting sand dunes of yellowish brown fine sand to loamy fine sand of 0.5 m to 1.0 m high, deep, excessive droughty | – | – | – |

**Table 2** *Details of resistivity, EC and landuse at different VES locations*

| VES No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Plot No. | 4 | 3 | 20 | 21 | 29 | 28 | 40 | 42 |
| Landuse | C | C | PF | PF | PF | PF | F | F |
| Thickness (M) | | | | | | | | |
| Layer I | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 1.5 |
| Layer II | 6.0 | 6.4 | 6.0 | 5.0 | 4.8 | 4.5 | 5.0 | 9.0 |
| Layer III | 29.0 | 30.0 | 6.0 | 28.0 | 5.0 | 31.0 | 25.0 | 16.0 |
| Layer IV | ? | ? | 20.0 | ? | ? | ? | ? | ? |
| Layer V | | | ? | | | | | |
| Resistivity (ohm – m) | | | | | | | | |
| Layer I | 55 | 92 | 80 | 56 | 58 | 125 | 74 | 16 |
| Layer II | 44 | 19 | 34 | 51 | 29 | 25 | 48 | 5 |
| Layer III | 4 | 1 | 6 | 3 | 3 | 2 | 9 | 1 |
| Layer IV | 110 | 40 | 2 | 52 | 120 | 15 | 1 | <1 |
| Layer V | | | 58 | | | | | |
| S ($dSm^{-1}$) | 0.31 | 0.38 | 0.27 | 0.28 | 0.35 | 0.28 | 0.22 | 0.94 |
| ECs ($dsm^{-1}$) | 0.14 | 0.18 | 0.29 | 0.28 | 0.23 | 0.23 | 0.71 | 0.67 |
| ECw ($dSm^{-1}$) | 0.09 | 0.11 | 0.14 | 0.18 | 0.14 | 0.13 | 1.43 | 25.01 |

F – Fallow ; PF – Partial fallow; C – Cropped plots

S – Logitudinal unit conductance

same depth has a linear relationship with this parameter (Henriet 1976, Kelley 1977).

Perched water samples from auger holes (1.5 - 2.0m below ground level) were collected in a close grid pattern (Fig. 1) and simultaneously in-situ electrical conductivity ($EC_w$) was measured with conductivity probe lowered to the water table in respect of each perched water sample location. The corresponding $EC_s$ values were estimated from the soil samples collected and $EC_s$ determined in 1:2.5 soil-water solution. The respective values of $EC_w$ and $EC_s$ for each VES point were computed by extrapolating the grid EC determined all over the farm value by included area method.

## Results and Discussion

Geo-electrical Section AB (Fig. 2) using the interpreted resistivity data (Table 2) indicate that the impervious gypsiferous layer has a varying thickness (2 to 26m) along the section. This is underlain by a highly saline water zone (resistivity 10 ohm-m). The surface alluvial layer has the resistivity ranging from 15.5 to 125 ohm-m depending on the soil water status at the time of measurements. The boundary of the gypsiferous layer has a depression around VES 4 resulting in an inward flow of subsurface water towards VES 4 from either side. It is observed that the $EC_s$ varied with soil types (Fig 3). That is, for $aP_3$ types of soils (Table 1) it is 0.14-0.28 $dsm^{-1}$, whereas the value is greater than 60 ds $m^{-1}$ for DA type of soils. However, for the soil (DA) at VES 7 which is a location around the transition phase of these two typs of soils, the value of ECs is higher than the one at other VES points. The longitudinal unit conductance (S) at 1.5m (Table 2) show a sudden Jump at VES 8 relative to other points. Plot of $S_{1.5m}$ ($EC_s$) and ($EC_w$) along the traverse (Fig 3) indicate that at VES 8 all three parameters have maximum values indicating high conductivity of soil and water. The plot of $EC_s$ versus $EC_w$ on log scale (Fig 4) show good correlation ($r = 0.89$) indicating the close relationship. The geo-electric section (Fig 2) also confirms the presence of highly saline zone at this location.

The minimum value of S ($= 0.22$ dS $m^{-1}$) at VES 7 may be due to the fallow condition of the soil, notwithstanding the high electrical conductivity values of 0.71 and 1.43 dS $m^{-1}$ for soil and perched

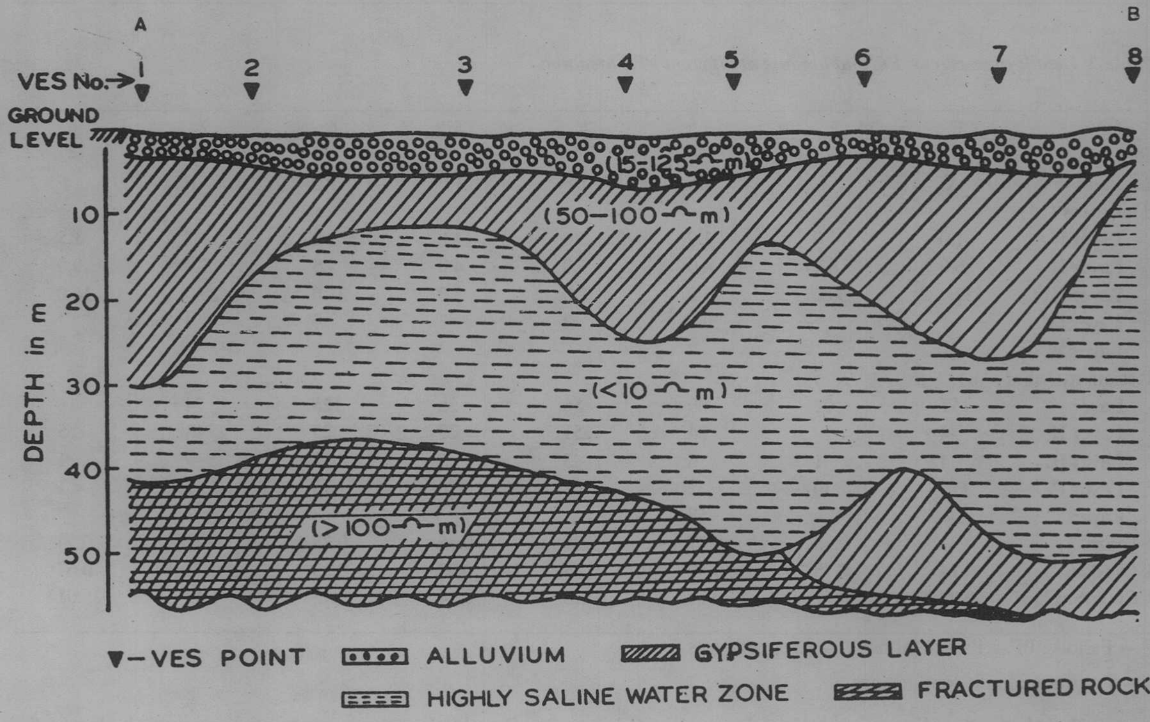


**Fig 2** Geoelectric section 'AB' in Lunkaransar farm

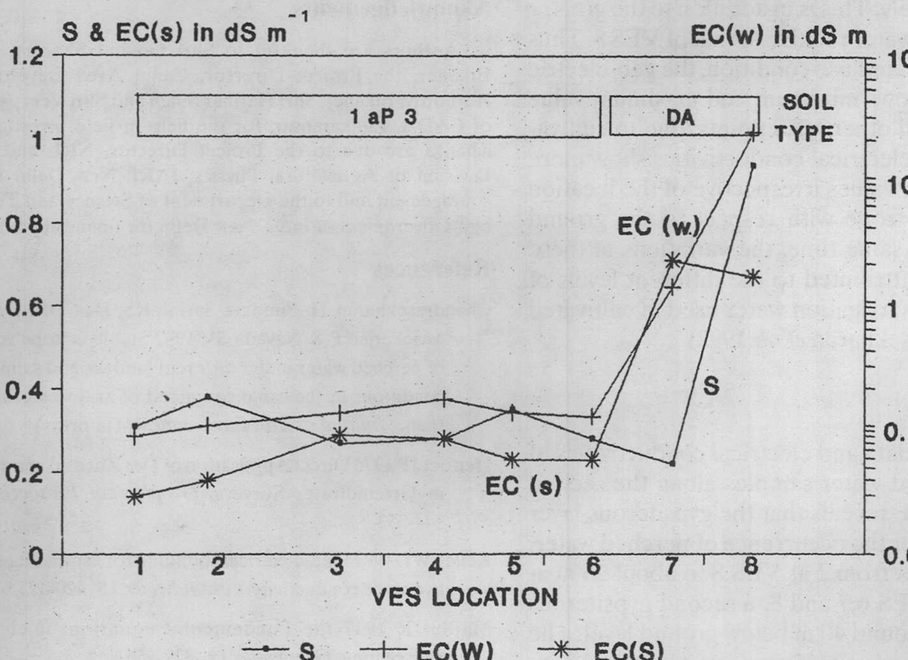


Fig 3 Variation of S, EC (w) and EC (s) along the VES traverse, Lunkaransar farm

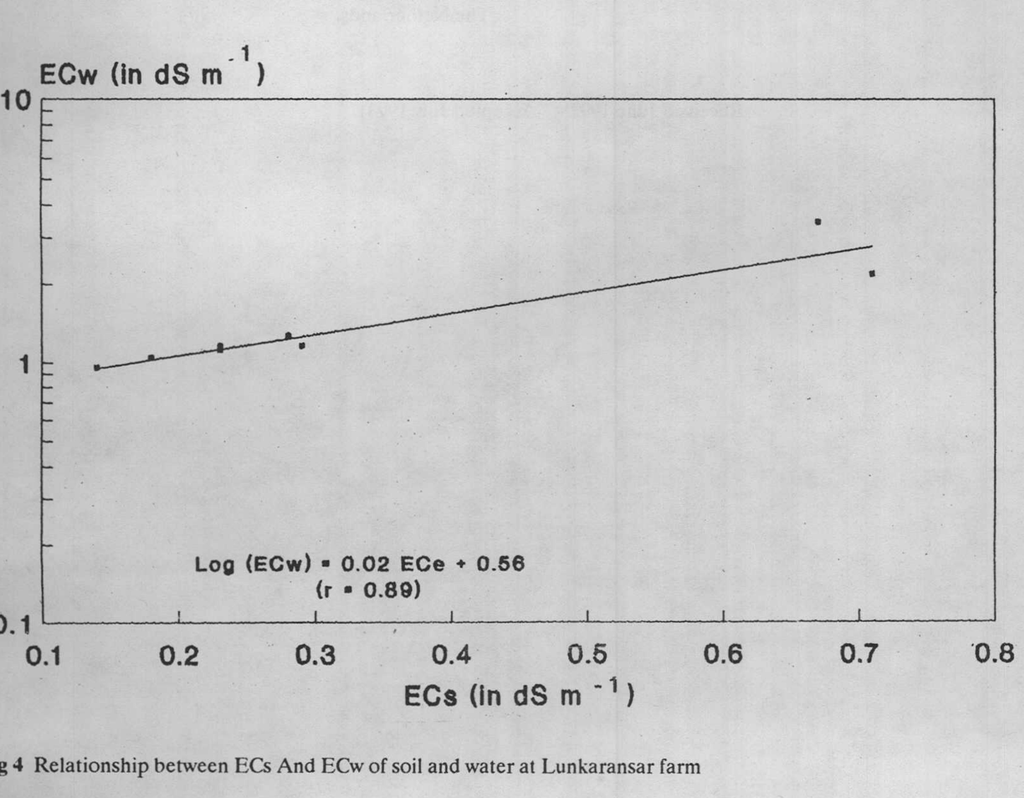


Fig 4 Relationship between ECs And ECw of soil and water at Lunkaransar farm

water respectively. This is in addition to the greater depth of saline water relative to that of VES 8. Thus under the same land use condition, the geo-electric parameter S shows minimum and maximum value (Table 2). At all other VES points, due to cultivation, S and the electrical conductivities show more or less the same values irrespective of the location of saline water zone with respect to the ground surface. At the same time, the variations in these values may be attributed to the different levels of mixing of excess irrigation water used in cultivated plots (Chandrasekharan *et al.* 1992).

## Conclusions

Resistivity data and electrical conductivities of soil and perched water samples along the section AB in the LSAF reveals that the gypsiferous layer is responsible for the occurrence of perched water, vary in thickness from 2 at VES 8 to about 26 m at VES 1. Near VES 6,7 and 8, a second gypsiferous layer is likely around 40 m below ground level. The salinity of perched water is expected to vary due to different contribution of canal water (as irrigation excess) in the farm area.

## Aknowledgements

Authors are thankful to Shri Govind Sharma, GWD, Bikaner, the Project Director, Canal Area Development Authority, Bikaner, Shri Harihar Singh and Shri Veerpal Singh of CADA, Lunkaransar, for the help in field investigations. Thanks are due to the Project Director, NRL and Head, Division of Agricultural Physics, IARI, New Delhi for encouragement and to the Department of Science and Technology, Government of India, New Delhi for financial grants.

## References

Chandrasekharan H, Sundara Sarma KS, Das DK, Datta D, Mookerjee P & Navada SV 1992 Stable isotope contents of perched water under different landuse and salinization conditions in the canal command of arid western Rajasthan. *Journal of Arid Environments* (in press)

Henriet JP 1976 Direct Application of Dar Zarrouk parameters in Groundwater Surveys; *Geophysical Prospecting,* **24** 344-353

Kelley WE 1977 Geo-electrical sounding for estimating aquifer hydraulic conductivity. *Groundwater* **15** 420-425

Maillet R 1947 the Fundamental equation of electrical prospecting. *Geophysics* **12** 529-556

Rijikswaterstaat 1969 *Standard Graphs for Resistivity Prospecting.* European Association of Exploration Geophysicists. The Netherlands.

(Received June 1992 Accepted July 1993)