SURVEY OF THE CHANCE OF SECONDARY SALINIZATION IN THE HOBBY GARDENS AROUND KARCAG

Zsembeli, József - Szűcs, Lilla
University of Debrecen, Centre for Agricultural and Applied Economic Sciences
Research Institutes and Study Farm, zsembeli@agr.unideb.hu

Keywords: irrigation, secondary salinization, drilled wells

SUMMARY

Irrigation involves the risk of secondary salinization on certain areas. The increase of the level of salty groundwater or the application of poor quality (salty) irrigation water can cause secondary salinization. Irrigation from drilled wells is very characteristic in the small hobby gardens located around Karcag during the frequently droughty summers. Mainly vegetables and fruits with high water demand are grown in these gardens, hence quite a large amount of subsurface waters are used for irrigation. Water samples were taken from 46 drilled wells located in the hobby gardens around the town of Karcag and analysed in order to survey the risk of secondary salinization. On the base of the results of the analyses and some indexes calculated from the chemical parameters of the irrigation waters, it can be established that none of the investigated wells supply water that is suitable for irrigation without improvement.

INTRODUCTION

Just like for the most areas of Hungary, negative climatic water balance is characteristic for the Great Hungarian Plain, as the annual potential evapotranspiration exceeds the amount of the annual precipitation. Droughty periods are very characteristic for the region of Karcag as it is one of the driest areas of Hungary: the mean annual precipitation is around 500 mm, while the value of potential evapotranspiration (PET) is between 700 and 800 mm. The difference between the amount of the precipitation and the PET (climatic water deficit) shows well the necessity of irrigation.

Taking into account this fact, water is the most determining ecological factor from the point of view of the development of agricultural production. On the opinion of Várallyay (1985) 550 mm of annual precipitation is theoretically enough to cover the water demand of most of the recently grown crops in Hungary, but due to the uneven spatial and time distribution of the precipitation it can happen that only a small fraction of the rainfall infiltrates into the soil and reaches the root zone of the crops when they have the highest water demand. Comparing to the basic climate conditions of Hungary, the frequency of extreme hydrological conditions (lack or surplus of water) is unreasonably high. Therefore irrigation is a good tool to complete the water demand of our crops and to lower the risk of crop production (Ruzsányi, 1996).

Nevertheless irrigation involves the risk of secondary salinization on certain areas. The increase of the level of salty groundwater or the application of poor quality (salty) irrigation water can cause secondary salinization. Salt affected soils are low fertility soils with unfavourable water regime. Alkaline salts, mainly sodium, are accumulated in these soils either naturally or this process can be human induced. The latter case is called secondary salinization and mainly related to improper irrigation. Intensively irrigated areas are endangered by secondary salinization worldwide (Letey, 1984; Mantel et al., 1985; Rhoades and Loveday, 1990). In the Great Hungarian Plain approximately 400,000 ha is the area where secondary salinization has occurred, mainly due to the rise of the level of salty groundwater. This was studied and proved by several scientists (Arany, 1956; Szabolcs, 1961, 1965; Várallyay, 1967a,b, 1968; Bacsó and Fekete, 1969; Fekete, 1969a,b; Rónai, 1985; Kuti et al., 1999). Blaskó (2005) monitored the salt- and water balance of irrigated areas and found the increase of salt content f the soil in several cases. During the 1980ies and 1990ies on 30% of the studied area (Jász-Nagykun-Szolnok County) increasing soil salt content could be detected, especially on the susceptible areas where the soil can be only potentially irrigated due to the high salt content in their deeper layers.

Subsurface waters (streams coming to the surface and low depth wells) have been used for irrigation by people for thousands of years. The utilization of the deeper aquifers was started in the 19th century and still the main water source in Hungary with its 2.7 million m^3 per day quantity. The quality of these subsurface waters depends mainly on the parent material or bedrock where the water is located or moving. If the water containing soil layer has a high salt content, it is obvious that the water itself gets salty too. When this salty water is used for irrigation, the risk of secondary salinization is high.

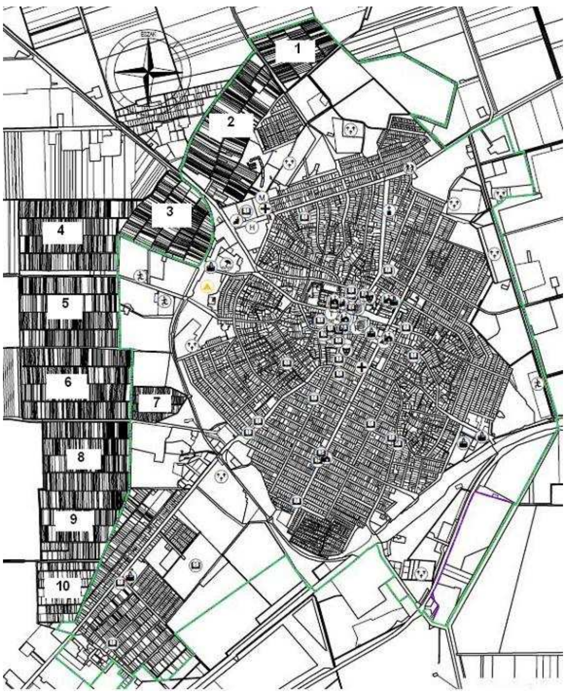
Irrigation from drilled wells is very characteristic in the small hobby gardens located around Karcag during the frequently droughty summers. Mainly vegetables and fruits with high water demand are grown in these gardens, hence quite a large amount of subsurface waters are used for irrigation. The quality of these waters is not checked by the owners of the gardens, the chemical composition, hence the suitability of the water for irrigation is not known. Furthermore most of these wells are illegal, not registered, therefore the central monitoring or control of irrigation cannot be solved in the gardens. Our hypothesis was that these waters are salty and irrigation with them involves the risk of secondary salinization. In order to quantify this risk, the following approaches were used:

- determination of the stratification of the soil on the base of soil samples taken during a well-drilling,
- collecting water samples from the wells in the hobby gardens where irrigation is applied,
- determination of the chemical composition of the irrigation waters,
- assessment of the salinization effect of the irrigation waters on the base of suitable indexes.

MATERIAL AND METHODS

Horticultural activities have been characteristic in the hobby gardens located in the northern and western areas around the town of Karcag for more than 300 years. Traditionally some citizens living in the town regularly go to their gardens where they grow mainly vegetables and fruits for their own consumption or even to sell these products in the local market. This way of life is still characteristic at the beginning of the 21st century. The location of the hobby gardens around is shown in *Figure 1*. The narrow and relatively long plots of the gardens look totally different from the large plots of the large-scale farming that also characteristic for the region. Most of the hobby gardens lay on meadow chernozem soil, while a smaller rate on meadow solonetz turning into steppe formation (with the deepest A-horizon among salt affected soils). Both soil types are characteristic only the areas with higher elevation and can be considered the best soils of the region. Nevertheless both soil types are endangered by secondary salinization due to their susceptibility.

Fig. : **The map of the hobby gardens located around Karcag**



Legend: 1: Agyagos kert, **2**: Nagyvénkert, **3**: Kisvénkert, **4**: Zug kert (I, II), **5**: Téglás kert (I, II), **6**:Komisz kert, **7**: Rokkant kert, **8**: Partos kert (I, II), **9**: Völgyes kert (I, II), **10**: Kolduskert

In our study started in 2009 water samples were taken from almost 46 drilled wells located in the hobby gardens around the town of Karcag. During the data collection we tried to get information on the depth of the investigated wells from the owners. Most of the owners knew the depth, so we could determine more or less the typical aquifers that are used for gaining irrigation water. Nevertheless we took part in the drilling process of a well carried out by a professional driller who has drilled approximately 2,000 wells in the region in the last 20 years. During the drilling process soil samples were taken from each layer reached, so we could determine the stratification of the ground. The different layers could be distinguished on the base of the material washed up to the surface by the auger. The samples were analysed in the laboratory of the Karcag Research Institute of RISF CAES, University of Debrecen to determine the particle size distribution of the soil.

In order to get information on the quality of the irrigation water the samples were analysed in the laboratory of the Karcag Research Institute of RISF CAES, University of Debrecen and the following parameters were determined: pH, electric conductivity, dry matter content, cation (Ca, Mg, Na, K) contents, anion (HCO_3, Cl, SO_4, NO_3) contents.

For the assessment of the salinization effect of the irrigation waters, the following indexes were calculated from the parameters determined in the laboratory:

1. Total salt content (c)

The total soluble salt content (c) was calculated on the base of the electric conductivity (EC) of the water according to the following equation:

$$c\ (mg/l) = 640\ EC$$

2. Relative Na percentage (Na%)

The relative Na percentage was calculated according to the following equation:

$$Na\% = \frac{Na^{+}}{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}} \cdot 100$$

3. Calculated sodium-carbonate equivalent (S_{eq})

Waters showing no phenolphthalein alkalinity can also contain sodium-carbonate and sodium-hydrocarbonate causing salinization. Its value was calculated according to the following equation:

$$Sq_e = (HCO_3^{-} + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) \quad (mEq/l)$$

4. Sodium Adsorption Ratio (SAR)

The Sodium Adsorption Ratio was calculated according to the following equation:

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

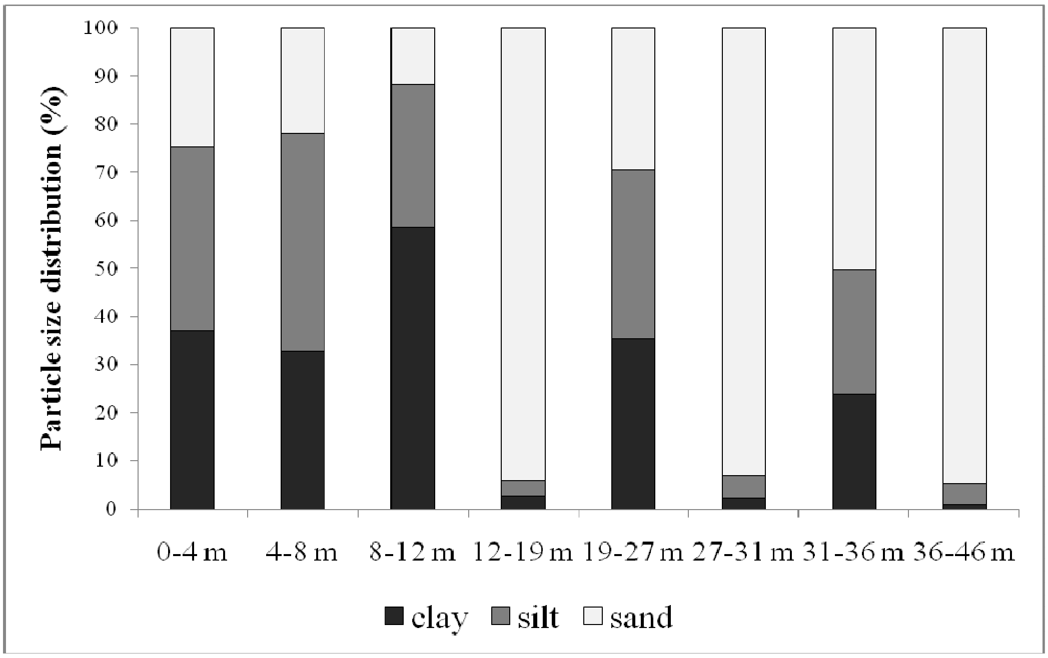
RESULTS AND DISCUSSION

Soil stratification

The depth of the investigated wells varied between 18 and 56 m. The most characteristic depth was 36-42 m. The deeper wells are rare, obviously due to the higher drilling costs. In order to have information on the stratification of the soil profile and the location of the water containing layers (aquifers), the particle size distribution of 8 layers were determined. As *Figure 2.* shows, the ratios of the 3 fractions (by Atterberg's classification) give a good chance to distinguish the layers of unconsolidated materials that have high rate of sandy particles, hence these are the layers where aquifers can be found between two aquitards with low permeability along the aquifers.

Three aquifers could be distinguished where the sandy particles are dominant with at least 90% (12-19 m; 27-31 m; 34-46 m). The upper layer of 0-4 m has loamy clay texture with quite even particle size distribution. In the layer of 4-8 m yellowish, in 8-12 m greyish colour characterises the impermeable clay and heavy clay layers.

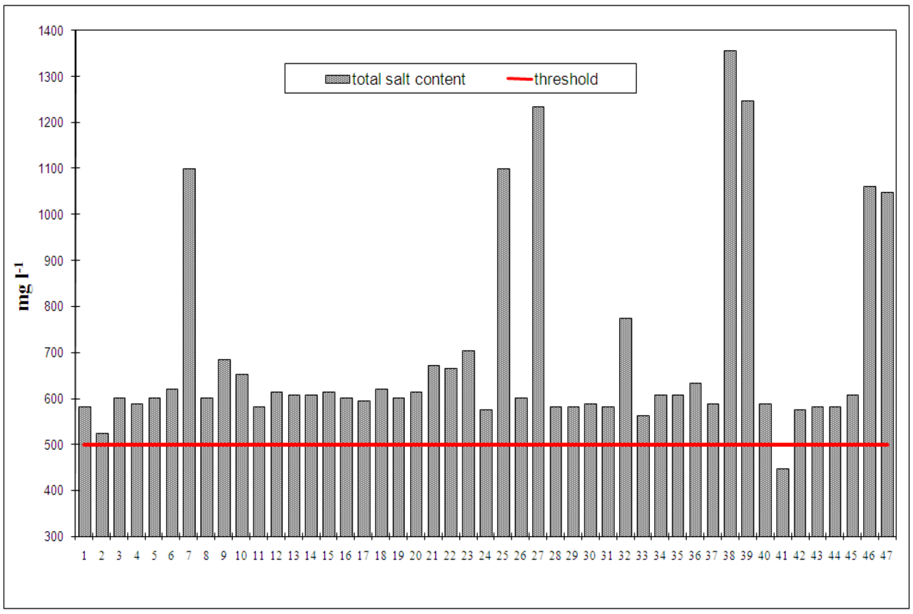
Figure. 2.: **Particle size distribution in the soil samples taken during the well drilling**



Assessment of the salinization effect of the irrigation waters

The salinization effect of the investigated well waters was assessed according to the four indexes described in the Material and Methods chapter. In the case of soils sensitive for salinization, the upper threshold of the total salt content (*Fig. 3.*) of the water is 500 mg l^{-1}, above this value the water is not suitable for irrigation. The total salt content of the investigated well waters varied in quite a wide range, but most of them were in the range of 550-600 mEq l^{-1}, the mean value was 689.1 mEq l^{-1}. Only 1 of the 47 samples had a value below the threshold, while 7 of them exceeded even the value of 1,000 mEq l^{-1}. The highest value was 1356.8 mEq l^{-1}. We tried to find correlation between the total salt content value of the water and the depth of the wells, but significant correlation could not be figured out. Nevertheless the waters with the highest values originated from shallow wells, mainly from the first aquifers (18 m).

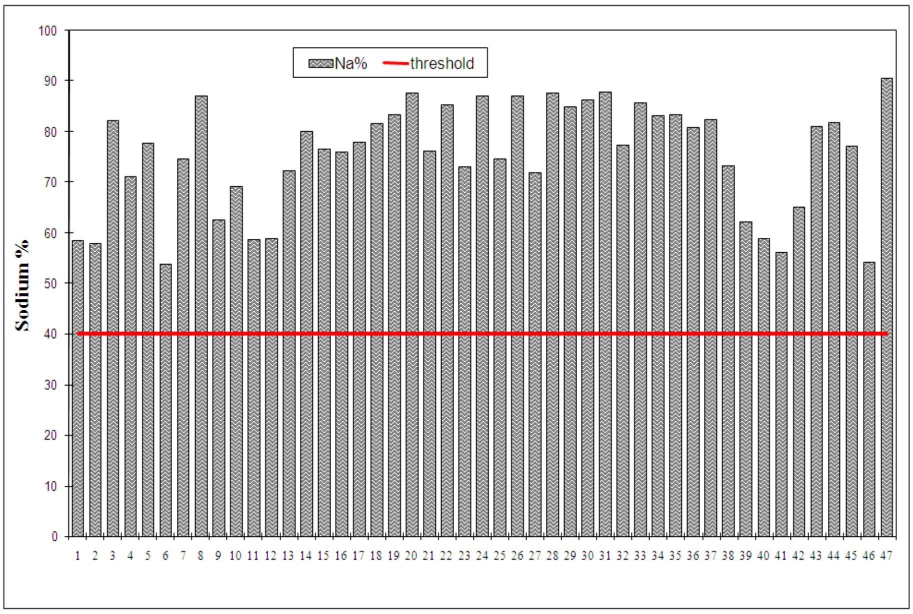
Figure 3.: **The total salt content values of the investigated well waters**



Legend: **1-9:** *Garden "Kisvén"*, **10-19:** *Garden" Zug"*, **20-24:** *Garden" Rokkant"*, **25-26:***Garden "Partos"*, **27-34:** *Garden "Völgyes"***, 35-37:** *Garden "Koldus"*, **38-41:** *Garden "Nagyvén"*, **42:** *Garden "Agyagos"***, 43-46:** *wells in the town* ,**47:** *tap water from the network*

Taking the ratio of sodium among the cations into consideration, it can be concluded that sodium is the dominant cation (*Fig. 4.*). The higher is the ratio of sodium, the higher is the risk of secondary salinization. A water is considered to be suitable for irrigation if the ratio of sodium among the cations is lower than 40%. The average Na% of the investigated well waters was 75.3%, even the lowest value (53.7%) exceeded the threshold. It can be concluded that irrigation with any of the waters we investigated involves the high risk of secondary salinization due to the dominancy of Na ions.

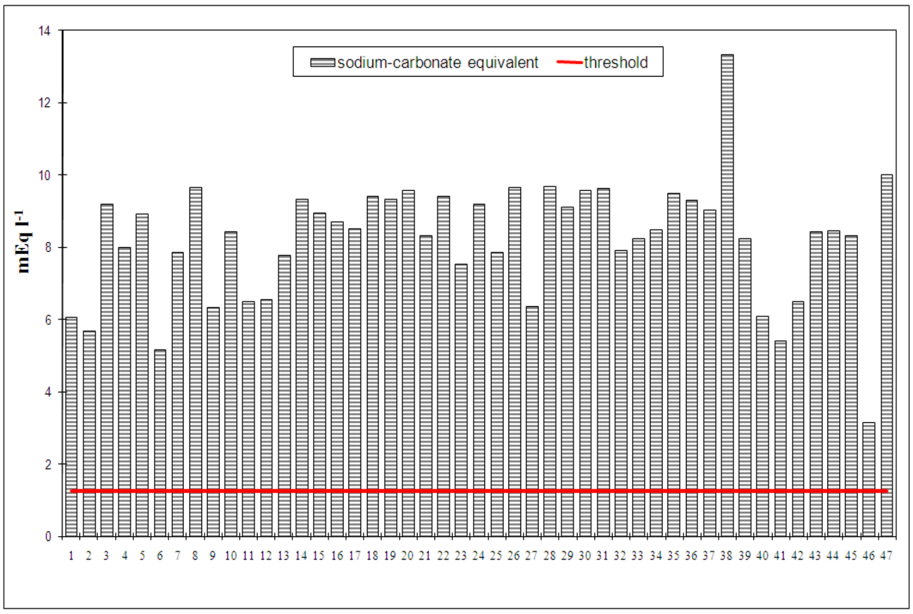
Figure 4.: **The Na% of the investigated well waters**



Legend: **1-9:** *Garden "Kisvén"*, **10-19:** *Garden" Zug"* , **20-24:** *Garden" Rokkant"*, **25-26:***Garden "Partos"*, **27-34:** *Garden "Völgyes"***, 35-37:** *Garden "Koldus"*, **38-41:** *Garden "Nagyvén"*, **42:** *Garden "Agyagos"***, 43-46:** *wells in the town* ,**47:** *tap water from the network*

The calculated sodium-carbonate equivalent *(Fig 5.)* is a good index to express the salinization effect caused by carbonates and hydro-carbonates. The threshold from the point f view of irrigation is 1.25 mEq l^{-1}, below this value the water is suitable for irrigation. Most of the waters we analysed contain 5-9 mEq l^{-1} hydrocarbonate anions, which is several times higher than the threshold.

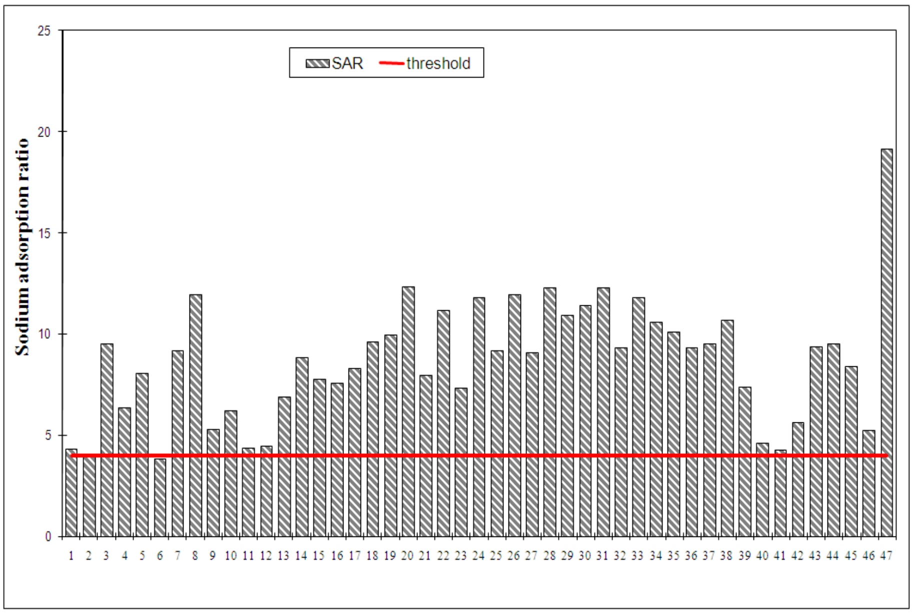
Figure 5.: **The calculated sodium-carbonate equivalent of the investigated well waters**



Legend: **1-9:** *Garden "Kisvén"*, **10-19:** *Garden" Zug"* , **20-24:** *Garden" Rokkant"*, **25-26:***Garden "Partos"*, **27-34:** *Garden "Völgyes"***, 35-37:** *Garden "Koldus"*, **38-41:** *Garden "Nagyvén"*, **42:** *Garden "Agyagos"***, 43-46:** *wells in the town* ,**47:** *tap water from the network*

The sodium adsorption ratio (SAR) is also an index that indicates well the salinization effect of an irrigation water. If its value is lower than 4, the risk of secondary salinization is not high, the water is suitable for irrigation. The SAR value of the waters we investigated (*Fig. 6.*) was mainly in the range of 4-10 with the average of 8.69. Only 2 samples had SAR value below the threshold.

Figure 6.: **The SAR value of the investigated well waters**



Legend: **1-9:** *Garden "Kisvén"*, **10-19:** *Garden" Zug"*, **20-24:** *Garden" Rokkant"*, **25-26:***Garden "Partos"*, **27-34:** *Garden "Völgyes"***, 35-37:** *Garden "Koldus"*, **38-41:** *Garden "Nagyvén"*, **42:** *Garden "Agyagos"***, 43-46:** *wells in the town* ,**47:** *tap water from the network*

CONCLUSIONS

On the base of the results we gained it can be concluded that the waters used for irrigation in the hobby gardens around Karcag are involves high risk of secondary salinization. All the indexes indicating the salinization effect of irrigation waters were above the thresholds in most of the cases, so it can be established that none of the investigated wells supply water that is suitable for irrigation without improvement.

REFERENCES

ARANY S.: 1956. A szikes talaj és javítása. Mezőgazdasági Kiadó. Bp. 408.

BACSÓ A. - FEKETE J.: 1969. Role of ground Water in the secondary salinization of meadow-chernozem soils in the Hajdúság area. Agrokémia és Talajtan. 18. (Suppl) 339-350.

BLASKÓ L.: 2005. Talajromlási folyamatok és mérséklési lehetőségeik a Tiszántúl kötött talajain. MTA doktori értekezés

FEKETE J.: 1969.a Öntözött réti csernozjom talajok sóforgalma a Hajdúságban. Agrokémia és Talajtan.Suppl. 18. 341-344.

FEKETE J.: 1969.b Salt Circulation in Irrigated Meadow-Chernozem Soils of the Hajdúság Area of Hungary. Agrokémia és Talajtan Tom.18. Suppl. 341-344.

KUTI L. – TÓTH T. – PÁSZTOR L. – FÜGEDI U.: 1999. Az agroökológiai térképek és a szikesek elterjedésének kapcsolata az Alföldön. Agrokémia és Talajtan. 48. 501-516.

LETEY, J.: 1984. Impact of salinity on the development of soil science. p. 1-9. In. I. Shainberg and J. Shalhevet (ed.) Soil salinity under irrigation. Processes and management. Ecological Studies 51. Springer-Verlag, New York.

MANTELL, A. – FRENKEL, H. – MEIRI, A.: 1985. Drip irrigation of cotton with saline sodic water. Irrig. Sci. 6. 95-106.

RHOADES, J.D. - LOVEDAY J.: 1990. Salinity in irrigated agriculture. P. 1089-1142. In B. A. Steward and D. R. Nielsen (ed.) Irrigation of agricultural crops. Agron. Monogr. 30. ASA, CSSA, and SSSA, Madison, WI.

RÓNAI A.: 1985. Az Alföld negyedidőszaki földtana. Geologica Hungarica Series Geologica 21. MÁFI Budapest

RUZSÁNYI L.: 1996. Az aszály hatása és enyhítésének lehetőségei a növénytermesztésben. In.: Éghajlat, időjárás, aszály (Szerk. Cselőtei L., Harnos Zs.), Akaprint, Budapest, 5-66.

SZABOLCS I.: 1965.. Salt-Affected Soils in Hungary. Agrokémia és Talajtan. Suppl. 14. 275-290.

SZABOLCS I.: 1961. A vízrendezések és öntözések hatása a tiszántúli talajképződési folyamatokra. Akadémiai Kiadó, Budapest.

VÁRALLYAY GY.: 1967.a A Duna-Tisza közi talajok sómérlegei II. Sómérlegek öntözött viszonyok között. Agrokémia és Talajtan Tom. 16. No. 1-2. 27-56.

VÁRALLYAY GY.: 1967.b A dunavölgyi talajok sófelhalmozódási folyamatai. Agrokémia és Talajtan. 16. 327-356.

VÁRALLYAY GY.: 1968. Salt accumulation processes in the Hungarian Danube Valley, Trans. 9th Int. Congr. Soil Sci. 1. 371-380.

VÁRALLYAY GY.: 1985: Magyarország talajainak vízháztartási és anyagforgalmi típusai. Agrokémia és Talajtan. 34. sz. 267 – 298.