Salt Affected Soils in the Hungarian Danube and Tisza Valleys

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The total area of salt affected soils in Hungary exceeds 1 million hectares, which is more than 10 per cent of the territory of the country. There are few countries in the world and none in Europe where the ratio of salt affected soils is so high. Salt affected soils include both the existing and the potential saline and alkali soils which have developed mainly in the Hungarian Plain and only in small spots in other regions of the country. More than 95 per cent of the existing salt affected soils is situated in the valleys of the Danube and the Tisza. The sediments of these rivers formed and filled up the Hungarian Plain whose alluvial origin is closely related to the location of salt affected soils.

Fig. 1. shows the map of salt affected soils in Hungary.

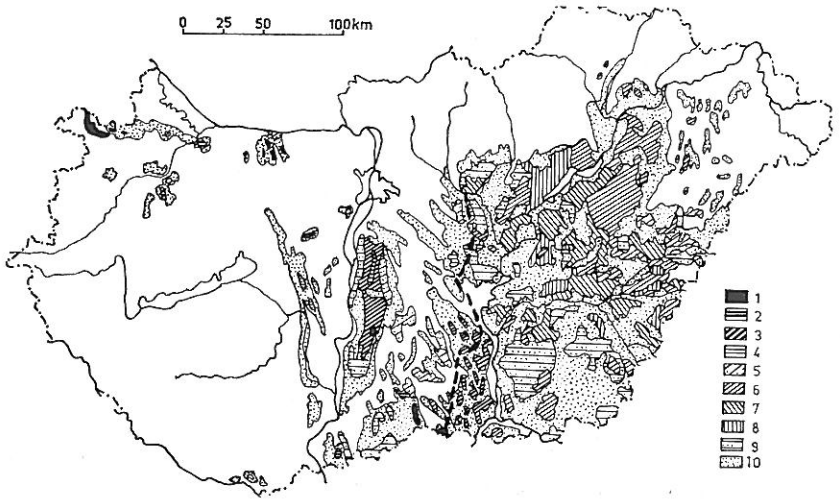

Fig. 1

The map of salt affected soils in Hungary 1. Chloride sulphate solonchak; 2. Soda solonchak; 3. Soda solonchak-solonetz; 4. Calcareous meadow solonetz; 5. Calcareous solonetz-like meadow soil; 6. Meadow solonetz; 7. Meadow solonetz turning into steppe formation; 8. Solonetz-like meadow soil; 9. Soils salty in deeper horizons; 10. Potential salt affected soils; — — — Border of Danube and Tisza valleys

The origin of Hungarian salt affected soils

In Hungary the main factor of the salinization and alkalization of soils is not the climate. The average precipitation in the Plain varies between 450 and 600 mm and the mean annual temperature is 10°C. Under such conditions chernozem soils, black meadow soils and other types with good fertility and without saline or alkali properties develop in some areas of the Hungarian Plain. It is mainly the hydrogeological properties which result in the formation of salt affected soils in other areas of the lowland.

In the groundwaters of the Danube and Tisza valleys often occur remarkable amounts of dissolved salts, and sodium salts frequently dominate. Whenever the salty groundwater is linking with the soil profile salt accumulation, and consequently the formation of salt affected soils take place. This phenomenon never occurs in the first terraces of the rivers, only in the second and third ones. In the valleys of both rivers, salt affected soils are mainly situated along the left bank and only to a smaller extent on the right.

Mineralized groundwaters represent only one, though very important, precondition of the formation of salt affected soils in the Hungarian Plain. The surface waters, collecting during the wet season, also contribute to their development. The surface waters accumulate in depressions and often link with the groundwater table which rises in the same period. As a result, stagnant water will cover the surface of the soil through a considerable stretch of time. The downward movement of the water is prevented by the heavy texture of the soils, as well as by the high groundwater table. The upward movement of the water and, with it, the salts, dominates and, as a result, salt accumulation occurs in the soil profile. However, the effects of the periodical downward movement of water and salt must not be underestimated. The repeated change in the direction of their flow leads to the formation of the most common type of Hungarian salt affected soils, namely to that of solonetz or, according to the classification of the Subcommission on Salt Affected Soils of the International Society of Soil Science, alkali soils with structural B horizon [6].

In the Danube and Tisza valleys great flood control projects were completed in the second half of the 19th and the first decades of the 20th centuries, respectively. As a result, the river-beds were straightened, the floods practically arrested and millions of hectares of land, formerly bogs and swamps desiccated. This huge ameliorative operation created the possibility for the transformation of the soil cover of the territory. However, the leaching of salts from the soils was not consequent in many places and was severely hindered by the poor physical properties of the soils as well as by the high water table, which generally retreated in the wake of the amelioration of the river valleys but, in many cases, not sufficiently enough to ensure a good natural drainage. Consequently, in places where the formerly saline swamps and bogs had been desiccated, the migration of slightly salty solutions frequently resulted in the formation of solonetz or solod soils. In other places, where drainage remained even poorer, or in depressions practically without drainage, solonchak soils developed. In the areas where the amelioration radically improved natural drainage, formerly salt affected soils have probably disappeared as a consequence of desiccation. The climate of the Hungarian Plain is sufficiently humid to leach the salts from the soil profile in case of good hydraulic conductivity and drainage.

In the salt affected soils of Hungary alkalinity, as a rule, plays a more important role than salinity. Except for a few cases, saline soils are not common; nearly all of our salt affected soils belong to the alkali class. Both alkali soils with structural B horizon (solonetz) and alkali soils without structural B horizon (soda-solonchak) occur in the Danube and Tisza valleys. In the Danube valley calcareous and in the Tisza valley non-calcareous varieties prevail.

The morphologic, physical, chemical, mineralogical and biological properties of these soils were repeatedly described [3, 4, 5, 6], therefore I wish to provide only some additional information for the participants of the excursions following the Budapest seminar to the salt affected areas of the Danube and Tisza valleys.

There are similarities and differences between the salt affected soils of the two river valleys.

The Danube's deposits are calcareous and the deposits of the Tisza river are of a slightly acid character. However, in the deeper layers (in some places at 10—20, in others at 1—2 m depth only) the deposits are rich in calcium carbonate in the Tisza valley, too. The explanation of this phenomenon is in the geological history of the Carpathian Basin and the Hungarian Plain. During the Holocene, the primaeval Danube covered the whole land with calcareous deposits. The Tisza river emerged in a later period of geohistory. It carried acidic materials from the Carpathian Mountains and these sediments were spread in an uneven layer over the calcareous Danube deposits. Evidently, the borderline of the two kinds of sediments changed in many cases under the influence of soil forming processes. As a concequence of rising groundwater table and solution flow, $CaCO_3$ and even Na_2CO_3 have often occurred recently near the surface of salt affected soils in the Tisza valley. On the other hand, when the downward solution flow dominates, even if only periodically in the Danube valley, the top layer of the soil can become free of lime and soda. The texture of salt affected soils is, as a rule, lighter in the Danube valley and heavier in the Tisza valley due to the different granulometrical composition of the sediments of the two rivers.

Salt affected soils and the problems of irrigation

While the extensive flood control of the river valleys in Hungary definitely lowered the basis of erosion in the lowland, the effects of later irrigation projects have not always been beneficial. Since the end of World War II the territory of irrigated lands has increased more than twentyfold in the Hungarian Plain, particularly in the valley of the Tisza river.

Like in many other alluvial plains of the world, the hazards of secondary salinization and alkalization exist in the Hungarian Plain, too. The sharp advance of irrigated agriculture after World War II led to the accumulation of salts at many places. As is well known, there are two main sources of the secondary salinization and alkalization of irrigated soils, namely the salt content of the irrigation water and that of the groundwater. If the groundwater rises, the salinization and alkalization of the overlaying soil layers become possible.

The quality of irrigation water is strictly controlled in Hungary, so secondary salinization and/or alkalization of soils, as a result of saline or alkaline irrigation water, very seldom occurs [1].

Mineralized groundwaters rising near the soil surface are mainly responsible for the secondary salinization and/or alkalization of soils in the Danube and Tisza valleys. The above mentioned processes, their prediction as well as prevention have been thoroughly studied and described [5, 7]. The water table should be kept under the "critical depth". Whenever the water table rises above the "critical depth", the hazard of progressive salt accumulation exists. For controlling soil salinity during irrigation proper methods have been elaborated [7].

Possibilities of reclamation of salt affected soils in Hungary

The reclamation of salt affected soils is possible regardless whether they cover extensive areas or occur in spots surrounded by soils of good quality. In Hungary reclamation was started already at the end of the 18th century by TESSEDIK [9], who mixed the top layer of these soils with sand and soils of good quality. In the first part of the 19th century IRINYI [2] discovered several chemical processes in the Hungarian salt affected soils and he was the first who recommended the application of $CaSO_4$ for amelioration of solonetz soils.

Towards the end of the 19th century a new method — the application of calcareous compounds — was introduced in Hungary for the reclamation of solonetz soils. TREITZ [10] and SZENTANNAI [8] introduced this method into practice and it is still in use in our contury.

Between to two World Wars the government supported the reclamation of salt affected soils and after World War II, parallel with the formation of big state and cooperative farms, the reclamation of soils has also been carried out by state-owned companies.

In comparison with the scale of soil reclamation during and after World War II, the area of improved soils increased markedly in the nineteen fifties and particularly during the sixties. In the seventies, however, a decrease set in, due to economic reasons.

In spite of decades of reclamation work, the recent survey of Hungarian soils shows that the area of salt affected soils has not diminished. This phenomenon may be explained by several reasons, for instance:

1. New salt affected spots have been discovered.
2. Secondary salinization and/or alkalization is rather frequent in irrigated lands.
3. Intensive farming (the application of high doses of mineral fertilizers) also contributes to the development of detrimental soil processes.

Hungarian soil scientists and agronomists fully agree that the reclamation of salt affected soils must be continued in the coming years. This work could be accomplished more easily and with less investment, if the properties and genetics of these soils were even more profoundly known. The accurate knowledge of the soil properties and of the quality and quantity of reclamation ma-

terials needed is desirable not only from the theoretical point of view but actually it is a precondition of success.

In Hungary and in the neighbouring countries solonetz soils are divided into 3 groups according to the possibilities of their reclamation (Table 1). Solod soils are also included in Table 1, because their properties closely resemble those of solonetz soils, and the methods used for their reclamation are also similar.

Table 1

Schematic grouping of solonetz and solod soils with regard to their amelioration

Genetic type	Relation with groundwater	Water soluble salt content in the surface layers	Amelioration*
1			
Solonchak-solonetz meadow solonetz meadow solod soils (shallow and middle)	permanently linked	more than 0.2 per cent (about 4 mmhos)	drainage and chemical amendments
2			
Meadow solonetz and solod soils turning into steppe formation	temporarily linked	about 0.2 per cent (about 4 mmhos)	chemical amendments, deep ploughing and drainage if necessary
3			
Deep solonetz and solod soils solonetz-like meadow soils	not linked	less than 0.2 per cent (about 4 mmhos)	low amount of chemical amendments, proper agrotechnics and suitable crop (deep ploughing, alfalfa, etc.)

* The necessity of irrigation depends on local conditions.

1. In the case of solonetz and solod soils where the soil profile and the top layers are capillarily linked with salty groundwater, and the horizons (A_1, A_2, B_1, B_2) contain large amounts of water soluble salts (about more than 0.2 per cent in the surface layer and 0.5 per cent at a depth of 40—50 cm) the leaching out of salts and drainage are unavoidable. Chemical amendments should be applied parallel with the above mentioned measures or afterwards. Soils belonging to this group are genetically named meadow solonetz and solod soils.

2. If the profile of a solonetz or a solod soil is only temporarily linked with the groundwater, and the salt content of the A, A_1 and B-horizons is lower than in the case of soils belonging to the first group, drainage is not always necessary. In these cases the application of chemical amendments (gypsum and/or others) as well as deep-ploughing and subsoil loosening may be useful. If the quantity of water soluble Na salts is not high in the B_2 and C-horizons and a considerable amount of gypsum is present, in the course of deep-ploughing it can be utilized as reclamation material. Soils belonging mainly to this group are called meadow solonetz and solod soils turning into steppe formation.

3. If the profile is not linked with the groundwater, its salt content (mainly in the top layers) should be taken into account when the suitable amelioration method is chosen. The climatic conditions, the possibility of irrigation, etc. are also decisive factors when the proper methods are chosen to remove the salts and to improve the physical soil properties. Chemical amendments, deep-ploughing and subsoil loosening may be used as indicated in paragraph 2. Soils belonging to this group are called mainly steppe solonetz and solod soils, and solonetz-like meadow and other soils.

When selecting one of the above described three types of reclamation and utilization of solonetz and solod soils, it must be carefully adjusted to the local conditions. The chemical type of the salt content is very important and it must be taken into account when the proper reclamation method is chosen. In the case of soda soils, for instance, the limit values of the permissible salt content in the soil profile are much lower than when the salinity is caused by neutral sodium salts.

As compared to neutral salt types, in the case of soils containing sodium carbonate not only the lowering of the salinity level is required for successful amelioration, but in order to eliminate or at least lessen the detrimental effect of sodium carbonate, the application of acid chemical amendments — as one factor of reclamation — is practically always necessary.

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