THE SOIL CONDITIONS OF THE PHYSICAL LANDSCAPES OF THE SOUTHERN GREAT PLAIN WITH SPECIAL REGARD TO THE POSSIBILITIES OF SOIL AMELIORATION

by

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Összefoglalás: *(A Dél-Alföld természeti tájainak talajviszonyai, különös tekintettel a talajjavítási lehetőségekre).* A tanulmány szervesen kapcsolódik az Acta Geographica Szegediensis 1973.évi kötetében megjelent *„On the Methods of Region Research with Special Regard to the Southern Great Plain"*. *(Adalék a tájkutatás módszereihez, különös tekintettel a Dél-Alföldre)* c. dolgozathoz.

Jelen tanulmány I. része a Dél-Alföld természeti tájbeosztását ismerteti *Stefanovits* talajtani osztályozása alapján. A II. rész a felszínt alkotó talajrétegek anyagának fizikai és kémiai sajátosságait ismerteti, míg a dolgozat III. részében a Dél-Alföld különböző talajtípusain sikerrel alkalmazható műanyagos talajjavítási módszerek ismertetésére kerül sor, az ide vonatkozó legújabb kutatások alapján.

Zusammenfassung: *(Die Bodenverhältnisse der Naturlandschaften des Südgebiets der grossen Ungarischen Tiefebene, mit besonderer Rücksicht auf die verwendbaren Bodenmeliorationsverfahren).* Dieser Aufsatz ist der im Jahre 1973 in Acta Geographica Szegediensis publizierten Arbeit *„On the Methods of Region Research with Special Regard to the Southern Great Plain" (Beiträge zu den Methoden der Landschaftsforschung, mit besonderer Rücksicht auf das Südgebiet der grossen Ungarischen Tiefebene)* eng verbunden.

Der erste Teil des Aufsatzes legt die Naturlandschaftaufteilung des Südgebiets der grossen Ungarischen Tiefebene auf Grund der bodenkundlichen Sortierung von *Stefanovits* dar. Der zweite Teil beschäftigt sich den phisischen und chemischen Eigenschaften der Materie der oberen Bodenschichten. Im dritten Teil wird die Bodenmeliorationsverfahren mit den Kunststoffen behandelt, die nach den Erfahrungen der neuesten Forschungen bei verschiedenen Bodenarten des Südgebiets der grossen Ungarischen Tiefebene mit gutem Erfolg angewendet werden kann.

Summary: This study is closely connected with the paper entitled *„On the Methods of Region Research with Special Regardt to the Southern Great Plain"* which was published in the 1973 volume of Acta Geographica Szegediensis.

The first part of the present study deals with the physical geographic regionalization of the Southern Great Plain on the basis of the pedological classification of *Stefanovits.* The second part deals with the physical and chemical properties of the soil layers forming the surface, while in the second part methods of soil amelioration with synthetic materials are described on the basis of the most recent researches.

I.

Physical geographic regionalization of the southern part of the Great Plain

The development of the genetic soil types must be determined for smaller areas because the correlations of the details can be demonstrated only within these small areas. In this respect we are in a lucky position because *Stefanovits* has described in detail the soil geography of this country in his work *„The soils of Hungary"* [1]. Knowledge of the soil conditions is essential for regional studies because it enables us to discern fine differences and to define the characteristic structure and development of the physical geographic units.

In our study *„On the Methods of Region Research with Special Regard to the southern part of the Great Hungarian Plain"* [2] we have dealt with a few theoretical and methodical principles and, in connection with genetical studies, with the stages of development of the present — day formations and with the influence of the surface — near layers on the development of the surface layers in the southern part of the Great Plain.

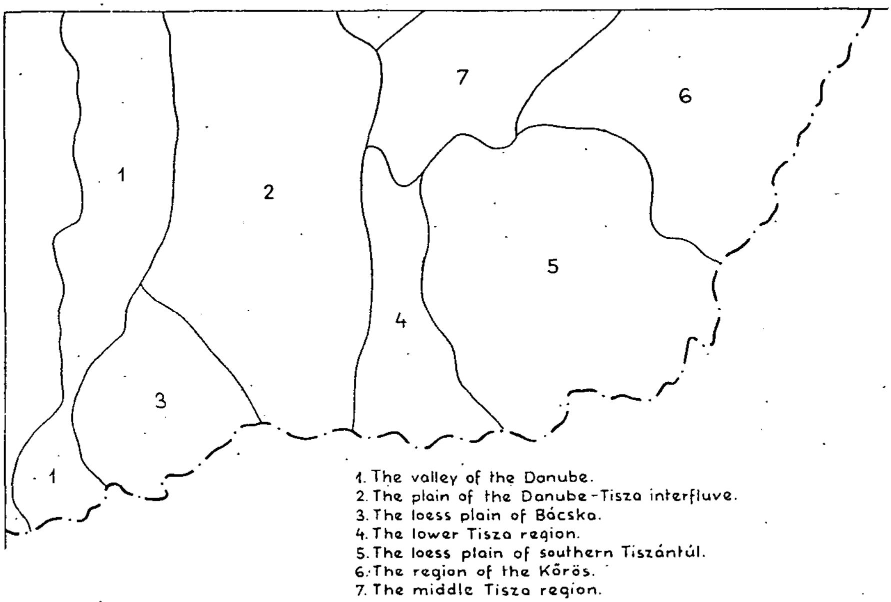

Fig. 1. The physical regions of the southern part of the Great Plain (after Stefanovits)
1. ábra. A Dél-Alföld természeti tájai (Stefanovits nyomán)

In the brief description of the soil conditions we took the physical regions of *Stefanovits* as a basis. This regional division was compared with the opinions of experts entrusted with studying the physical geographic conditions of Hungary. It is no mere chance that the boundaries of the area units of ten coincide with the lines separating the types of soil because the soil — forming factors are identical with the region — forming factors [1].

In dealing with the physical geographic regional division of the southern Great Plain we concentrate, according to the aim of our study, on the description of the soil conditions of the Danube valley, the Danube — Tisza interfluve, the loess plain of Bácska, the region along the lower Tisza, the loess plain of the southern part of the region east of the Tisza, and the region of the Kőrös (Fig. 1).

The valley of the Danube

This is an area which narrows from north to south. Its soil conditions are varied but their common feature is that the alluvium of the Danube and the groundwater have had a decisive influence on their formation. According to *Pécsi* [3] the remains of terraces and flood — basins can be found among the geomorphological formations.

Studying the correlation between the geomorphological conditions and the types of soil it was found that the sodic soils occur in the low — lying areas with low — lying flood basins — in the eastern part of the region — because before the flood control the *floods* could inundate without obstacle the low — lying flood — basins, while after the flood control the dam of the flood — basin hindered their recession. After evaporation of the considarable quantity of water remaining behind, the pores of the surface of the flood — basin were stoppe up. The arrangement of the sodic soils is due, besides the floods, to the soil conditions. On the rolling plain the groundwater table is 0.5—1.5 m under the surface, i.e. on an average 110—135 m above sea level while in the flood-basins it is 95—100 m above sea level. Thus there is a flow toward the lower — lying areas but there are considerable differences in the pressure and temperature of the plain and the floodbasin [4]. During flowing the groundwater undergoes changes. The physicochemical balance of the colder groundwater under greater pressure changes when it gets into warmer places with less pressure. The dissolved Ca and Mg salts, retained in the solution under greater pressure, precipitate under less pressure at higher temperature and form layers, the carbonate content of which often amounts to as much as 60%. Owing to evaporation from the surface and evapotranspiration of the plants the solutions rich in sodium condense, and in consequence of the concentration of sodium alkalization takes place. The result of this process is an increase in the amount of sodium salts and soda in these areas.

Herke's observation has revealed yet another regular fact, namely, that within the connected sodic areas the degree of alkalization grows as we proceed from north to south, then it decreases again. The same regularity can be found in other sodic areas too. Herke attributes this phenomenon to crustal movements. He also refers to the amelioration of the solonchak — solonetz and solonchak sodic soils with gypsum and lignite powder. Among the calcium — containing ameliorating materials he recommends mainly the latter because its effects can be enhanced by irrigation [5]. In all cases amelioration must be preceded by area planning so that occasional surface — near groundwater should not interfere with the work of amelioration.

The other dominant type of soil in the valley of the Danube is the *meadow chernozem* which can be found mainly in the higher — lying flood areas. During its development it passed through the alluvial and meadow stages, and the table of its groundwater sank. This type of soil stretches as far as the area of Kalocsa. South of this the sodic and the meadow chernozem is replaced by *alluvial meadow* and *meadow soils*. In this region sodic soils occur only at the mouth of the Sió, north of Szekszárd and in the vicinity of Hajós. The terraced arrangement — from north to south sodic soil, meadow chernozem, alluvial meadow, and meadow soil — is probably connected with the varying level of the groundwater. In some places swamps have developed. Such swamps are those of Csévharaszt and Kalocsa, where peat masses are accumulated.

The soils of the Danube alley are, with the exception of the sodic soils, very fertile. The agricultural conditions of the region can be greatly improved by irrigation as shown by the example of the sprinkling irrigation system used in the area of Hajós.

The plain of the Danube — Tisza interfluve

After breaking through the gate of Visegrád the Danube built a huge alluvial fan on the Great Plain. The water masses of the Danube wandered over a relatively wide area between southwest and south. The large amount of gravel deposited by the Danube is found near the surface at Budapest, while in the middle of the plain the gravel is covered by alluvial deposits in several hundred meters thickness. The main mass of the deposits was sand which was transformed into drift — sand owing to the destroying effect of winds during the drier periods and this sand cover has given a heterogeneous picture to the landscape. The irregularly occurring and often drainageless depressions between the sand dunes and ridges have led to alkalization and in some places to swamp formation. Today the plain lies 50 m higher than the flood — basin of the Danube. The plain is not characterized by drift — sand; drift — sand occurs a s a dominant factor mainly in the area bounded by Bugac, Kiskunhalas, and Jánoshalma. In the other areas the sand has to a great extent become humous, while loess is found in many places, in the areas of Gödöllő, Cegléd, and Kecskemét, in a NW—SE direction.

The hydrography and the soil conditions of the region are entirely attributable to the evolution of the region. The loess, sand, and gravel layers retain the rainwater and the groundwater table is relatively high, the result of which is frequent flood damage in the lower — lying parts in spring. In the course of the development of the soil conditions the position of the Danube at the end of the Pleistocene and the beginning of the Holocene already ensured that the material of the detrital cones could dry out and so the finer particles could move away in the form of windblown drift — san or loess. The intervening wetter period stopped the movement of the soil, and soil formation began, the results of which are the meadow and chernozem soils. In the following drier period the winds moved again the surface layers which then covered the already formed surface in the form of a sand blanket [6]. The water supply (in the maxima and minima) of the varied area was not ensured; this is why meadow and bog soils formed in the lower parts and drift — sand, humous sand, and chernozem — like sand in the higher parts. With the passage of time, however, the drift — sand buried the lower parts 1—2 m deep. These buried parts are capable of storing humidity and nutrients; therefore the conditions of production are very good in them. In the now existing depressions in the northern part of the area a mixture of bog soils or meadow clay and sand predominates. The depressions of the southern part are alkalized, with sodic and alkali solonchak soils.

The thickness of the covering sand blanket on the sand dunes and rolling parts can be guessed from the vegetation growing on them, for where the drift — sand is deep, there are junipers and feather — grass; where it is shallow — in the depressions —, there woods predominate. Where the subsurface layers are improved and contain more humus, there oaks appear.

The productivity of these soils needs to be increased by such ameliorating methods as improve the water and nutrient economy of the soil. Manure, peat, bentonite, artificial fertilizers, or readily decomposing organic matter can be applied.

Not negligible besides sand are the large patches of loess in the areas of Kecskemét, Kisfunfélegyháza, and Abony. This soil contains much Mg and occasionally Na, which are unfavorable to the water economy. In some places chernozem soil can also be found in the depth. In the depressions of these areas mainly solonchak — solonetz types of sodic soils occur; utilization of them is difficult. On the chernozem soils intensive cultures which nearly inevitably use soil amelioration and irrigation, are prefereable for the sake of economicalness.

In examining the various factors of these sandy areas the erosive work of winds must always be reckoned with, especially in spring and in dry weather when the average wind velocity is the gratest in Hungary. Therefore the struggle against deflation, besides soil amelioration, is of decisive importance.

The loess plain of Bácska

The loess plain of Bácska is a formation originating from falling dust. The loess is mixed with sand and beside it sandy patches can be found. The dominant soil type is lime-covered chernozem and its subtypes. The thickness of the humus layer is 60—80 cm, and its organic matter content is 4.5%. The carbonate content is demonstrable already at the soil surface and its amount increases with the depth. The nitrogen and phosphorus bound to organic matter ensure good growth of the vegetation. Sodic soils occur in the deep — lying parts, and a very considerable salt content can be demonstrated in the southern part of the area, e.g. in the vicinity of Gara. The profiles with magnesium and sodium content in the subsoil are well distint, their humous horizon is compact, with a pH higher than 8.5. Only such plants can be grown in this area as can well suffer a sodic subsoil. On the chernozem soils plowland cultivation is used, on the sandy soils rich in loess orchards and vineyards thrive.

The region along the lower Tisza

Stretches from the mouth of the Kőrös to south of the border on both sides of the Tisza. This region is wedged in between the loess plain of the southern part of Tiszántúl (the lowland east of the Tisza) and the sandy plain of the Danube—Tisza interfluve. The Tisza altered its course between these two regions until it formed its present-day bed in the recent geological past. Thus the alluvial soil is situated between the sandy plain and the loess plain, gradually widening from north to sout. All types of soil can be found in this area from the crude alluvial soil, which occurs near the river bed, through the alluvial meadow and simple meadow soils to the meadow chernozem. Characteristic of the Tisza and Maros valleys are the black clay horizons. These can, however, be found also in the flat regions of the Bodrog, the Tisza, the Kőrös and the Maros where year after year large areas were covered by water. The sediments in these areas formed the black horizons. The organic substances that got under the water decomposed, and the minerals were not leached out but they formed new colloids. Such areas, if they are not free from the influence of water for a longer time, soon become alkalized. The black clay layers generally lie at a depth of 1—2 m and have an important influence on the surface sediments both chemically and from the point of view of water economy.

The loess plain of the southern part of Tiszántúl

This is an area enclosed by the alluvia of the Kőrös, the Tisza, and the Maros. The loess plain continues in the territory of Roumania. In the formation of the area the Maros which used to flow through other areas, has played a great part. Three periods can be distinguished till the time when it occupied its present bed [7]; others [8] distinguish several periods of alluvium transportation and deposition.

At different times the river flowed NW, then SW and deposited its alluvium. In connection with the Pleistocene deposits *Miháltz* already referred to accumulation in the area. During the process of accumulation a sequence of deposits formed which ara coarser below and finer above. This sequence was occasionally repeated. The sequence thus formed was modified also by climatic changes in consequence of which sand, silt, and clay layers cover the accumulated layers. The above — mentioned stratification was frequently changed at the surface by the changing air flows, the result of which is the varied drift — sand surface blown there from the flood area. At the end of the Pleistocens this surface was covered by falling dust, and thus loess formed. *Sümeghy* [9] called this surface formation „lowland loess". Holocene lowland loess formed under similar conditions.

Szücs and *Sümeghy* demonstrated that lowland loess differs considerably from the loesses of Transdanubia because there is a higher percentage of larger granules in the loesses of Transdanubia, but the amount of silt and clay particles is much less. Chernozem and meadow chernozem soils formed on the silty loesses of the lowland, while meadow and sodic soils formed on sandy loess.

In the higher — lying areas of the southern part of Tiszántúl (the plain east of the Tisza) the loess is light, loose, and sandy; in the lower — lying areas it is clayey. The cover of the higher areas is chernozem, that of the lower areas meadow chernozem; in some places salt chernozem and sodic soils dominate in the deeper parts.

In these alluvial formations the layers containing groundwater lie generally deep. The vertical movement of the groundwater may be even several meters; yet independently of this the groundwater is disproportionately high in the higher — lying areas, which is of decisive importance for soil formation. According to the data of *Rónai* the groundwater in the southern part of Transdanubia is mainly characterized by a high salt content; on the other hand the quantities of sodium and magnesium salts in it influence the fertility of the soils.

Summarizing it can be said that lowland limy chernozem together with meadow and salt meadow chernozem occurs in a NE—SA direction in the loess plain of the southern part of Tiszántúl, while meadow solonetz and steppe-derived meadow solonetz occur in the lower areas.

The utilization of the soils depends on the salt content; the type of cultivation must also be chosen according to the location of salts in depth. In spite of this the climatic and soil conditions ensure also the possibility of growing more sensitive plants. Amelioration is especially justified on the meadow solonetz and steppe-derived meadow solonetz soils.

The region of the Kőrös

The tributaries of the Tisza frequently altered their course forming a network over much of the area. The intensively sinking area of the plain left very many reedy, swampy grounds in the place of the old, abandoned river beds after the controlling of the rivers. The areas freed from water cover slowly dried out, the groundwater table sank deeper and could influence the formation of soils in the area to a lesser degree. Nearly half of the meadow clays of the country are found in this region. The subsoil of the pitch black, clayey areas is often sodic, containing much sodium and magnesium. According to the observation of *Máté* [10] the thickness of the humus layer of the soil is minimal, while the ratio between the clay and the humus is reversed.

The views concerning the formation of the meadow soils are very different. *Sigmond* attributes the formation of meadow soils to too much moisture, *Csiky* ascribes it to the acidity of the clay deposited by the rivers, *Endrédy* again attributes it to the effect of water, while *Ballenegger* thinks it is derived from bog soil. In many cases, however meadow soils formed also on loess [11]; an example for this is the loess plain of the southern part of Tiszántúl. Meadow soils occur also on acid alluvia. Whatever the theory may be, water always plays the decisive role in the formation of meadow soils or clays.

If we study maps from before the flood control, we come to the conclusion that meadow soils formed in the low — lying, periodically water — covered areas, while sodic soils formed in the higher areas with periodic water cover, and chernozem soils formed in the areas free from water cover. This proves that the location of the meadow soils is closely connected with the bog soils, peat and turf soils. With the erosion of the surface formations began the development of a new humus layer which contributed to the formation of meadow soils.

Meadow soils are not essy to till. They are generally rich in nutrients, but in case of wrong cultivation they become compact and areas with stagnant waters soon develop. Well — chosen methods of amelioration can influence decisively the fertility of the soil.

Besides the meadow soils considerable areas are occupied by solonetz — like sodic soils as well as limy — sodic variants of these, the solonchak — solonetz soils. They have been ameliorated by yellow earth covering and limestone powder and lime mud covering [12]. The rate and intensity of amelioration must be increased because the water of the now existing irrigation canals can be utilized only after amelioration of the sodic areas.

The sodic and meadow soils of the regeion are characterized in places by steppe formation. The precondition of this process is alteration of the water budget which results in quantitative and qualitative changes in the productive humus layer. The air deficiency of the soil disappears, the acidity of the meadow soil besomes reduced, that is it develops favorably from the economical point of view.

The soils in the northern and eastern parts of the region possess more favorable properties; meadow, salt meadow, and limy chernozem soils have developed there.

The loess plain of Szolnok

This plain lies in the southern part of the riverside region at the middle course ol the Tisza. The northern and eastern edges of the area end with the flood area of Borf sod—Heves and the Hortobágy plain. In spite of their common origin the surface soi- is diversified here. The soil conditions under the loess are varied; there is much inl fusion loess. The depth of the groundwater level varies between 3—5 m, but it stil- influences the development of the upper soil layers. The chernozem soils of the region are of the meadow type. Their color is variable, their structure is compact and crumby, their humus layer is thick. Magnesium accumulations in the subsoil — under 1 m — are frequent. Alkalization occurs sporadically in the form of solonetz meadow soils and solonetz soils.

As to the origin of the region, it can be demonstrated that it is part of the sand plain of the Danube—Tisza interfluve cut in two by the Tisza. This area, however, has become humified and there is no drift-sand in it. Various kinds of plants can be grown here. This region is, however, the driest part of the country. The harvest yields in the region depend to a great extent on irrigation.

II.

The material of the surface layers Wind-blown deposits

The grains of river — transported sand are sharp-edged and angular, while the grains of wind-blown sand are roundish. The two kinds of sand can be distinguished on the basis of their percentage composition [9]. The origin of some sandy areas can be determined on the basis of the *intervening silt layers*. The sporadic occurrence of silt invariably indicates fluviatile origin; it never occurs in wind-borne san. Another indication is the occurrence of various kinds of snails, because in windblown sand only land snails or stagnant water snails can be found. The most frequent grain size in wind — blown sand is 0.1—0.3 mm. Vertically up toward the surface the diameter of the grains increases, while horizontally from W to E it decreases.

The water premeability of wind-blown sand is $k=10^{-3}$ cm/sec, that of river-borne sand $k=10^{-2}$ cm/sec. The difference is due tot the difference in compactness.

Loessial wind-blown sand can be found in Pleistocene layers, usually with a 0.1—0.2 mm grain size, as well as the loess fraction with 0.02—0.05 mm grain size, the permeability of which varies between $10^{-4}-10^{-5}$ cm/sec.

Loessial fine sand or loess sand is a transition between the vertically arranged *loess* and the *loessial driftsand* and the *loose drift-sand* on top. It can be found over a vast expanse in the vicinity of Kiskunhalas, Kiskunfélegyháza, Csongrád, and Csanytelek. Its grains are 0.05—0.1 mm in size and they are mixed with more or less drift — sand; the permeability factor is $10^{-5}-10^{-4}$ cm/sec.

The loesses come from falling dust; fine sand and normal sand in varying quantities can be found in them. Loess with fine sand occurs as a transition on the edges of drift — sand areas.

The name of *dry-ground loess* contains the explanation of its origin. Its structure is loose and porous, its permeability is 10^{-5} cm/sec, the lowest among the various kinds of loess. It occurs in the area examined in the vicinity of Kiskunhalas, Jánoshalma, and Soltvadkert as well as in the higher-lying grounds near Kiskunfélegyháza, Kecskemét and Nagykőrös. It occurs only in patches in the regions of Szeged, near Öthalom, Szatymaz, Szentmihálytelek, and Kiskundorozsma.

In the lower-lying areas *wet-ground infusion loess* and in some places *bog loess* has formed. In the case of the first the dust fell into periodic, in the case of the latter into constant, stagnant water. Its percentage of lime carbonate content is lower, 10—20%, than that of dry-ground loess, which is 30%. Its permeability is 10^{-6} cm/sec, which is less than that of other kinds of loess.

Flood-basin loess formed in the flood areas of the Tisza, increasing the clay-silt content of the soil, for when the floods receded large amounts of aerated clay were left behind. The permeability of floed-basin loess, 10^{-7} cm/sec, is much less than that of the other kinds of loess.

On the drainageless alluvial soils of the Tisza *sodic clayey loess* with a high clay content has formed. Its formation is partly the result of present period alkalization [9]. Its origin can be explained by the transporting work of the river water.

Holocene formations

The dry period of the Holocene rearranged the Pleistocene sand of the surface accumulating it in places over the topmost loess layer. Large amounts of the new drift-sand blown away from the Danube valley were deposited on the western edge of the plain.

The present — day formations are the result of the work of the prevailing north-west wind in the Holocene, which shaped the undulating ridges that stretch from north-west to south-east. Similar developments took place in the eastern areas of the plain, but there the deposits derive from material transported by the Tisza. The remains of snails in both areas exclude a fluviatile origin [10].

In the drainageless depressions in the Danube—Tisza interfluve *alkalization* took place. When the lime and magnesium carbonates became concentrated, *caustic* *sludge* formed as a consequence of the precipitation of granules. In the less sodic areas *meadow limestone* formed owing to the *carbon dioxideabsorbing* effect of the vegetation. Under the influence of the climate becoming wetter, the vegetation grew more and more vigorously, alkalinity decreased, and thus humous, *silty sand* could deposit in the lower areas.

Considerable amounts of carbonate deposits can be found in the southeastern part of the plain in the areas of Kistelek, Jászszentlászló, and Pusztamérges. In the depressions of the higher grounds, thus in the areas of Kiskunhalas and Félegyháza, a humus layer can be found. Owing to changes in the climatic elements, the bound drift-sand moved again, covering in places as a *blanket* the caustic sludgy and humous areas. The thickness of the sand blanket varies between 1—5 m. The water-impermeable layer under it — sodic or caustic sludge — is of great importance for the agriculture. The sand blanket, which is the youngest geological formation, deposited on the higher grounds of the plain. In the lower-lying areas *meadow clay* and in the sodic depressions *sodic humous clay* can be found, as for example in the area of Fehértó (the „White Lake") and the area of Csanytelek (Fig. 2).

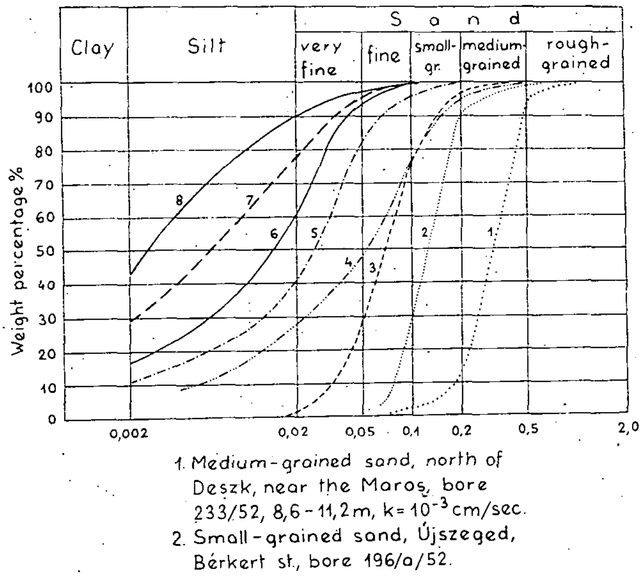

Fig. 2. Comparison of the grain composition of wind-blown sand and different kinds of loess (after Miháltz)

2. ábra. Szélhordta homok és lösz fajták szemcseösszetételének összehasonlítása (Miháltz nyomán)

The fluviatile sediment layers

The borings made by *Miháltz* in the vicinity of Szeged in 1952 [4] make it possible for us to survey here briefly the fluviatile deposits of the Tisza River valley and Tiszántúl. According to *Miháltz*'s findings fluviatile deposits can be demonstrated at a few meters depth in the Tisza River valley and in Tiszántúl. *Miháltz* classes the deposits of stagnant waters with the deposits of fluviatile origin.

The *fluviatile sand layers* of the Tisza River valley are fine-grained or medium grained (0.1—0.4 mm) in both the Pleistocene and the Holocene lyaers, their water permeability is 10^{-4} cm/sec. The layers are arranged so that the *mediumgrained* sand layer is below and the *fine-grained* sand layer above. Fine-grained sand occurs in the

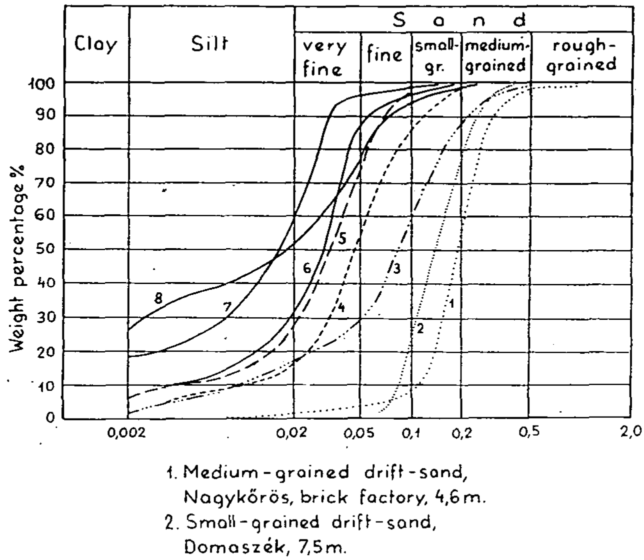

Fig. 3. Grain composition curves of the types of fluviatile deposits (after Mihàltz)
3. ábra. Folyóvízi üledékek típusainak szemcseösszetételi görbéi (Mihàltz nyomán)

southern section of the Tisza valley, medium-grained sand somewhat farther to the north in the region of Szegvár, while *coarse-grained* sand with water permeability of 10^{-2} cm/sec occurs in the region of the Maros. Medium-grained sand is characteristic of the deposits of the Kőrös and the Maros. In the southeastern corner of Tiszántúl,

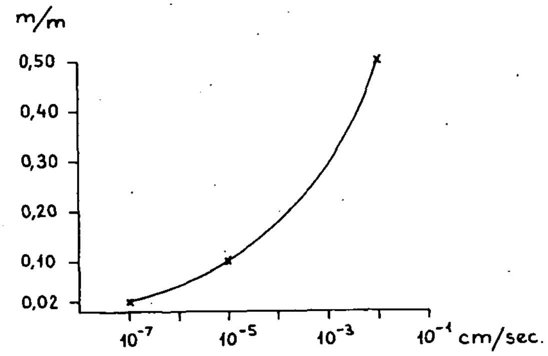

Fig. 4. The correlation between grain size and permeability
4. ábra. A szemcsenagyság és a szivárgási tényező összefüggése

however, *gravelly coarse sand* can be found near the surface. In the middle of the Great Plain, however, sand derived from the Tisza is predominant, *The coarse-, medium-, and fine- grained sands should be placed in the category of loose fluviatile sand.* (Fig. 3).

Differentiation of the grain diameters leads us to categorization of the kinds of sand and differentiation of the permeability values, e. g.:

grain size 0.5 mm (coarse sand) — permeability 10^{-2} cm/sec
grain size 0.1 mm (fine sand) — permeability 10^{-5} cm/sec
grain size 0.02—0.002 mm (silt) — permeability 10^{-7} cm/sec.

The permeability factor is almost in direct ratio to the grain size (Fig. 4).

If the value of permeability is 10^{-8} cm/sec, the material is clay, that is a water-tight layer. Thus the permeability factor of alluvial silt 10^{-7} cm/sec, is not far in value from that of clay. If alluvial silt is the covering of grassy ground, its permeability value is higher.

III.

Methods of soil amelioration with synthetic materials applicable in the southern part of the Great Plain

After characterizing briefly the material of the surface layers we are going to discuss the problems of amelioration with traditional methods and with synthetic materials [13]. In this chapter we deal only with the soils that are predominant in certain areas of the southern part of the Grezt Plain.

In connection with the acid soils we deal with the amelioration of acid meadow and alluvial soils. In this case we do not describe the amelioration of forest soils because in the area studied they can be considered only as subdominant factors.

a) **Meadow soils**

They are characterized by compactness in the case of clay. Such soils are poorly aerated and their water: air ratio is unfavorable to microorganisms and plants. For efficient cultivation these soils must be made looser and richr in air. The modern method of achieving this is to use, besides liming, close-pored Ps foam containing 98% air or similar synthetic material foams. These foams are neutral substances, which do not bind water or nutrients, decompose slowly, and retain their effectiveness for years. After their decay the ground remeins loosely porous.

If under the meadow soils there is a water-impermeable solonetz lyaer near the surface and therefore stagnant water gathers in the layer over it which hinders its cultivation, then the compact layer can be eliminated by subsoil loosening and the introduction of closepored synthetic material foam.

b) **Alluvial soils**

These soils need structure improvement if they formed long ago on carbonate-free clay. The deposited alluvium of the Tisza is not clay but rather silt; therefore conservation of its structure can be achieved by limingand the use of polyelectrolites.

If, however, these acid, humous alluvial soils are compact, they must be limed and their aeration and water permeability must be ensured by synthetic material foams. The ameliorated soil must also be preserved by polyelectrolites. We recommend the use of similar methods on $CaCO_3$ — free clay — i.e. on alluvial meadow soils.

c) **Detrital soils of slopes**

The essential thing in their amelioration is to know what type of soil they derive from, chernozem, forest, acid, or compact soil, for amelioration depends on the properties of these soils. As is well known, polyelectrolites protect the structure of the soil, while foames increase its water permeability.

The amelioration of sodic soils

Can be discussed on the basis of *Prettenhoffer*'s classification of methods [14].

a) **Non-limy, acid, and near-neutral sodic soils**

These occur chiefly in Tiszántúl. Classically they are ameliorated by liming, occasionally by deep manuring with lime. Their amelioration is achieved by developing a favorable structure in them, while their crumby structure can be preserved by the use of polyelectrolites; when they break down, they provide N for the plants.

In the Soviet Union crude oil, purified from aromatic substances, is also used for amelioration of sodic soils.

b) **Non-limy, slightly alkali/transitional, sodic soils**

They also chiefly occur in Tiszántúl. The classical method of their amelioration is deep manuring with black earth, acid or gypsum-containing yellow earth, and surface manuring with lime and gypsum. Here, too, we think of ameliorating the soil with the materials mentioned above. We want to eliminate the soluble salts already present and the Na ions that formed during amelioration by utilizing the loosening and permeability-increasing effect of close-pored foam materials.

c) **Alkaline and limy sodic soils**

These occur chiefly in the Danube—Tisza interfluve and in smaller areas of Tiszántúl. The classical method of their amelioration is the use of acid materials; first of all gypsum powder and gypsum by-products of factories can be considered. Modern methods, however, require the addition of artificial materials, polyelectrolites and foams.

In the places where the groundwater has been brought under control — especially in the Danube—Tisza interfluve — the sodic soils with light mechanic structure can be improved within a few years by the application of gypsum and closepored synthetic material foams.

The amelioration of sodic soils with heavy mechanic structure, especially in Tiszántúl, is much more complicated; here the application of gypsum powder and polyelectrolites is more effective.

In the case of „B"-horizon soils containing little Na the already known agrotechnical method, in the presence of a larger amount of Na the introduction of chemical ameliorating materials simultaneously with subsoil amelioration, is effective. The ameliorating materials must be spread simultaneously with the manure. The procedure used can be repeated several times.

Sand soils

It would be worth-while ameliorating a large part of the sandy areas nearly one a half million hectares — of the country [15]. In the case of sand soils too high or too low water-retaining capacity, poverty in nutrients, and tendency to deflation are to be fought against.

The old traditional methods of amelioration using stable dung, bentonite, bog soil, peat, clay minerals, composts, green manure, and layer improvement continue to be of great importance. At the same time we propose to apply synthetic materials, polyelectrolites, open-pore synthetic resins, and emulsions to eliminate the unfavorable properties of the soil.

The polyelectrolites hinder the decomposition of organic matter in the sand, while their ion-exchanging atom groups transmit the nutrients to the plants.

To improve the nutrient economy of the soil, first of all synthetic material foams combined with mineral fertizizers can be used. These bind the water absorbed in the sand and transmit it together with the nutrients to the plants. Owing to their slow decomposition they are nitrogen sources themselves [16].

KP foam is used also in other forms for binding sand surfaces and dunes and planting them with grass. For example the foamy synthetic material is mixed into a mush with mineral fertilizers and water and sprinkled on the surface of the soil; then the material adheres to the soil, stores water, hinders the drift of sand, and makes a good bed for seeds [16].

All three methods are first of all intended to change the unfavorable properties of the sand, but emulsions and solutions of the different materials may also be used for this purpose. These solutions are used either on the surface or at certain depths, depending on their destination.

Bog soils

We do not recommend amelioration of these soils with synthetic materials besides the classical methods — draining, liming, supply of nutrients, mixing with sand, burning, etc. — because of their high organic matter content and their good structure. The most important interference in the dynamics of these soils is the draining of superfluous water.

Besides the classical methods of amelioration the application of synthetic materials may be justified in the following cases:

a) When the A and B horizons are missing and only the gleyey mother rock, the C horizon has remained. In this case closed-pore synthetic material foams must be applied. Aeration of too wet soils can thus be secured.

b) When the meadow bog is highly acid. In this case lime must be applied.

c) When the meadow bog has solonchak soil. In this case drainage must be ensured. If this is hindered for instance by an intervening clay layer, the movement of the water must be ensured with closed-pore synthetic material foams.

Similar procedures must be used where limestone banks, cemented gravel or gleyey layers occur. The movement of the water can be ensured by mixing synthetic material foams into these layers.

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