THE DISTRIBUTION OF PRECIPITATION AND SOIL AMELIORATION WITH ARTIFICIAL MATERIALS

by

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Zusammenfassung: *(Die Niederschlagsverteilung und Bodenverbesserung mit Kunststoffen.)* Auf Grund der Niederschlagskarte von Hajósy und der Bodenkarte von Stefanovits stellen die Verfasser die territoriale Verteilung der Verbesserung benötigenden Sand-, Moor-, Soda- und Sauerböden unter den landwirtschaftlich benutzten Gebieten Ungarns in Zusammenhang mit der territorialen Verteilung des Niederschlags dar.

Die Abhandlung berichtet auch über die Bodenverbesserungversuche der Verfasser, wobei Kunststoffe, Polyelektrolite, Kunststoffschäume und Emulsionen in den Boden eingeführt wurden. Auf Grund ihrer Ergebnisse denken die Verfasser, dass die Kunststoffe in der Bodenverbesserung in der Zukunft eine grosse Rolle spielen werden.

Summary: The authors describe on the basis of Hajósy's rainfall map and Stefanovits's soil map the territorial distribution of sand bog, alkali and acid soils needing amelioration among the agriculturally used areas of Hungary in connection with the territorial distribution of rainfall.

The paper reports on the authors' attempts at soil amelioration in the course of which artificial materials, polyelectrolites, artificial material foams, and emulsions were introduced into the soil. On the basis of their experiments the authors think that in the future the use of artificial materials will play a great role in soil amelioration.

It is commonly known that about 50% of the agriculturally used area of Hungary needs amelioration and receives very little precipitation (1).

Our aim, therefore, is to discuss the value of artificial materials besides the traditional methods in soil amelioration on the basis of some theoretical and methodological principles of the classification of the regions.

The differences between the regions are determined by their geographic character and unity. The classification according to character is the result of differences in surface, climate, soil types, waters, vegetation, and fauna. The geographic unity, on the other hand, is the result of the inseparability of the various factors (2).

According to SOLNTSEV the above-mentioned factors can be classed in two large groups: to the first belong the lithogenic and hydroclimatogenic factors, which have a great power of resistance, to the second belong the biogenic factors with their lower power of resistance (3).

According to GERENCHUK the chief lithogeomorphological complexes manifest themselves also through the vegetation and the types of soil. He proposes that the differentiation of the landscapes should be made according to the spread of the overlying rocks (4).

Of primary importance for agriculture is the favorable or unfavorable quality of the overlying rock, the soil, which may constitute the basis of a possible classification. It was on the basis of this idea that we classified those agricultural areas of our country, which, on account of their unfavorable properties, need amelioration in the interest of a larger production.

The possibility is given to us to deal comprehensively, according to our aim, with the artificial materials that can be used for amelioration of the acid, sodic, sandy, and bog soils in this country. In the majority of cases, the amount and quality of the agricultural crops, i.e. the efficiency of production, are determined by the suitability of the soil for cultivation and by the precipitation conditions.

Under the influence of external forces some relief forms disappear or change in the course of long periods of time. Accordingly, within each region smaller areas, morphological systems, differing in soil or appearance, develop. Since the morphological units occur in different proportions in different regions or microregions, it is possible to show the areas cartographically by means of surveys or photographs. At the same time we can categorize and examine the acid, sodic, sandy, and bog soils as constituent parts, i.e. basic landscape units or landscape mosaic, of the agriculturally used area of the country.

In connection with our theme, either method of classification can be used, though the latter method seems more suitable from our viewpoint.

Detailed characterization of the landscapes is at this moment not our primary task; thus according to our aim, soil amelioration is gicen attention from the point of view of artificial materials that canbe used for the poorer soils under given precipitation conditions.

Over the territory of our country the climatic elements satisfy more or less the needs of plant cultivation. At the same time it is a long-known fact that the yield is in very many cases a function of the conditions precipitation.

In the middle of the last centruy, then after the foundation of the Hungarian Meteorological Institute, many Hungarian climatologists studied the precipitation conditions in the basin of the Carpathians on the basis of the material collected. With a view to recording the great variability of precipitation the then existing observation network was further developed. HAJÓSY and his contemporaries (4—5) had already the data of the enlarged observation network at their disposal for evaluation. The old data, however, were, on account of their sporadic and unsystematic nature, only good for finding out general laws.

The western territories of our country represent abundance of precipitation, and the areas of the Great Plain around the middle section of the river Tisza scarcity of precipitation. The driest areas of the country are the regions of Hortobágy, Szolnok, Szarvas, and Kunszentmárton, where the annual amount of precipitation does not reach even 500 mm. The larger part about 70% of the territory of the country however, gets an annual average of 500—600 mm. To this areabelong the largest part of the Great Plain, the Small Plain, and Mezőföld. In most parts of Sopron, Vas, Veszprém, Zala and Somogy counties in Transdanubia (the part of Hungary west of the Danube, and in the parts of the northern mountains above 400 m the annual precipitation is over 700 mm. In the south-western part of Vas, Zala, and Somogy counties the annual amount is over 800 mm (6).

In connection with the territorial distribution of precipitation we show the soil needing amelioration in the agriculturally used areas. The territorial distribution of the acid, bog sandy, and socid soils is classified on the basis of the precipitation map of HAJÓSY and the soil map of MATTYASOVSZKY, GÖRÖG, and STEFANOVITS.

1. To the areas with less than 500 mm of annual precipitation belong areas with sodic soil in the region of Hortobágy, and the weakly and strongly acid, strongly compact mud soil between Szolnok and Kunszentmárton.

2. To the areas with 500—600 mm of yearly precipitation belong in the lowlands the weakly or strongly acid sands, weakly and strongly acid, strongly compact mud soils and clays, the sodic soils in the region of the Kőrős rivers, and the acid bogs along the northwestern border and in the region of the Kőrös rivers.

3. To the areas with 700—800 mm of annual precipitation belong the weakly and strongly acid sand soils, the weakly and strongly acid sandy mud soils, and themoderately compact mud soils of Sopron, Vas, Veszprém, Zala, and Somogy counties.

4. To the areas with more than 800 mm of annual precipitation belong the weakly and strongly acid moderately compact mud soils of the south-western parts as well as the weakly and strongly acid sporadic sands and mud soils of Vas, Zala and Somogy counties.

In general it can be stated, that in the territories east of the Tisza the continental character is predominant, with a maximum in June or July and a lower second maximum in fall, west of the Danube the Atlantic character prevails. In the land between the Danube and the Tisza the continental and Atlantic air masses mingle, mostly under the greater influence of the continental current.

In connection with the territorial distribution of the total annual precipitation the scattered bos, acid, sandy, and sodic areas can be regarded as landscape mosaics even if the agricultural areas of our country are divided by a threefold classification. Thus we can define the landscape unit of Transdanubia, that of the land between the Danube and the Tisza, and that of the land east of the Tisza with their characteristic microlandscapes, landscape mosaics, and basic landscape units.

I. Characterization of *Transdanubia* as a landscape on the basis of the distribution of the average precipitation:

the acid sand soils of Sopron, Vas, Veszprém, Zala and Somogy counties their acid sandy mud soils and medium compact mud soils and bogs may be regarded as landscape mozaics.

II. According to the soil units of *the land between the Danube and the Tisza* as a landscape:

a considerable part of the limy, poor sand is scattered over the area; acid mud soils and clay are to be found immediately beside the Tisza; these areas may be regarded as landscape mozaics.

III. According to the soil units of *the land east of the Tisza* as a landscape: the sodic lands of Hortobágy, the sodic areas between Szolnok and Kunszentmárton and in the region of the Kőrös and sporadic acid bogs, mud soils, and clays may be regarded as landscape mozaics.

It can be said of all landscape mosaics that they are forms of mesorelief, which besides a given rock composition possess nearly similar productive soils and complex plant associations.

According to many experts GERENCHUK's view of the landscape mosaic is correct: „the urochische is nothing else but the combination of genetically similar facies evolved in mutual relations" (8).

In the division of the above three landscapes I, II, III into landscape mosaics SOLNTSEVS' method (3) can be used, on the basis of which from the landscape mosaic of the land between the Danube and the Tisza as a morphological unit the weakly and strongly acid sandy soils may be taken out and examined as dominant factors in the landscape mosaic. The less common acid mud and clay soils can be examined as subdominant components of the landscape mosaic.

On the basis of any classification of a similar nature the use of suitable artificial materials in the areas can be determined in advance according to whether we want to preserve the structure of the soil with polyelectrolites, artificial foams, emulsions, or true solutions, or else we want to influence the air, water, and heat balance of the soil.

We have made such a classification on the basis of biogenic factors in the area of Csévharaszt in the land between the Danube and the Tisza. We delimited the basec landscape units in the territories of the landscape mosaics; at the same time we described the flood-basin microlandscape as the genetic unit of several landscape mosaic components.

The woody steppe on sandy soil is a cultivated area interspersed with pastures; its hillock systems preserve the ancient vegetation. But the larger part of the vegetation is identical with the vegetation of the sandy areas between the Danube and the Tisza. The continental Pontic and the Pontic Mediterranean elements give the woods and moorland greens an eastern and southeastern character, although southern elements, as for instance Dianthus diutinus, are also represented (9).

The flood-basin microlandscape examined is a genetically homogeneous area characterized by a uniform geological base, a peculiar plant association, and a local climate. The soil surface both on the pastures and on the cultivated lands needs quick and effective amelioration.

A further aim of agricultural investigation, which serves the exploitation and amelioration of the natural resources, is to find materials similar to humus and of a asting effect. This aim has partly been achieved by the manufacture of artificial materials which preserve (condition) the soil structure.

The advantage of the artificial materials, artificial soil stabilizers, over the natural structure amelioratorss (humus and clay) is partly that they do not decompose so rapidly in the soil, partly that they can be used in greater concentrations.

The artificial materials, artificial resins that can be used for soil amelioration ara mainly organic or mineral, surface-active or neutral materials with generally large molecules. They possess the common property that they preserve the soil structure thus favorbly influencing certain soil properties, for instance the air and water balance.

Their simplest classification is: 1. polyelectrolites, 2. artificial foams, and 3. emulsions and true solutions.

1. *The polyelectrolites* are artificial polymers containing electrically charged components, cations and anions, which adhering to the surface of the soil particles in the form of string colloids, glue them together into water-resistent lasting crumbs. Their effect depends on the quality and quantity of their active groups (e.g. OH, COOH), the size of the dose applied, the mechanical and mineral composition, pH, salt content, ets. of the soil.

The salts of the soil, for instance, if they are easily soluble (Na salts), have a great effect threshold of polymers. These salts hinder the formation of giant molecules, the string colloids consisting of elements with ramifying structures. Thus they hinder a lasting aggregation of the soil crumbs. Ca and Mg carbonates for example as salts not well soluble in water do not influence the structure-preserving effect of hydrolyzing polyelectrolites (10).

Besides this, as we have mentioned, the chemical nature of the soil can also influence the applicability of artificial resins, because the active groups of the latter may be different.

The pH generally has no effect on the less hydrolyzing polyelectrolites.

Hydrolyzing polyelectrolites can effectively used for soil amelioration only in the range of pH 4,5—9.

If the soil is strongly acid, — its pH value is less than 4,0 —, the area must first be limed (10).

The effect of the polyelectrolites is that they glue the soil particles together into crumbs with, small bridges of artificial material, then as string colloids they enmesh them. This keeps the crumbs from falling to pieces and from the silting effect of water. The lasting structure so formed ensures a favorable change in the water, heat, air, and nutrient conditions of the soil (11).

The polyelectrolites are chiefly acrylic, metacrylic, and maleic acid derivatives, or more exactly, different Na, K, and NH_4 salts of these.

In the Soviet Union, under laboratory conditions, a kind of polyacrylamide has been produced which contains liquid nutrients — easily absorbable NPK. This material, used as base or top dressing besides ameliorating the structure of the soil, ensures the nutrient supply of the plants. (12)

When we calculate for dry soil, the polyelectrolites and artificial resins must be applied in quantities between 0,02—0,2 per cent. Those in pulverized form are introduced into the soil by means ofadisk fertilizer spreader, and those in liquid form by means of a distributor, also used for spraying herbicide. Previous to introduction in to the soil, a crumbly structure must be deceloped by a suitable agrotechnical method, because only structures already existing can be stabilized with these artificial materials (13).

2. *The artificial foams* can be loosening materials with open, hydrophilic, or dosedpore, hydrophobic structures. Their primary property is that they exert a chifly physical influence on the soil. This consists in improving the water economy of the soil, producing lasting looseness, and preventing a quick destruction of the soil structure so formed. The environment thus changed, the larger amount of oxygen and higher temperature, activates the life of the soil and mobilizes the nutrients in it.

The interstices of the artificial foam materials with open pores may be permeable to air up to 70 per cent. Thus their volume can be filled nearly completely with water or nutrient solution, and this is practically utilizable for the plants, while the artificial material foam slowly decomposes. The nitrogen liberated is utilized by the plants.

Of the type of metarials mentioned above the carbamide — formaldehyde foam (in the following CF foam, hygromull) is the best known. Its volume weight is 8—15 kg/m^3. Annually about 3—5 per cent of the foam decomposes; as it contains 30 per cent of nitrogen, the amount of liberated vegetable nutrient may be considerable (14).

CF foam can also be made in the form of a filmy coating, which provides good protection against wind erosion (16).

In soil amelioration about 300—500 m^3 of this open-pore material is used for one hectare. As it decomposes very slowly, the duration of its effect is estimated at 10—15 years.

The CF foam is best introduced into the soil in fall, so it can have time to become saturated with humidity.

The artificial material can be used successfully also in arid regions. Besides this the area may be treated with sprinkling irrigation.

Under a ratio of 50 per cent CF foam can well be mixed with peat, compost, mud, clay, etc. (15).

The next artificial material, polystyrol foam (in the following PS foam, Styromull), has closed pores. It contains air as an inclusion. From all points of view it is a neutral material, which is incapable of binding water and nutrients. The volume weight of the foam is also very little: 15—20 kg/m^3. The globules or flakes made of it and used for amelioration have a diameter of 4—12 mm. Depending on what kind of soil is to be ameliorated with it, PS foam can be applied in quantities of up to 500 m^3 per hectare.

Owing to its extremely large volume the foam is not transported, but like CF foam, it is made on site.

In soil amelioration the way of introduction of the material always depends on the goal. For instance if the plowed layer is to be loosened, the PS foam must be spread on the surface, than worked in to a small depth with a disk harrow or cultivator, and then plowed in. If the aim is to improve the subsoil, then the material spread on the surface must be worked into the soil by plowing down to the required depth. If the soil is too wet and we want to dry it, filled with artificial foam (16).

With this method the area, if it has a proper inclination, can be drained without drainpipes.

3. *Emulsions and true solutions* are materials which can form a chemical soil cover and a waterimpermeable layer under the root zone.

Their effect chiefly depends on their place of application. On the surface of the soil they reduce above all evaporation and weed growth. Introduced into a certain depth they retain the water in the root zone.

The above — mentioned materials are generally used on soils with a light structure. Then the film formed on the surface of the soil raising the temperature of this layer by 10 °C creates more favorable life conditions for the plants already at the beginning of the vegetation period. If an "asphalt bed" is made in the subsoil, it helps to retain the water and nutrient supply in the root zone.

These materials can be brought onto the fields with the help of devices like the machines for spraying plant — protecting chemicals (17).

The effect is variable and depends on the material sprayed. For instance oily latex forms a film. Not only does this film protect the surface, but it also ensures that precipitation and irrigation water get into the soil more easily, and the bitumen or emulsion introduced forms an "asphalt bed". On the other hand quaternary ammonium salt as a true solution makes the soil crumbs so water — repellent that the water does not rise to the surface through the capillaries. Evaporation is thus reduced.

The long-term effect also depends on the qualities of the materials. This effect varies between six, seven, and fourteen months. It depends on how rapidly the micro-organisms can decompose the film formed on the soil surface (13).

The use of asphalt in the lower layers considerably increases the long-term effect, prolonging it to 10—15 years. In this case the bitumenous material is introduced into the soil behind a device resembling a goose's foot — shaped cultivator hoe. The thickness of the water — impermeable layer, the artificial „asphalt bed" is about 3 mm.

By this method, as we have mentioned, the pore space or sand is used for storing water, and the watertight layer is formed under the root zone.

Little has been done in this country regarding the utilization of artificial materials for soil amelioration. We can say that only the first steps have been made in this direction

Utilization of the materials described above for soil amelioration under dry conditions mainly depends on the distribution of precipitation and the type of soil in the landscape mosaic.

In the following we are going to describe the soil types according to STEFANOVITS (18) the Methodological Manual of Genetic Soil Mapping (19), and the works of PRETTENHOFFER (20).

As we have mentioned, about 50% of the total plow-land area of the country needs. amelioration. The soils needing amelioration are:

1. Acid soils
2. Alkali soils
3. Sandy soils
4. Bog soils

As their chemical, physical, and biological properties — in their original state — are very different, we think it suitable to deal with them one by one.

1. Acid soils

A common feature of these soils is that the surfaces of their colloids are unsaturated, there is much adsorbed H in them, and there is a high H ion concentration even in their liquid phase.

Unsaturated soils, if they contain many clay particles, are difficult to till, they have a bad, puddled structure, and when dry they become caked.

Thus chemical amelioration of the soil (liming) is achieved not only by neutralizing the acidity harmful to plants but also by the fact that the Ca—containing ameliorating substances, replacing the exchangeable H ions bound on the soil colloids, exert a favorable effect on the dispersion conditions of the latter and on the structure of the soil.

In addition, the effect of liming is very complex: it favors the processes of nitrification, the storage of nutrients, etc.

A considerable part of the costs of chemical soil amelioration is accounted for by the transportation charges, which are particularly high in the mountainous regions. One way of reducing the costs is to extend the efficacy of amelioration to as long a time as possible. This purpose is very well served by synthetic materials, some of which can be made on the site, and combined with the ameliorating substance they surely prolong the efficacy of amelioration.

The acid soils of the country (almost 3,000,000 hectares) are made up mainly of *acid, brown forest soils, and acid meadow soils.* The *acid log soils, sand soils and alluvial soils* cover a relatively small area.

Brown forest soils are found over large areas of the country, and as a considerable part of them are in need of amelioration we are going to deal with them in somewhat greater detail.

In a smaller area of the country there are *highly acidic, non-podzolized brown forest soils* formed on $CaCO_3$-free rock. The organic matter derived from the roots of the undergrowth is extremely acidic: its pH value is 3,5—4,0. Even the mineral layers under the "A_1" horizon are strongly acidic, their pH is 5,0—5,5. They have ashy crumby structure with generally poor water holding capacity.

Similary small areas are accupied by, *podzolized brown forest soils* which have also developed on $CaCO_3$-free mother rock. It is characteristic of them that under the humified "A_1" horizon there is an ashy gray "A_2" horizon with powdery structure. This is the so-called podzolic horizon which is acidic and very poor in nutrients.

The two kinds of soil described above are covered exclusively by natural or replanted forests. According to what follows, amelioration with synthetic materials may be of great importance in reforestation.

The largest areas of forest soils in Hungary are *clayey brown forest soils* a large part of which has been tilled. They are soils in which the clay minerals of the eluvial horizon are washed down in unchanged form, without decay, into the "B" horizon where they accumulate. In the structure of the profile, the "A_1" layer, which may be 10—20 cm thick, produces the humus — enriched horizon. This is usually loam with powdery, crumby structure, or bound with sand. It is slightly acidic with pH 6,0—6,2. The "A_2" layer is the eluvial horizon whose humus content is much lower. This layer, when tilled, is often mixed with the "A_1" layer, and the original 5—8% humus content found under the forest falls to 1,5—2,0%. The structure of this layer is powdery, lower down occasionally plate-like, lamellar; its physical kind is loam or sand with soma clay. The pH is here strongly reduced and shows the lowest value in the profile, around 5,0.

Plowland cultivation of these soils changes not only the humus layer but also the acidity of the soil, because both hydrolitic acidity and exchange acidity become reduced. At the same time the pH value of the soil grows, for while the pH value of the eluvial horizon under the forest is 5,0—5,5, in the profiles under plowland cultivation it is around 6,0—6,5. It often happens that when subjected to plowland cultivation, the "A" horizon is destroyed and the plowed layer is formed on the accumulation horizon "B".

To sum up: Our primary task on these soils is to neutralize the acidity of the soil and, in order to reduce erosion, to increase the water — holding capacity of the surface.

Pseudogleyey brown forest soils in larger connected areas are mainly found in the western part of the country. They are characterized by very great differences between the water conductivity of the eluvial and enrichment horizons. Periodically supersaturation (stagnant water) occurs between the two horizons in consequence of which anaerobic conditions develop and a process of gleying starts in the "B" horizon.

Apart from this characteristic, their properties agree with those of the clayey brown forest soils.

A considerable part of the soils of Őrség in western Transdanubia belong here. Their deterioration is first of all due to the climatic and relief conditions, secondly to unfavourable physical and chemical properties of the soils.

The unfavourable physical and chemical properties can be eliminated by liming, and the harmful superfluous water by drainage.

In Transdanubia and the North Hungarian Highlands *Ramann's* brown forest soils cover large areas. They were usually formed on $CaCO_3$-containing native rock. Acidulation of the profile is only slight, its pH is rarely less than 6,5. The upper layer consists of small crumbs, contains no $CaCO_3$, and is loamadhesive.

An important subtype of it is *Ramann's rusty brown forest soil of* formed on sandy basement rock; accordingly, its structure in the "A" horizon is loose sand and in the "B" horizon slightly compact sand.

Flow of sand is frequent on these soils and so protection against deflation is very important.

Among the acidic sandy soils of Nyírség and Somogy wider stretches of iron incrustation brown forest soils can be found which have been formed on $CaCO_3$-free sand owing to the influence of forests. This type has got its name from the zigzag ferrous stripes deep in the profile. In these there is no connected "B" horizon in the eluvial layer but parallel compact acidic, colloidal layers at 10—25 cm from each other.

The iron incrustation brown forest soils are, owing to their better water economy, generally more fertile than the sandy soils. As a result of their light mechanical structure, deflation is frequent on them, especially in spring when the plowlands, are mostly barren of vegetation and the green crops do not contribute to protection.

In the case of these soils it is of prime importance to make the water economy more favorable and to provide protection against deflation.

The meadow soils have been formed under varied natural conditions and thus there are sometimes very great differences between the different types. They are generally found in the alluvia of rivers, first of all of the rivers of the lowlands (the Tisza, the Kőrös rivers, the Maros), and to a smaller extent of the Danube and other rivers, in depressions between sand dunes as well as in the valleys of the hilly and mountainous regions. They are soils formed owing to the influence of the nearness of the ground water table and they are either $CaCO_3$-containing or $CaCO_3$-free. The chemical properties of the profiles are very varied according to the soil-forming rock. There are profiles that are limy already from their upper layer on, but more often the "A" horizon, occasionally part of the "B" horizon, is non-calcic. In such cases the chemical reaction of the upper layers is slightly acidic, which does not exclude the possibility that in the case of heavy clay adhesiveness the hydrolitic acidity may be greater than lo. From the point of view of pedological conditions or soil amelioration, alluvial soils are judged similarly. Their amelioration consists in structure development by artificial materials.

From the point of view of amelioration *bog soils* under plowland cultivation fall in the same category. They are formed in the presece of an abundance of humidity. The chemical reaction of moss moor soils (moss peat saturated with water is highly acidic, around pH 4,0). The *low moor soils* (depressions filled up organic matter) are less acidic, their pH value is rarely below 5,5—6,0. In the case of bog soils hydrolytic acidity may be very great (around 100) owing to the great degree of cation replaceability of humic matter.

2. Alkali soils

About 1/2 million hectares of the arable land of the country can be qualified as alkali soil. (Of this about 1/2 million acres are non-calcic, acid, and nearly neutral alkali soil.)

By alkali soils generally soils are understood in the formation and characte of which water-soluble salts, namely sodium salts, play a decisive rola.

Alkali soils are of several types and subtypes with very many varieties. The degree of alkalization, the accumulation of salts, the thickness of the "A" horizon, the position of the "B" horizon, etc., all play a decive role from the point of view of alkalinity and agricultural utilization. They agree mora or less in that they are hard to till, they are compact; if they contain many clay particles they become crevassed when dry and dissolve and disperse when wet. Their water economy is very unfavourable stagnant water pools are common on them.

Their amelioration — depending on their character — can be effected in several ways:

a) Non — calcic, acid, and near — neutral alkali soils: A common feature of the soils belonging in this category is that to a smaller or greater depth they do not contain $CaCO_3$. Their pH value is below 7,5. From the acid alkali soils with less unfavorable properties both the salts and the Na of the absorbing complex have begun to be eluted, thus the upper layer has become acid, i.e. unsaturated. In the adsorption complex of the *near-neutral alkali soils* the accumulated Na ions play an important part.

b) Non-calcic, alkalescent (temporary) alkali soils: Here belong the non-calcic alkali soils whose Na-saturation is so great that their pH is above 7,5. The salinity of the soil profile in the plowed layer varies between 0,1—0,2% and increases toward the subsoil. On such alkali soils it is necessary to add also acid ameliorators to facilitate the solubilization of lime.

c) Basic and/or limy sodic alkali soils: Limy alkali soils are highly alkaline, their pH being higher than 8,2—8,3, often reaching or exceeding 9,0. In these soils Na is clearly predominant in the soil solution.

Applying the above — mentioned facts to *genetic soil types:* liming and limy subsoil manuring can be used for the amelioration of solonetz — like meadow soils, steppifying medium and deep solonetz meadow soils.

Loessial subsoil+acid upper layer and lime+gypsum spreading can be used for the amelioration of columnar, shallow, medium meadow solonetz soils. The columnar, shallow solonchak — solonetz soils can be ameliorated only in patches with acid substances.

3. Sand soils

Of the three extensive sandy areas of our country the land strip between the Danube and the Tisza, Somogy, and Nyírség, approximitely 1,5 million hectares need amelioration.

The elevated sandy plain between the Danube and the Tisza is generally limy, the lime content decreasing from the Danube toward the Tisza, while the sandy areas in Somogy and Nyírség are acid.

Liming of these soils is always of doubtful value and other methods of amelioration should be considered.

It is well known that the water and nutrient economy of the sandy soils is bad, and their amelioration is a primary task because it is in this way that the conditions of successful agricultural production on them can be ensured.

Now known means are:

a) Dung (medium ripe)

b) Bentonite, fen clay, peat

c) Clay minerals, special ameliorating substances

d) Various composts

e) Deepmanuring, green manure

4. **Bog soils**

About 100,000 hectares of bog soil of this country need amelioration. Amelioration of the bog soils is a very hard task and work on this project is constantly going on.

In the case of these soils first of all problems of water economy have to be solved. Besides this the anaerobic processes in the soil must be altered favorably and the decomposition of a large amount of organic matter must be controlled and utilized. (Bog soil exploitation.)

After describing the soil types (21, 22) we come to the discussion of their amelioration with artificial materials as well as traditional methods.

Amelioration of Acid Soils

In this part we deal chiefly with the amelioration of acid brown forest and acid meadow and alluvial soils.

To the first belong the nearly exclusively forested, strongly acid *non-podzolic* and *podzolic* brown forest soils. On replanting, the soil of the tree sockets dug up must be mixed to 10—15 volume per cent with open-pore (CF-piatherm foam) foams. These foams are suitable for binding water and nutrients which the plants can take up easily from them.

We have in mind forested areas on steep slopes where the transportation of ameliorating substances and fertilizers is very expensive and difficult. Therefore it is advantageous to use foam that can be made on the site and transported artificial fertilizer concentrate.

From the point of view of agricultural use, *clayey brown forest soils* are far more important. On these soils the most important thing to do is netralization of the acidity, increasing of the water absorption capacity, and protection against erosion.

Neutralization of the acidity of the soil can be effected by using the traditional liming method. The last two tasks can be achieved by more modern means and more durably.

Polyelectrolites can be used to stabilize the soil structure; open-pore CF foams to increase the water absorption capacity and to reinforce protection against erosion or to ensure a morelasting effect than with the traditional methods.

If the "A" levels decay, the modern methods of amelioration agree practical with those mentioned above.

In *pseudogleyey brown forest soils*, which are chiefly found in Őrség, the elimination of similarly harmful properties is necessary, as in the clayey brown forest soils. In these, increasing of the water absorption capacity, decreasing of the acidit, and protection against erosion are necessary. There is no essential difference in the achievement of the last two things, but there is an essential difference in the balancing, of the water economy, depending on the properties of the soil type in question.

Between the "A" and "B" levels there is, in this case, a gleyey layer which is impervious to water. Thus the top soil fills very quickly with water — stagnant water — and slides down the slope, this is known as solifluxion. For leading off the excess water and stopping the sliding of the soil we suggest the application of drainage with artificial materials between the two above-mentioned levels. KNOBLOCH's method (23) is perfectly suitable for this purpose. The reduction processes (gleying) here are already partially stopped by drainage, but deep loosening can improve the effect.

For *the rusty brown subtype of Ramann's forest soils* which forms on sand we suggest the following: amelioration is generally possible as described in datail in connection with sand by laying down polyelectrolites, open-pore foams, and emulsions on the surface and deeper, for instance in the form of films and "asphalt banks." Applied on the surface also against deflation.

We recommend the methods described in connection with sand chiefly for *sand with iron incrustation* which occurs in Nyírség and Somogy.

a) Meadow soils. Their characteristic in the presence of clay and heavy clay is compactness. Such soils are airless and their water: air ratio is unfavourable to microorganisms and plants. In this case the microorganisms take even the little air away from the plants.

In the interests of successful farming these soils must be made looser and richer in air. This can be achieved in a modern way by using, in addition to liming, closed-pore artificial material foams (PS foam) containing 98% of air. These foams are quite neutral materials, not binding any water or nutrients. As they decompose very slowly, they retain their effectiveness for years. They decay in time but cavities remain in their place.

A great part of the meadow soils have a buried solonetz layer near the surface. This is an extremely compact layer which is impermeable to water, and thus stagnant water gathers in the layer over it. The stagnant waters that appear then are a hindrance to agricultural cultivation. In this case the compact layer can be eliminated by loosening of the subsoil and the introduction of closed-pore artificial material foam; thus the soil becomes permeable to water and can be used again.

Following this, the favorable soil structure formed in the plowed layer must be stabilized with the help of polyelectrolites.

b) Our *alluvial soils* need structure amelioration chiefly if they were formed on carbonateless clay a very long time ago. One of our large rivers, the Tisza, of a middle course type, its deposited alluvium is not clay but rather silt. Its adhesiveness is not great, therefore its structure can be stabilized also by liming and using polyelectrolites.

If these acid, humic alluvial soils are compact, clays, they must be limed and their aeration and water permeability must be secured with closed-pore artificial material foams, and the structure so formed must be preserved.

The same methods of amelioration must be employed on *alluvial meadow soils* if they were formed on $CaCO_3$-free material.

c) In the amelioration of the *alluvial soils of slopes* by means of artificial materials the decisive thing is their origin: chernozem or forest soil, acid or compact layers. It is these properties that determine the necessity of liming or the manner and place of the use of the polyelectrolites. In this case, too, these last serve for preserving the structure, and the foams serve for increasing the water permeability. It can happen in such caser that the water conservation of loose alluvia of light mechanical composition derived from the A_2 level of forest soils must be ensured by the sprinkling of true solutions and the development of film or hydrophobic properties.

2. Amelioration of Alkali Soils

We can deal with the amelioration of these soils most suitably according to Prettenhoffer's classification (20).

a) *Non-calcic acid and near-neutral alkali soils* are found chiefly east of the river Tisza. Their classical method of amelioration is liming that modern amelioration should use the afore-mentioned methods, and that after the development of a suitable structure, polyelectrolites must also be used in order to stabilize the artificially formed soil crumbs.

The effect of the polyelectrolites can manifest itself, besides stabilization of the structure, in the fact that on decomposition of their nitrogen content-polyacrylamide, polynitrile-, they supply N to the plants.

In the Soviet Union crude oil purified from aromatic compounds is also used experimentally and with good results for the amelioration of alkali soils.

b) *Non-calcic, slyghtly alkaline (transitional) alkali soils.* These, too, are chiefly found east of the Tisza. They are traditionally ameliorated with limet gypsum, black earth — acid — deep layer spreading or with gypsum — containing yellow earth. Here, too, we want to use the above-mentioned materials for amelioration but with the addition that we stabilize the good soil structure that has been developed. Thus we hope to remove from these alkali soils the soluble salts and the Na ions exchanged in the course of amelioration with the help of the loosening and water permeability-enhancing effect or closed-pore foam materials.

In the case of these alkali soils we must reckon also with the colloid-precipitating effect of the considerable amount of soluble salts. The effect of the alkaline pH on the hydrolizing polyelectrolites must also be taken into consideration.

c) *Alkaline and calcareous sodic soils.* They are found mainly in the land between the Danube and the Tisza ans in smaller areas east of the Tisza. The classical method of their amelioration is the use of acid materials. In this case first of all gypsum powder and gypsum by-products of factories may come into consideration. We want to achieve the amelioration of these soils, too, by the use of the aforementioned materials with the addition that they would be applied in combination with artificial materials — polyelectrolites, foams, etc. — in different physical states.

On the land between the Danube and the Tisza, if the *subsoil water* has been controlled these sodic soils, having generally a light mechanical composition, can be ameliorated quite deeply in a matter of a few years by gypsum treatment and the use of closed-pore artificial foams combined with irrigation.

East of the Tisza the amelioration of this type of soil is much more difficult. The amelioration of larger connected areas — with the exception of the patches in the plowlands — requires much material and is still very expensive. Amelioration can therefore be carried out only in small areas at present and can be used to search for cheaper methods.

The amelioration of these areas is nearly the same as the amelioration of the sodic patches found in plowland areas, yet with this difference that in this case gypsum powder must be used as ameliorating material. Thus the good structure formed by cultivation must be preserved with the help of suitable polyelectrolites.

In connection with the amelioration of alkali soils it must be mentioned that the soil amelioration can also be carried out using a well-known agrotechnical method. This can be applied chiefly to soils with a "B" horizon containing but little Na; in the case of a larger Na content amelioration will be effective if simultaneously with the subsoil amelioration chemical ameliorators are introduced into the soil.

The washing out of Na can be facilitated by filling the interstices with artificial material foams thus hindering their closing. The closed-pore Ps foam makes the penetration of precipitation possible thus directly promoting better leaching. On patches of alkali soil amelioration can be carried out, as explained above, according to their alkaline nature. On these patches the ameliorating materials must be spread by abundant manuring. Occasionally black earth underspreading as wellas loosening combined with the introduction of ameliorators can be used. In order to achieve perfect amelioration it may be necessary to repeat the procedure several times. It must be noted, however, that the use of polyelectrolites on alkali soils does not always have the same effect; in case of wrong application it may be ineffective. *The effect of the polyelectrolites depends on their composition, dosage, the manner of their application, the mechanical structure and porosity of the soil, the quality of their active functional groups, the alkalinity caused by Na, the water control, etc.*

3. Amelioration of Sand Soils

In the foregoing we have already mentioned that a large part of the sandy areas of this country, about 1,5 million ha, need amelioration (22). On these soils, as is known, the unfavourable properties must first be eliminated; they are:

(1) excessive water permeability, that is poor water holding capacity,

(2) scarcity of nutrients,

(3) tendency to deflation.

Besides the now traditional means of amelioration such as stable dung, bentonite, bog soil, peat, clay minerals, composts, green manure, layer amelioration, etc., or in combination with these, we recommend the use of artificial materials, polyelectrolites, open-pore artificial resins and emulsions of the hygromull type.

The polyelectrolites hinder the breakdown of organic substances in sand, and their ion exchanging atom groups convey the nutrients to the plants, and by their slow decomposition they may also provide nitrogen. To balance the nutrient economy of sands we use first of all artificial material foams and their combinations with mineral fertilizers. The CF and piatherm foams mixed with peat and artificial fertilizers are introduced into the soil by traditional means. Then they bind the water that gets into the sand and they transmit it together with the nutrients to the plants. By their slow decomposition they themselves constitute nitrogen sources (15). CF foam is used for binding and grassing sandy surfaces and sand dunes. Thus, for instance, the foamy artificial material is mixed into a kind of mush with the addition of grass seeds, mineral fertilizers, and water, and the liquid mass is then sprinkled over the area with the help of pumps. Thus the material, adhering to the soil, stores the water like a sponge later on too, hinders deflation of the sand and provides a good bed for the germinating grass seeds (15).

All three methods are first of all aimed at *changing the unfavorable properties of the sand;* at the same time emulsions and solutions of the different materials are also used for this purpose.

a) Surface treatment

The emulsions of the different kinds of asphalt or petroleum resins and crude oil products as well as the CF foam material must be brought on to the surface of the sand with an equipment suitable for the spraying of plantprotecting materials. However, the film that forms is pervious to water to such a degree that the soil under it can be saturated with water. The thin connected film reduces evaporation and absorbs the light rays. Owing to this, the temperature of the sand under the covered parts is higher. The film protects the seeds sown from erosion by rain and wind, but the plants coming up can break through it easily and develop undisturbed. In general these films do not contain any nutrients for plants and so the sand soils treated in this manner must be enriched with nutrients and artificial fertilizers.

b) Deep treatment

In this case the large pore space of sands is used for storing precipitation or irrigation water. In such a case the water-imprevious layer forms under the root zone. With the help of a suitable equipment — the winged hoe — asphalt emulsion must be introduced 40 cm deep into the sand. The American machine generally lifts the soil 25 cm deep and from 26 nozzles it squirts an 85 cm wide, instantly solidifying asphalt layer. The artificial asphalt bed in the sand doubles the amount of residual water. Besides this, the increase in organic substances in this layer over the years is also significant.

4. **Amelioration of Bog Soils**

Besides the classical methods — draining, liming, addition of nutrients, sand treatment, burning, etc. — we do not recommend amelioration of these soils with other methods or artificial materials because of the large organic matter content and the good structure. The most radical interference in the dynamics of these soils without drying them out to much is draining of the excess water. Plowing of the topsoil, loosening, occasionally liming, manuring, and artificial breeding of the bacteria add to the effect. All these measures serve to break the predominance of reductive conditions.

For the amelioration of meadow marshes the classical methods are satisfactory with the exception of the following cases:

(1) if the profile is incomplete, the "A" and "B" horizons are missing, only the gleyey mother rock, the "C" horizon has remained; if this latter is $CaCO_3$-free and it is clay, then addition of closed-pore artificial material foams is necessary. In this way the aeration of overly wet soils will be ensured. At the same time the favorable structure developed by cultivation must be preserved with the help of polyelectrolites.

(2) If the meadow marsh is highly acid at pH 4,5, liming adjusted on the basis of experiments is necessary.

(3) If the soil of the meadow marsh is mixed with solonchak, continuous draining combined with washing through must be employed. If a disturbing circumstance, e.g. an intervening clay layer, hinders this, closed-pore artificial material foams must be introduced into the compact layer in order to ensure free percolation of water.

(4) If the soil of the meadow marsh is mixed with solonetz, amelioration must be carried out as in the case of the alkali soils.

(5) If at the surface of the soil or near to it there is a compact layer, such as a limestone bank, a cemented pebble layer, ironstone, a gleyey layer, etc. which is impervious to water, the soil becomes unsuitable for cultivation. This can be repaired by opening the way to percolating water through the introduction of chiefly closed-pore artificial material foams into this layer, if it is feasable at all.

The above-described method must be used also in analogous cases of drained and tilled meadow marsh soils.

In the literature mechanical, chemical, and biological methods are recommended for the amelioration of the oxygen economy of bog soils. Surveying the different methods we see that we can deal only with the amelioration of such soils as constitute about 40% of our agriculturally productive areas. We have not dealt with the preservation of the structure of our best soils, the chernozems and the barren stony, rocky, mining waste tip areas.

We think that the use of artificial materials in the afore-mentioned areas will be of great importance in the near future. It is not meant that only the methods of amelioration described here can be used for the different types of soils, but that the methods indicated should be considered in preference to other methods.

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