SOIL AMELIORATION AND THE MAIN CLIMATIC FACTORS

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Soil amelioration is more than the usual agrotechnical procedures; it is a complex of operations by the effect of which the fertility of soils with unfavorable properties increases lastingly (Fekete et al, 1967). Such operations are for instance reduction of the strong acidity of forest soils by liming, loosening of the compactness of meadow clays with subsoil loosener, and the green manuring of sands.

We can distinguish — in the order of the above-mentioned examples — chemical, physical and biological soil amelioration.

We can think of amelioration also as an artificial interference with the process of soil formation, that is as of another soil-forming factor of human activity.

It is known that there are six main groups of soil-forming factors: geological, relief, vegetation and animal, climate, and human activity.

Here we deal only with the correlation of the last two factors, i. e. some of the more important relations between human activity — chemical and physical soil amelioration — and the climate.

The above-mentioned factors are not always and not is equal measure important in the forming of the different types of soil.

There are cases when a factor belonging to one of these groups becomes predominant and then it rules alone. In other cases a group of several soil-forming factors determines the true character of the soil.

The climate, as one of the soil-forming factors, may facilitate the division of larger areas into smaller parts by various methods. Then we can deal complexly and separately with the different soil-forming factors according to the landscape units determined in this way.

The basic landscape units are characterized by the same lithogenic composition, humidity conditions, microclimate, soil types, and a definite biocenosis. The vegetation, climatic factors, and differences of the soil may serve as criteria for their further division.

The division into landscapes cannot be substituted by climatic, soil geographical, or geobotanical division into districts because it is based on an all-round investigation of the common processes of physical geography.

Berg establishes various fundamental principles and methods for the differentiation of basic landscape units, landscape mosaics, and small landscapes (Juhász, 1968).

According to modern complex investigations — with special regard to soil amelioration — the conditions are more favorable when our rules refer to larger areas and our results are valid for those too.

The effect of the climate on the formation of the soil and on the soil itself is double; direct and indirect.

Direct effects are, for instance, the weathering, eroding, evaporating influences of atmospheric factors. An indirect effect is, for instance, the influence of the atmosphere exerted through the biosphere because directly or indirectly the whole living word takes part in it. Therefore it is important to know to what extent the climate is suitable for the life of plants, animals, microorganisms and humans.

On the inhabited lands we must consider the role of civilized man, the most important factor in soil formation because he is able to exchange the original vegetation and fauna and to change the properties of the soil radically by tilling and amelioration.

The ecological factors of the environment must be examined, in general, in each area on the basis of the same principles because the factors are connected in such a way that changing of any one of them results in changing of the others. The changes in light (weakening or intensification), the air and soil temperature, the soil and air humidity, result in changes in the microbiological processes in the soil.

Among the ecological factors such as the climatic, soil climatological, topographical, botanical and antropogenic factors, the climatic factors must be mentioned particularly.

It is an established fact that the soil conditions are determined by the climate to a considerable extent. The atmospheric factors penetrate into the soil and determine the development of the soil climate. This penetration is mutual because part of the light is reflected, heat is produced and evaporation takes place.

Chemical amelioration is the artifical interference in the life of the soil when the balance of the exchangeable (adsorbed) cations of the soil is shifted with the help of hydrolyzing substances in a direction favorable for cultivation.

This may happen in order to develop a better structure, to change the chemical effect (pH), to ensure the supply of nutrients, or for other purposes. In this case for instance we replace the property-determining H or Na ions with Ca ions in the adsorption complex of the soil.

The adsorption complex consists of clayey mineral and organic humus part. The former may be thought of as a giant molecule with amphoteric character which is a grating layer formed from a polyaluminium hydroxide plane network connected with a polysilicic acid plane network by separation of water. At the edges of the grating layer — owing to the discontinuty — negative SiO and positive Al ions or SiOH and AlOH electrically active radicals appear.

Again, the humus particles may also be thought of as amphoteric giant molecules containing hydroxil, on their surface, carboxil, amide and amino radicals or negatively or positively charged ions.

On the surface of the two constituents (clay mineral) and humus or soil particles the negatively charged are capable of cation adsorption or uptake of protons, the positively charged ions are capable of adsorption of anions or binding the hydroxil ions.

The number of the places suitable for the occurrence of the above-mentioned chemical reactions on the soil particle depends on the composition of the solvate layer which covers it and belongs to it. The quality of the solvate layer is a function of the composition of the soil solution.

On the basis of the above the cation adsorption or cation exchange occurs in the following way: the cation predominating in the system (solvate layer and soil solution), for instance Ca^{++}, which is in the soil solution, changes place with the other cation adsorbed in the solvate layer (for instance with Na^{+} or H^{+}). The reaction is reversible in consequence of which a state of dynamic equilibrium (between the solvate layer and the soil solution) sets in where the number of exchange cations entering the solvate layer from the soil solution or leaving the solvate layer for the soil solution per second is the same (Di Gleria et al., 1957).

This process, i. e. soil amelioration, like chemical reaction in general takes place only in certain media. Since here we are dealing with hydrolyzing substances, the medium is precipitation, rain water, molten snow and subsoil water. The amount of the latter in the soil depends to a great extent in the first on the climate, the macroclimate. In the second place it depends on the microclimate, the quality of the soil its covering, evaporation, etc.

The macroclimate is given; it can be influenced only to a small extent. Therefore we deal with it only little.

The more important climatic factors that influence soil formation and the development of different types of climate are the following: (a) precipitation and the vapor content of the air, (b) winds and air pressure, (c) radiation and heat (Sigmond, 1934).

(a) The amount of precipitation and the vapor content of the air are factors that not only determine the decisive character of the climate but have also the greatest influence on soil formation.

Owing to the capriciousness and the varied territorial and temporal distribution of precipitation in the different small landscapes, landscape mosaics and basic landscape units, a picture of the precipitation conditions, even on a national scale, can only be formed on the basis of observations made by station networks.

Depending on the situation of the areas and the closeness of the plant associations the vapor content of the local air layers near soil is liable to variations. The spaces near the soil often warm up and cool off intensely. Thus a certain amount of proportional correlation between the saturation values can be observed. With combined examination of the air temperature, saturation value and relative humidity the absolute vapor content and the saturation deficiency have been demonstrated in the different basic landscape units (Juhász, 1969).

As we have seen precipitation is the most important factor from the point of view of soil amelioration and realization of the chemical reaction. In this case, too, it is essential in what portions the rain falls on the ground, for it is known that lasting slow rain is the best at the time of growing humidity. Stormy rain usually wets the soil only cursorily and superficially, but a downpour mostly flows away on the surface and causes more damage than advantage. On the other hand, foggy rain may be very substantial from the point of view of wetting.

Another influencing factor as regards the chemical reactions is that the rain (or precipitation) falls in winter or in summer.

Precipitation water is therefore a first-class factor from the point of view of chemical soil amelioration.

In the case of physical amelioration, the situation is different as we shall see, because then the climate or precipitation plays only a secondary indirect role. It promotes chiefly the trans-formation of structure. On the other hand, in the physically ameliorated soil with a lasting structure the climatic factor receives a very important role because it provides the well-ordered water, heat, air balance with an adequate quantity of water, air, and heat.

(b) We are concerned with the air pressure and winds only in as the former is one of the chief causes of the winds and air currents. The winds have a great influence on the humidity conditions of the soil and especially on evaporation and capillary water movement. These again may come into consideration from the point of view of rapid or slow soil amelioration.

(c) Radiation and heat. A large portion of the solar radiation is lost but a small part of it serves as heat energy for warming the lithosphere and the atmosphere, that is for increasing their energy supply.

The radiating energy reaching the surface of the earth warms up the upper soil layers and these transmit the energy partly by conduction to the lower soil layers and the adjacent air layers, partly by eradiation to the upper air layers.

In our country the heat loss of the soil in the afternoon is greater than the heat gain. Thus it is easy to understand that the air is usually hottest not at noon about 2 o' clock in the afternoon. Since the solar radiation decreases more and more in the afternoon and the et from the soil grows at the same time, the soil and the adjacent air gradually cool off till sunrise. After this, irradiation increases till noon. In our country in spring it is the diurnal incoming, in fall the outgoing nocturnal radiation that preponderates. These phenomena influence the chemical, biological and physical processes in the soil both directly and indirectly.

The air of physical soil amelioration is first of all to restore and maintain a good, lasting, crumbly state and ripeness for a long time, in a soil with unfavorable structure the endeavor is, to change favorably the physical properties (such as the water-holding capacity and permeability, aeration, crust formation, and heat balance) of the soil. To achieve this, so far stable manure, green manure, peat, compost, and animal wastes besides chemicals ($CaCO_3$, $CaSO_4$, artificial fertilizers) have been introduced into the soil.

The shortcoming of the methods and materials was that if there is little humus and mineral colloid in the soil, the crumbly structure, which is strongly resistent to irrigation by water and rain, forms with difficulty. (Dzubay, 1967).

Structure formation with the help of perennial grass is also unsuitable because it takes a long time, about the years, and its effect ceases again in 5 or 6 years (Kaufmann et al., 1967).

The above-mentioned classical methods and materials have already solved the problem of amelioration for the most part both theoretically and practically. We feel that in this field only very little progress is possible while for want of knowledge the physical and chemical border surface phenomena cannot, be extended to the polydisperse soil-water-air system of largely heterogeneous composition.

A great practical progress could be made only by having recourse to artifical materials, artifical soil structure stabilizers or soil-conditioning materials. The advantage of these materials over the traditional ones is partly that they do not decompose so rapidly, partly that they can be used in greater concentration. According to Kaufmann and Vogel (1968) they can be divided into (a) polyelectrolytes, (b) artifical material foams and (c) emulsions, and true solutions.

(a) The polyectrolytes are reactive polymers containing active groups (OH^-, $COOH^+$, etc.) and possessing an electric charge. Their effect is that they stick the soil particles together into crumbs with artifical material bridges and the cover them with a filamentary colloid network. The latter protects the crumbs from falling apart and from the silt-forming effect of water. The lasting structure formed in this way ensures a favorable change in the water, heat, and nutrient balance in the soil.

(b) The artificial material foams may be looseners of cellular structure with open (hydrophilic) or closed (hydrophobic) pores. Their primary property is that they exert a chiefly physical influence on the soil. They improve its water, heat, and air balance properties. They bring about a lasting loosening and improvement of the structure and prevent the favorable properties from deteriorating rapidly. The environment so changed, the larger amount of oxygen and the higher temperature, activate the life of the soil and mobilize the nutrients.

(c) The emulsions, true solutions and other materials are materials forming a chemical soil cover or some other shading or a water-impermeable layer under the root zone whose effect chiefly depends on their places of application. On the surface of the soil they mainly reduce evaporation and weediness, while applied at a certain depth they retain the water that has got into the root zone.

The above-mentioned materials are used mainly on sand. Sprayed on the soil surface they form here a film underwhich the temperature is 5—10 °C higher than that of the environment. Thus more favorable life conditions are created for the plants already at the beginning of the vegetation period and if emulsion is introduced into the subsoil, a so called bench is formed which makes retention of the nutrients and the water supply in the root zone as well as their by the plants possible.

It follows from the above that the artificial materials serve above all for physical soil amelioration, for lasting improvement of structure.

In the following we deal with a few procedures that greatly affect the microclimate and thereby soil amelioration and fertility.

These procedures are soil covering with various materials and soil shading with living vegetation. Their practical aim is to turn the radiation, heat, water, and air balance in a favorable direction. For instance extreme warming and cooling of the soil can thus be prevented. These phenomena appear and exert their influence not separately but always in close connection with each other. Change in one factor causes change in the others as well.

One way of changing the heat balance of the soil is influencing the capacity of radiation absorption. This can be achieved by spreading layers of extremely absorptive materials on the surface of the soil. White spreading materials with a high albedo, for instance chalk powder, Buda earth, quartz powder, reduce the capacity of radiation absorption of the soil and consequently its warming. Black materials (soot) have the opposite effect.

According to experiments made with materials of the above-mentioned opposed colors the temperature of the soil in 10 cm depth on a cloudless summer day was 3° warmer with black covering than with white. On the other hand, nocturnal cooling was more intense in the soil with white covering (Di Gleria et al., 1957).

To prove how wrong it is to judge the effect of the artificial alteration of the heat balance properties one-sidedly, we must mention that while black clovering was found to be more favorable for the development of plants with high heat requirement because it increased warming of the soil, flowering took place earlier on the plots with white covering. This phenomenon is due to abundance of radiation artificially produced over the white surface.

According to the experiment the plants with high heat requirement utilized the energy of radiating heat well. We used aluminium sheets painted white which covered 75% of the ground. The white sheets absorbed only half as much of the light and heat energy of the sunshine as the uncovered ground; they reflected and projected the sunshine upon the plants.

Covering changed the warming and the water balance of the soil and air. The covered parts of the ground did not warm up so much as the rest. This effect was measurable to a depth of nearly half a meter.

Owing to less intense warming of the covered surface and reradiation of a large portion of the energy, the temperature over the covered parts in calm was lower use of closeness and less intense warming soil humid under the covered surface remained greater than under the freely evaporating uncovered surface (Bacsó 1966).

The influence of living vegetation on the heat balance of the soil manifests itself not in its capacity of radiation absorption but in its insulating effect which modifies the intensity of incoming radiation. The vegetation equally moderates the intensity of incoming or of outgoing radiation, i. e. it reduces the diurnal and summer warming as well as the nocturnal and winter cooling.

To support this opinion we refer to the paper of Kreybig and Bajai (1952) according to which warming reached 40 °C even in 10 cm depth on a plot with no vegetation, while under carrots the temperature in the same depth was only 30 °C.

A similar insulating effect can be achieved by covering the soil surface with dead organic matter, e. g. straw.

There is an essential difference in the way of the effect of mineral covering material spread in a thin layer and covering with organic matter or living vegetation. While mineral covering changes only the radiation absorption capacity of the soil and has no effect on the intensity of outgoing radiation, the vegetation or organic matter applied in relatively thicker (1—3 cm) layer gives very effective protection against outgoing radiation, i. e. against nocturnal cooling of the soil, too.

Modification of the properties of light by covering influences the heat regime of the soil. This influences also the humidity content of the soil. Any interference that results in reduction of the soil temperature also reduces evaporation, i. e. helps maintain the water supply of the soil (Bacsó, 1966).

On the basis of the above facts we can say that soil covering or shading has an influence on the warming or cooling of the air over the soil surface, i. e. it creates a new microclimate.

Thus soil covering, changing of the albedo, controlling of the sunshine and rational management of controlled heat energy have a definite advantage not only in the cultivation of plants but combined with a favorably modified microclimate also in soil amelioration.

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