Critical and Optimal Groundwater Tables in Peat Soils Determined by Hydrophysical Properties

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The aim of an amelioration system is to establish optimum conditions in the soil for the growth of plants by creating correct air-water relations. In Poland peat soils, the total acreage of which is 1.5 million hectares, are used as grassland. A shallow root system is characteristic of such soils. The main bulk of the grass roots appears in the surface layer up to a depth of 30 cm. The growth and yield of the grass depend on the air-water relations in this layer.

Under the climatic conditions of Poland, which are characterized by a predominance of evapotranspiration over precipitation during the vegetation period, the humidity in the 0-30 cm layer of grasslands is dependent on two basic factors. These are soil retention, i.e. the ability of the soil to retain rain water, and the intensity of capillary rise, by which water lost from this layer by evapotranspiration is replaced. These two factors are closely dependent on the physical properties of the peat which constitutes the parent material.

Taking into consideration the degree of peat decay, the peat soils found in Poland can be divided into three basic types:

a/ weakly decayed - fibric peat soils;

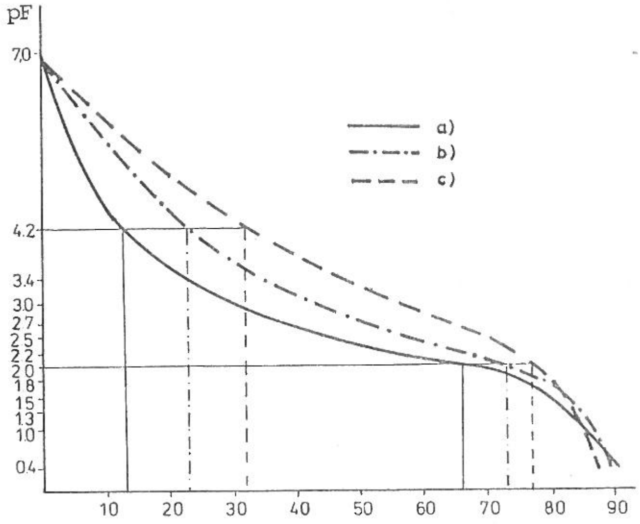
b/ moderately decayed - hemic peat soils, and

c/ strongly decayed - sapric peat soils.

There is a clear dependency between the type of peat and the retention and capillary rise capacities. This is due to differences in the ratio of micro-, meso- and macropores /Fig. 1 and Table 1/.

Soils developing from peat after peat dehydration undergo modifications in relation to the parent material due to soil processes. They retain, however, the differences which arise from the structure of the parent material /Fig. 1/.

These differences show that as the degree of peat decay increases there is a parallel decrease in the number of mesopores, which is connected with the retention of water. On the other hand, the number of macropores increases, leading to a corresponding increase in efflux. This leads to an increase in the air content, as well as to great susceptibility to drying. The optimum air-water conditions for grass in the 0-30 cm layer are obtained when the air content makes up 10% of the volume and the moisture is not less



100 g HOH/100 cm of peat

Fig. 1
Differences in the water volume of peat at different suctions /pF/. a/ Fibric; b/ hemic; c/ sapric peat type

Table 1
Differences in the pore-size distribution of peat soils formed on various parent materials

Soil formed from	Micropores	Mesopores	Macropores
		%	
Fibric peat	21.6	53.2	13.8
Hemic peat	24.1	43.5	19.8
Sapric peat	24.8	30.8	30.6

than that which appears at a suction equal to pF 2.7. A smaller amount of air in the soil /6-8% of the volume/ is also admissible, as well as a differentiation in the suction, depending on the depth from the surface. This value may vary from pF 3.2 /0-10 cm layer/ to pF 2.1 /20-30 cm layer/.

Both the air content and the soil moisture in the surface layer depend on the depth of the groundwater table. The aim of any amelioration system is to maintain the groundwater table at a depth which will be optimum for the air-water relations. To achieve this aim it is necessary to determine which groundwater table levels are optimum for various soil types, and which should be considered as critical for the growth of grass. The specification of these levels provides the guidelines for the planning of an amelioration system and the principles for its use.

Research on this subject has been carried out for several years /OKRUSZKO, 1976; SZUNIEWICZ and SZYMANOWSKI, 1977/. The air-water relations have been investigated in various peat soils both in spring, when the level of the groundwater table is high, and in summer, when the evapotranspiration is intensive and the water level low. Experiments have also been carried out on monoliths and micro-plots, under simulated conditions as regards the groundwater table, the evapotranspiration and the rain supply. The results obtained make it possible to demonstrate basic differences in the optimum and critical groundwater tables in peat soils formed on the three kinds of parent material.

The first critical level of the groundwater table is when the minimum amount of air /in the 0-30 cm layer/ indispensable for the growth of grass appears in spring. It is agreed that this amount should be 6% of the volume for the soils of grassland and 8% in the soils of pastures. The levels of the groundwater table at which this amount of air is found in the root zone are symbolized as h_1 and h_2. A groundwater table providing a 10% air ratio is defined as optimum /h_{opt}/. The results obtained show the correlation between the level of the groundwater table and the amount of air in the root zone of grasslands for three basic peat soils. The results illustrated in Fig. 2 demonstrate considerable differences, which are clear from the run of the curve. Differences in the depths of dehydration are also given in Table 2.

The water reserves in the soil and the level of the groundwater table decrease parallel to the vegetation period and the growth of plants. The lowering in the level of the groundwater table makes the capillary rise less effective. If the rise does not compensate for losses of water during evapotranspiration the soil moisture will decrease. The groundwater level at which the moisture in the root zone /0-30 cm/ reaches a value equal to the water content at a suction of pF 2.7 is considered to be the lowest permissible /h_3/ level. For a given soil this is the critical depth below which the water level should not fall during the vegetation period. The estimated maximum permitted depths of dehydration for three different kinds of peat soils are shown in Fig. 3.

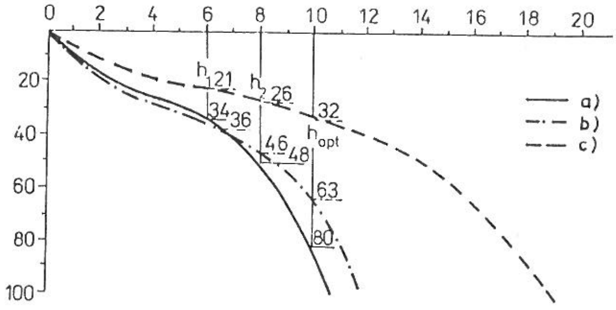


Fig. 2

The interdependency between the groundwater levels in the 0-30 cm layer of peat soil under spring conditions. Horizontal axis: Moisture in vol %. Vertical axis: Depth in soil profile, cm. a/ fibric; b/ hemic; c/ sapric peat

Table 2
Critical and optimum depths of dehydration of peat soils

Peat soil	Depth of dehydration, in cm			
	h_1	h_2	h_{opt}	h_3
Fibric peat	34	48	80	130
Hemic peat	36	46	63	96
Sapric peat	21	26	32	58

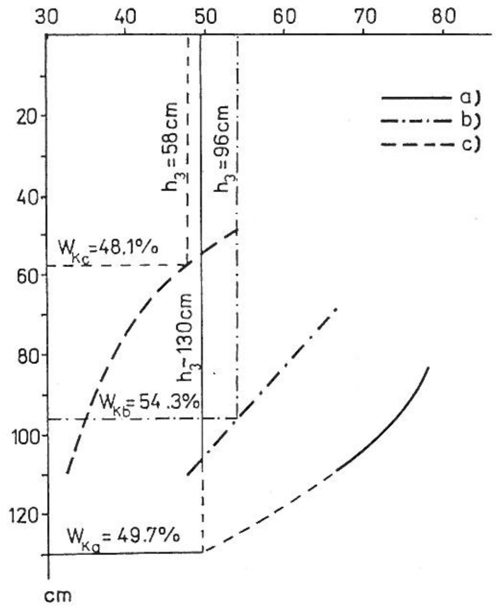


Fig. 3
The relation between the groundwater table and peat soil moisture in the 0-30 cm layer during intensive evapotranspiration. Horizontal axis: Moisture in vol %. Vertical axis: Depth in soil profile, cm. a/ Fibric; b/ hemic; c/ sapric peat soil; W_k = moisture content at pF 2.7; h_3: lowest permissible level of groundwater

These depths were given by the crossing points of two curves: the curve which shows soil moisture at different levels of the groundwater table, and the curve which shows the water capacity in a given soil corresponding to a suction of pF 2.7 /W_k/. The data show sharp differences in h_3 for various types of peat soils: 130 cm for fibric peat, 96 cm for hemic peat and 58 cm for sapric peat /Table 2/.

The values given in Table 2, which characterize the critical and optimum levels of the groundwater table in peat soils, are averaged figures and show the differences occurring between different soil types. In reality, for each soil type both optimum and critical groundwater table levels fall within certain limits marked by the soil differentiation. The state of soil differentiation is the result of soil processes which change the peat in various ways, depending on the degree of decay /OKRUSZKO, 1968, 1974/. As a result, soils arising from peat with a weak extent of decay are resistant to changes and are only slightly differentiated. These soils are designated in Poland as Mt 1 aa /the soil is weakly changed - Mt 1 from fibric peat - a/. Soils with moderate decay are more differentiated and are designated as Mt 1 bb or Mt II bb /weakly - Mt 1 or moderately Mt II changed from hemic peat - b/. Soils arising from strongly decayed peat are susceptible to changes and are designated as Mt II cc or Mt III cc /moderately - Mt II or strongly - Mt III changed from sapric peat - c/. The differentiation within the soil types leads to a situation where the critical levels of the groundwater table on the peat-land originating from fibric peat show only very slight differences /10 cm/. As far as soils arising from sapric peat are concerned, the levels are more differentiated and vary depending on the state of change /Mt II-III/ within the 20-30 cm layer.

Summing up, the characteristics of optimum and critical groundwater tables in peat soils show a clear correlation of this feature with the type of peat constituting the parent material. The peat type is determined by the degree of peat decay from which the peat soil appears after dehydration of the peat-land.

Summary

This paper is aimed at specifying the critical and optimum levels of the groundwater table in peat soils. It was shown that there is a clear dependency of these levels on the type of peat: fibric, hemic or sapric, which constitutes the parent material of the soil. The degree of decay of the organic matter in these soils determines the groundwater table.

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