DRAINAGE OF HISTOSOLS

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Abstract: *Histosols form on parts of landscapes where there is concentration of run-on, retention of precipitation, or discharge of groundwater. Histosols cover approximately 275 million hectares plus 40 million hectares on humid coastal plains. In Romania, peat bogs are included in the class Histisols, with only one genetic type of soil – Histosol, that have in the first 100 cm of soil profile a T – histic horizon with at least 50 cm thick. Distribution of Histosols in Romania is in the high moor and in the low moor. The high moors are situated in 265 bogs, with 1351 hectarea, in the depressions of the mountains, like Sebeş, Semenic, Bucegi, Dorna, Borsec, Tuşnad, Oaş. The low moors are in the bogs from Eriu, Crasna, Livada, Ciuc. The main process is the accumulation of organic materials under anaerobic conditions. Another difference with mineral soils is that peat soils show a certain rate of oxidation after drainage. Utilization of Histosols for cultivation is affected by several of their properties. In such cases the land needs some improvement methods, like a drainage system, liming material, chemical fertilizer. The consequences of an improved drainage are: shrinkage of the top layers; oxidation of organic matter; compression of the layers below the groundwater table; irreversible desiccation of the organic matter. A specific feature of Histosols is their generally low bulk density, which range from 0.19 to 0.22 g/cm*^{3}*. Water content of Histosols are related to degree of decomposition, and ranged from 100% for undecomposed, near-surface sphagnum moss peat to less 80% for deeper, more decomposed peat. Field capacity at Histosols – Ciceu, ranged between 48.6 to 260.0 %. Saturated hydraulic conductivity ranges from 101 to 281 mm·h*$^{-1}$*. As far as the soil desiccates subsidence can be determined using the specific volume. Another approximation of subsidence can be found by applying the following formula:* $S=KDT^{0.707}$*; the subsidence will be 0.383m or 38.3cm. It will be clear that the prediction of subsidence is highly important to the planning of the drainage system. The optimum depth of the groundwater level of grassland in summer is in the temperate zone 50 to 70 cm below land level.*

Key words**:** *histosols, peat, drainage, subsidence, oxidation*

INTRODUCTION

Histosols form on parts of landscapes where there is concentration of run-on, retention of precipitation, or discharge of groundwater. These conditions most often occur in topographic depressions or very flat areas. Accumulation of organic materials is favored by cold and wet climates because they inhibit decomposition of the materials. They are most prevalent in the cool, humid boreal forest areas of northern Asia, Europe and North America. More than 0,5% of the total peat reserves of the world are located in the temperate zone of the northern hemisphere. Nearly all Histosols in the Netherlands, Germany and Switzerland have been lost. About 75% of Europe's remaining peat soils are located in Finland, Norway and Sweden. At lower latitudes Histosols occur locally on humid coastal plains for example, South-East Asia, Indonesia and North America. These coastal areas are inundated by tidal waters. [1]

Histosols cover approximately 275 million hectares, plus 40 million hectares on humid coastal plains.

Histosols, in accordance with W.R.B. [4] are a reference soil group including soils that have a histic or a folic horizon. This horizon must be either ≥ 10 cmthick from the soil surface down to a lithic or a paralithic contact, or ≥ 40 cm thick with the uppers boundary within 30 cm from the soil surface. Histic horizon is saturated with water at least one month in most years, unless artificially drained, and has an organic C content of: (a_1) ≥ 18% if the mineral fraction contains ≥ 60 % clay; or (a_2) ≥ 12% if the mineral fraction has no clay; or (a_3) ≥ (12% plus clay percentage divided by 10) if the mineral fraction contains < 60% clay. [9]

In Romania, peat bogs are included in the class Histisols, with only one genetic type of soil – Histosol, that have in the first 100 cm of soil profile a T – histic horizon with at least 50 cm thick. [5]

There is a good correlation between SRTS – 2012 and WRB – SR – 1998, for Histosols – subtypes.

Table 1

SRTS - 2012	WRB – SR - 1998
Distric (TB di)	Dystric Histosols (HS dy)
Eutric (TB eu)	Eutric Histosols (HS eu)
Teric (TB te)	Haplic Histosols (HS ha)
Salinic (TB sc)	Salic Histosols (HS sz)
Tionic (TB to)	Thionic Histosols (HS ti)

Distribution of Histosols in Romania is in the high moor and in the low moor. The high moors are situated in 265 bogs, with 1351 hectarea, in the depressions of the mountains, like Sebeş, Semenic, Bucegi, Dorna, Borsec, Tuşnad, Oaş [7, 8].

The low moors are in the bogs from Eriu, Crasna, Livada, Ciuc, Gheorgheni, Timiş-Bega, Mândra-Făgăraş. Less acid organic soils are called fens if they lack trees and are dominated by grasses and/or sedges, or swamps if they are at least partially forested.

The dominant pedogenic process is the alteration of recognizable organic forms of leaves, stems and roots, to unrecognizable organic materials. The main process is the accumulation of organic materials under anaerobic conditions where preservation allowed a net gain through time. The processes are physical, chemical and biological ripening. Physical ripening involves a decrease in volume, chemical ripening is the decomposition of organic materials and biological ripening involves the reduction in particle size.

Peat is formed in and under water. As the specific weight organic material is only slightly above 1, the weight of it under water is very low. Therefore, the pressure of overlying layers on the underlying ones is also small. This is the cause that peat has a spongy structure with a high pore volume, very high water content and a low consolidation constant. As lowering of the water level gives the same increase of the grain pressure as for mineral soils, this increase is more important, because of the low initial pressure and the low consolidation constant. Another difference with mineral soils is that peat soils show a certain rate of oxidation after drainage. [12]

Most Histosols provide wetland functions of protecting surface and ground water quality, preserving biological diversity reducing surface water runoff. Peat is still used for fuel and for generation of electricity in some areas.

Utilization of Histosols for cultivation is affected by several of their properties: soil reaction, cation exchange capacity, bulk density, water retention, hydraulic conductivity, shear strength and shrinkage. In such cases the land needs some improvement methods, like a drainage system, liming material, chemical fertilizer.

MATERIAL AND METHODS

The study represents a continuation of our preoccupations for Histosols [7] and soil improvement [10]. The subsidence problem which appears in the case of soil drainage was presented, also, in a number of papers, as a result of some previous researches in connection with Histosols, in Semenic. The paper relied also, on the soil survey effectuated during the last decade. The subsidence may be calculated using the formula taken from soil mechanics. One of the early more intensive uses of Histosols was grazing, especially during the summer when water tables were naturally lower. For low peat, situated in the Ciuc depression and Berveni – Carei, with drainage system, these lands were cultivated with potatoes, sunflower and cabbage. Because drainage and reclamation of peat mean a disturbance of the natural conditions and of their consequences – subsidence, this effect must be calculated.

RESULTS AND DISCUSSIONS

The consequences of an improved drainage are:

- shrinkage of the top layers by desiccation. Shrinkage causes crack formation and a considerable increase of permeability;
- oxidation of organic matter;
- compression of the layers below the groundwater table;
- irreversible desiccation of the organic matter. Fibrous peat desiccates to a dry sponge with a high water retention capacity.

Heavily humificated peat; with 10 to 30% mineral matter (Terric - HS) may desiccate to hard, compact black clods which are difficult to rewet and are very unfavourable for plant growth. The first three items together cause subsidence.

A profile description of cultivated Eutric Histosols from Ciceu – Ciuc is given in table 2.

Table 2

Profile description of a cultivated Histosol [13]

0-22cm	Tp, sapric, black (10YR2/1), rubbed, highly decomposed organic material, friable, frequently roots
22-45cm	T_2, sapric, black – very dark brown (10YR2/1-10YR2/2), highly decomposed organic material, < 1/3 fibers
45-70cm	T_3, hemic, dark brown (10YR3/2), 1/3-2/3 of the volume is intermediate in degree of decomposition
70-135cm	T_4, hemic, 10YR4/4
135-150cm	GT, clay loam with hemic, 10GY5/1
150-170cm	Gr, sandy loam

Selected physical and chemical properties of the same pedon are giving in table 3.

Table 3

Analitical data

Horizon	Tp	T_2	T_3	T_4	GT
Depth, cm	0-22	22-45	45-70	70-135	135-150
Density, g/cm^3	1.89	1.71	1.64	1.73	2.69
Bulk density, g/cm^3	-	0.22	0.19	0.20	1.02
PT, %	-	87	87	88	62
Void volume, %	-	55	66	64	33
K, mm•h^{-1}	-	159	153	281	101
Clay, %	-	-	-	-	33.6
CC, %	-	260.0	257.7	255.2	48.6
C•1,72, %	53.99	80.50	82.78	59.09	5.78
pH	7.28	7.50	5.80	5.20	7.60
T, me/100g	121.4	153.5	118.6	129.8	66.2

The pH of organic deposits is largely a function of the nature of the water and the vegetation.

Eutric Histosols at Ciceu-Ciuc, formed from eutrophic Moos or fen, are low acidic, with pH 5.2-7.6. Acid – loving plants such as sphagnum moss, produce more acidic materials than base-loving plants, and pH is 3.45-3.60 at Dystric Histosols, situated in Caldera Luci-Sâncrăieni, Harghita.

The cation exchange capacity is pH – dependent and ranges from 60 to 153.5 $me \cdot 100g \cdot soil^{-1}$ at pH 7.5. Histosols have high cation exchange capacities compared to mineral soil because of the carboxyl radicals, phenolic, enolic and quinonic hydroxyls and heterocyclic nitrogen structures. A specific feature of Histosols is their generally low bulk density, which range from 0.19 to 0.22 g/cm^3. Bulk density increases with increasing mineral content.

Water content of Histosols are related to degree of decomposition, and ranged from 100% (w/v) for undecomposed, near-surface sphagnum moss peat to less 80% for deeper, more decomposed peat. Field capacity at Histosols – Ciceu, ranged between 48.6 to 260.0 % (weight). Saturated hydraulic conductivity of Histosols – Ciceu ranges from 101 to 281 $mm \cdot h^{-1}$. After drainage, the hydraulic conductivity decreases.

Calculating subsidence. As far as the soil desiccates by climate and plant growth, not deeper than 70-100cm, subsidence can be determined using the specific volume. Specific volume is the volume of 1 gram of dry soil in undisturbed condition. Subsidence may be calculated using formula [10]:

$$T_2 = \frac{sv_2}{sv_1} \times T_1$$

T_1 – original thickness (cm);
T_2 – thickness after subsidence (cm);
sv_1 – original specific volume (cm^3/g);
sv_2 – specific volume after subsidence (cm^3/g);

Volume weight = bulk density = weight of 1 cm^3 of dry soil. So:

$$vw = 1/sv \text{ and } sv = 1/vw$$

The specific volumes of undrained peat layers may be estimated from the water contents, assuming the specific weight of the mineral matter to be 2.65 and of the organic matter 1.0.

Example: an undrained peat soil consists for 80% of organic matter (20% mineral matter) and has a water content of 900.

$$\text{100g dry matter means} \begin{cases} \text{80g organic matter : volume } \frac{80}{1.0} = 80cm^3 \\ \text{20g mineral matter : volume } \frac{20}{2.69} = 7.43cm^3 \end{cases}$$

The pores have a volume of 900: 1.0= 900cm^3

The total volume of 100g dry matter plus pore: 987.43cm^3

Volume of 1g dry matter in natural position: 9.87cm^3, and this is the specific volume.

The specific volume after subsidence have to be found by sampling an area with the same kind of peat and the same land use and drainage and age.

Because peat areas are always very variable, calculations can never be accurate. Another approximation of subsidence can be found by applying the following formula of Segeberg:

$$S = K \cdot D \cdot T^{0.707}$$

in which:

S – subsidence (m);

T – initial thickness of peat (m);

D – final depth of drainage (m);

K – coefficient.

The coefficient depends on the pore volume (P) as follows:

$$K = 0.05 + \frac{1}{100 - P}$$

The formula for S holds for acid peats in the temperate zone. For Histosols – Ciceu, the subsidence will be:

$$K = 0.05 + \frac{1}{100 - 87} = 0.05 + 0.077 = 0.127$$

$$S = (0.127 \cdot 1.5 \cdot 1.35)^{0.707} = 0.383\text{m}$$

It will be clear that the prediction of subsidence is highly important to the planning of the drainage system. As mentioned, desiccation causes crack formation and hence a considerable increase of permeability. Therefore, usually a spacing of tile drains and field ditches of 10 to 20 m is sufficient. The right distance may be found by means of trial fields.

The optimum depth of the groundwater level of grassland in summer is in the temperate zone 50 to 70 cm below land level.

CONCLUSIONS

In Romania, Histosols have a histic horizon in the first 100 cm of soil profile, with at least 50 cm thick. The high moors are situated in 265 bogs, and the low moors are in the bogs of river basin like Eriu, Crasna, Ciuc. Peat is formatted in and under water. The consequences of an improved drainage are shrinkage, oxidation of organic matter, compression of the layers and irreversible desiccation of the organic matter. This together cause subsidence. Subsidence can be determined using the specific volume. For Histosols from Ciceu, the subsidence was calculated, and it will be in the case of drainage 38.3cm. That is highly important to the planning of the depth of the drainage system.

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