Theory of Kulczyński on hydrological classification of peatlands in the light of contemporary investigations

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(Received: March 9, 1990. Accepted: August 20, 1990)

Abstract

Basic assumptions of the peat science theory of Kulczyński presented by him in every detail in his work "Peat bogs of Polesie" at particular consideration of the effect of hydrological phenomena on the development and differentiation of peatlands are discussed. While developing the Kulczyński's theory, own concept of hydrological classification of wetlands is presented, which distinguishes four types of wetlands on the basis of hydrological alimentation of site and nine kinds of wetlands on the basis of hydroecological conditions in the site.

Key words: wetlands, water conditions, hydrological classification, raised bogs, transitional bogs, fens, watershed

INTRODUCTION

In the course of works carried out on the Polesie wetlands under the guidance of Kulczyński the problem of classification of peatlands arose. The state of knowledge of that time concerning this problem in relation to raised bogs and fens was different. As concerned the classification of raised bogs there was a theoretically well conceived trial of their classification undertaken by Oswald, who divided them into Continental, Baltic, Atlantic and upland ones. There was also the raised bog theory developed by Sernander and Post and widened by Oswald and others (Kulczyński 1939-1940, 1949).

Contrary to that the knowledge concerning fens and transitional bogs was much poorer. The problem of biology of fen, mechanism of the growth, transformation and classification remained to be an open question. In the scope of biology of fens there was the Weber's concept known as "terrestrialisation hypothesis", which treated this question only partly.

Kulczyński was not able basing on the Weber's terrestrialisation hypothesis to explain all stratigraphic, floristic and biologic material obtained from investigation of Polesie peatlands. Therefore he worked out and presented his own theory on development of peatlands. This theory was based on hydrological phenomena, while stressing the importance of vertical and horizontal water movement. This allowed him to present in wider range the theory of development of raised bogs in the continental climate, to define the principles of transition of fens into raised bogs, to determine the growth mechanism of fens and to elucidate a number of intricate questions concerning transitional bogs.

BASIC PRINCIPLES OF THE KULCZYŃSKI'S THEORY

The theory of the development of peatlands as conceived by Kulczyński can be presented in short in the several following theses:

1. The hydrological conditions, particularly the water dynamics are responsible for the development of peatlands and for formation of their types. Waters affecting the peat formation can be divided into three basic systems:

I. System of ground and surface waters, stagnant, without any underground inflow and consequently regenerating themselves exclusively by precipitation water. Ground waters of watershed areas, waters of lakes without in- and outflow, waters saturating the copulae of raised bogs in Atlantic climates jointly with waters of small pools occurring on their area belong to this system.

II. System of mobile ground waters continuously exchanging, alimented by waters of easily permeable soils, moving along in permeable layers. Waters filtrating through the peat massif with one-sided dip and disposing of a certain catchment area belong also to this system.

III. System of mobile surface waters forming in rivers, streams, fluvial lakes and river floods (inundation waters).

2. Peatlands developing in stagnant water of the system I assume the character of raised bogs. They are, as a rule, peatlands of watershed areas, without any inflow, alimented directly by precipitation. Water losses occur mainly due to evaporation, that is much higher then a small outflow. The outflow occurs in the periods when peatland is fully saturated with water and at the time of precipitation excess over evaporation. Hence the water balance of the peatland is determined by the precipitation and evaporation values. Since evaporation depends, first of all, on climatic factors (temperature, air humidity, wind), the water balance of raised bogs is formed differently in various climates. In this connection the basic types of raised bogs (continental, Baltic, Atlantic, upland) expressing their water balance prove a remarkable climatic regionalism. The climatic factors regulating precipitation and evaporation are controlling the development of peatlands.

3. Peatlands developing under influence of flowing waters assume always the character of fens.

Differentiation within these peatlands occurs in connection with the water maintenance way in them. There are two main kinds of peatlands: river peatlands with surface water flowing (system III) or periodically stagnant (system III/I) and turf peatlands with flowing ground water, in system III/II or II.

4. The most significant hydrological feature of fens is the flow occurrence. The flow can be continuous or periodical, superficial or deep, while the flow decline is tantamount to the loss by the fen of its eutrophic character. Indispensability of flow is connected with trophicity of sites at an appropriately high level. The flow affects, namely, the vegetation as a repeated multiplication of nutrients. It causes a continuous inflow of nutrients to the peatland, on which the development of eutrophic fen vegetation and deposition of peats of increased ash content depend. Furthermore, the water movement affects strongly the oxygen balance of peatland determining thus the trends of biological and chemical decomposition of peat and is responsible for its acidity. The water movement is a factor more important than the site fertility. In the poorest sites the mobility of peat water in it is sufficient to assume by the mire the features of fen. On the other hand, the flowless peatland developing in the stagnant water, assumes even in fertile sites the features of bog.

The effect of surface waters on the edaphic conditions of the peatland depends on the amount of flowing water as well as on quality and quantity of materials transported by these waters in the form of solved salts and mechanical suspension. The content of nutrients in water depends, first of all, on the fertility of soils in the catchment area of the peatland. Of great importance there is also the morphology of the catchment area, which depending on the arrangement of slopes, enriches waters in eroded material. Thus the development of fens and their types is forming after Kulczyński under the effect of remote pedologic and morphologic factors affecting peatlands by means of flow.

5. The flow is forming the peatland, irrespective of edaphic effects, by its hydrodynamical influence on the peatland vegetation as well as of physical and chemical features of the peat itself. Both flow current and oscillations of the flowing water level and the course of these oscillations in the year's period are acting here. Under the effect of considerable intensification of the current connected with wide oscillations of the peat water level small perennials and mosses become floatable. In consequence the reed swamp vegetation of the pure immersive composition appears, whereas a lack of current and oscillation favours the development of pure emersive sedge-moss (*Parvocaricetum*) communities. Under average hydrological conditions the vegetation composed simultaneously of immersive and emersive species joining into the plant community of disjunctive or crypto-disjunctive structure (sedge-moss communities of the *Magnocaricetum* type). Slow oscillations of the ground water level and

permanent submersion of the peatland favour the deposition of weakly decomposed and light peat bulk. Under conditions of quick oscillations of the water level and periodical depressions of this level more strongly decomposed and heavier peat is forming. The current favours accumulation of heavy allochthonic material in peat, whereas a lack of the current favours the deposition of the peat bulk with low ash content.

6. The hydrodynamical effect of the flow depends on the precipitation, evaporation, outflow and retention. Still the most important factors responsible for hydrodynamical properties of flow are inflow and retention forces of the peatland, i.e. forces checking and accumulating flowing waters.

Retention forces depend on a number of circumstances. The peatland with great area gradient is able to transfer more easily the waters, i.e. develops lower retention forces than the peatland with quite small gradient. Greater retention forces are developing in the closed peatland with well-formed trough and narrow outlet then in the peatland lying in a flat landscape, where any rise of the water level increases the outflow possibility. Weak retention forces show peatlands crossed a stream or small river, while by strong retention forces are characterized peatlands, in which the water infiltrates through the whole massif of the deposit not using any cleared ways of flow.

In peatlands with considerable retention force and with permanent and strong waterlogging weakly decomposed light and low-ash peat bulk is deposited, with the tendency of floating in the periods of high water levels. On peatlands with low retention force a strong hydration and waterlogging occur only in the period of a high inflow. Summer and autumn minima of waters and decrease of the hydration state of the deposit favour an intensive decomposition of plant matter and deposition of stronger decomposed peats of high ash content and heavy bulk, showing the tendency to submersion in water. Waters from the low-ash peatland with low retention force are outflowing superficially and therefore at much lower resistances than from the peatland with high retention force and with swelling and floating upper layers. The surface waters with strong current are bringing into the peatland and depositing there heavy allochthonic material in the form of silt.

The inflow value depending on the catchment area size as well as retention forces of the peatland opposing the flow determine the basic hydrological properties of the flow. They affect its current, the course of water level oscillations in the deposit and decide on whether there it is superficial or deep flow. They control also decomposition and silting of peat bulk. Thus they are responsible for the character of the given site and consequently also of vegetation. Low retention forces in connection with wide amplitudes of water level oscillations in the deposit, connected with large catchment area, are acting towards formation of reed swamp peatlands. On the other hand, high retention forces, with smaller water level oscillations in the deposit favour the development

of turf peatlands of the *Parvocaricetum* type. Consequently the peatland is developing along the lines determined by the retention value.

At lowering water inflows under conditions of small catchment areas the amplitude of vertical oscillation of the ground water levels is narrowing, whereas no changes occur in the slow or quick course of these oscillations, which depend exclusively on the value of retention forces.

Under conditions of high retention forces the peatland is enriching in mosses and *Parvocaricetum* (emersive) perennials, whereas at low oscillations of its water levels immersive perennials are not eliminated off the plant community. The association of floristically rich *Magnocaricetum* type with well-formed moss layer develops on the peatland.

On the other hand, at low retention forces (of intensified flow) development conditions of mosses and small perennials are worsening. At small water level oscillations (a lack of outflow possibility) a full elimination of the plant community does not take place. Under such conditions floristically impoverished *Magnocaricetum* of the *Carex stricta* type develops.

Thus the retention effect on the formation of peatland depends directly on the catchment area size.

If the catchment area size is nearing a certain minimum and the transformation of the peatland of flowing type into ombrophilous type occurs, the retention role as a factor responsible for the peatland development fully vanishes. This role take over the climatic factors controlling precipitation and evaporation.

7. Life and growth of the peatland occur not at a permanent water level, as it was assumed by Weber, but at current changes of its level in the deposit. For the peatland thickness growth a long-term steady gradual rise of water levels in it is necessary. They are the so-called progressive movements. The phenomenon of gradual water level rise in the peatland means the retention increment. The water level in the peatland is rising, namely, due to increasing resistances opposing the flow. Thus increases the water storage in the peatland and consequently increases its retention. Hence the retention is a factor responsible for both differentiation of the plant species and the peatland growth.

Vertical movements of waters of progressive character have been divided by Kulczyński into two categories: autonomic movements caused by the peatland vegetation activity and movements initiated from outside, caused by the factors outside the peatland, so-called imparted ones.

To autonomic movements connected with the peatland growth belongs the phenomenon of rising the water level in the raised bog of the Baltic type, caused by the increment of peat bulk, capillarily active, storing efficiently higher and higher amounts of precipitation waters. The phenomenon of the water level rise in turf peatlands belongs also to them. It is caused by the overgrowth and the check of flow by peatland vegetation.

To movements initiated from outside (imparted) connected with the retention increment belongs, among other things, the phenomenon of water impoundment in the peatland caused by general rise of ground waters of the ambient area in connection with the bottom rise of neighbouring river valleys. Hence the peatland thickness increment mechanism is not a simple biotico-successive process as Weber supposed, but is closely connected with progressive impoundment of waters in the deposit.

Autonomic movements causing impoundment of waters in the peatland are responsible for the increment of raised bogs of the Baltic and Atlantic type (increment of capillary active peat bulk) and fens of the turf type (checking of flow by the vegetation). The water impoundment caused by the phenomenon from outside controls the increment of raised bogs of the continental type and fens of the rivular type. The increment of some transitional bogs and fens is consequence of the effect of coordination of autonomic movements and movements initiated from outside. These movements are causing the water rise in the peatland, what is connected with the increment of both retention of peatlands and retention of adjoining areas.

OUTLINE OF THE HYDROLOGICAL CLASSIFICATION OF PEATLANDS AFTER KULCZYŃSKI

In the classification given by Kulczyński the — fens (A), transitional bogs (B), and — raised bogs (C) are taken into consideration.

A. FENS

A.1. Rivular reed fens, are characterized by a lack of own catchment area and of the underground flow (drainage). The water management is based mainly on inundation waters (system III) and stagnant ground water (system I) with a very great predominance of waters of the system III. The growth of peatlands depends on the ground water impoundment of the system I (imparted growth).

A.1.1. Reeds swamp peatland, almost whole year being under water, with predominance of stagnant water without any distinct movement, alimanted almost exclusively by precipitation.

A.1.2. Sedge and reed-sedge peatlands, the water management as above, of ombrophilous-inundation type, with less flood intensity. They occupy higher places in the valley terrace system, with seldom flood. Their growth is connected with the accumulation phase of the river.

A.1.3. Alder and osier peatlands, on areas with still shorter river flood periods than the above, what concerns especially the alder peatlands. This is connected with transition of river from accumulation into erosion phase. Their development is connected mainly with the peatland hydration state decrease.

A.1.4. Alder and osier peatlands changed by tree cutting, dominated by

substitutional reed and reed-grass communities with prevalence of *Phalaris arundinacea*, *Glyceria aquatica*, *Carex vesicaria*, *Calamagrostis canescens* and *Poa palustris*.

A.2. Turf (sedge-moss) fens, usually with own catchment area and underground flow (drainage). Flowing water management, based on the continuous inflow of ground water (system II), sometimes combined with inundation waters (system III). The peatland growth is based on checking and impoundment of flow (autonomic growth).

A.2.1. Floristically rich *Magnocaricetum*, occurs in those parts of the flooded terrace of the river, which are affected by ground waters of own catchment area. A great trophism of the peatlands is decreasing along with the flood or catchment area reduction, what constitutes the cause of a considerable differentiation of plant communities and distinct reference of their botanical composition either to rivular or to typical *Parvocaricetum* peatlands.

A.2.2. *Parvocaricetum* alimented exclusively with ground waters of own catchment area (deep flow) at a total elimination of the surface (inundation) flow.

A.2.3. Osier-birch and birch peatlands, the development of which is connected with the general drop of the water level in peatlands of the *Parvocaricetum* type or floristically rich *Magnocaricetum* type (with admixture of alder).

A.2.4. Sedge-grass peatlands, derivatives of osier-birch and birch peatlands developed in consequence of their mowing or grazing. The floristic composition of vegetation is very different depending on the water level oscillation as well as on the chemical composition, decomposition degree and physical structure of peat and on the mowing, grazing and fertilization intensity.

B. TRANSITIONAL BOGS

B.1. Transitional bogs with constant, but weak water drainage, of the ombrophilous flow water management, at a low share of the latter.

B.1.1. The *Carex stricta*-*Sphagnum* s. *cuspidata* community with minimal flow due to small catchment area. A consequence of the decline of water inflow is a certain oligotrophism of these peatlands and long duration of low water levels in the growing season. This causes a lack in the plant community of extremely hydrophilous emersive species and occurrence of species characteristic for raised bogs (ombrophilous). The growth occurs in consequence of impoundment of ground waters of the area (imparted growth).

B.1.2. The *Magnocaricetum*-*Sphagnum* s. *cuspidata* community, growing on peatlands approximating most closely fens. They are characterized by strong hydration in consequence of checking the flow. In vegetation the occurrence in one and the same community of big immersive perennials of eutrophic character and of oligotrophic species is observed. This is consequence of a distinct

independence of vegetation tiers of the community. One tier is rooted in peat rich in nutrients, another with shallow roots forms a mat floating over the ground water level, consisting of small sedges, *Sphagnum*, mosses, white beak sedge, etc.

B.1.3. The *Parvocaricetum-Sphagnum s. cuspidata* community, characterized by a permanent hydration and intensive increment of peak bulk. It was formed, similarly as in case of birch and *Magnocaricetum-Sphagnum cuspidata* peatlands, under the flow checking effect.

B.1.4. Birch forest peatlands developed in a flat landscape, near watersheds, with a weak drainage limited by checked flow. It is characterized by a considerable hydration of site and low, thin tree stand as well as weakly developed tussocks, mainly of *Sphagnum palustre*.

B.2. Transitional bogs without drainage, of ombrophilous water management.

B.2.1. The *Carex lasiocarpa-Sphagnum s. cuspidata* community connected with the system of stagnant ground water accumulated in permeable soil, regenerating itself directly from precipitation. These peatlands were formed under the effect of ground water level rise in the area under conditions of a distinct oscillation of water and its periodical rise above the area surface.

B.2.2. Pine-birch wood peatlands, occurring frequently at watersheds, old terraces and fen margins. They were formed from fens by eliminating the water flow by means of the inflow decline (water catchment in the area). It is characterized by distinctly lowered ground water level, well-developed old tree stand and the area of strong tussocks of *Sphagnum medium*.

C. RAISED BOGS

C.1. Baltic raised bogs developed due to storage in peat deposit of high precipitation water amounts, retentioned by capillary active peat bulk, composed mainly of dead, strongly higroscopic *Sphagnum* mosses. The growth of these peatlands occurs under the effect of cyclic succession of tussocky and pool communities (lenticular regeneration), coupled with automatic water impoundment in the peatland (autonomic growth). This process leads to the growth of the peat massif in the form of a distinctly outlining cupola risig above the ambient area.

C.2. Continental raised bogs — small peatlands of the character of paludified pools distributed over the interrriver area, where they are connected closely with the depression curve of the ground water table of the area. They are characterized by a flat surface adapted to the ground water level. The growth of these peatlands occurs only in conditions under of permanent water impoundment in neighbouring valleys (imparted growth). In these conditions also the ground water impoundment in the interrriver area depends.

C.3. Karst raised bogs of the continental type — are developing in lakes, in

which karst phenomena of rapid break or gradual depression of the water reservoir bottom is taking place. In the first case strongly higrophilous formations are lying on formations of semiterrestrial character. Under quiet settling conditions of the reservoir bottom a steady peat bulk increment and uniform peat deposition are observed.

C.4. Hummocky raised bogs of the continental type, forming big peat complexes covering flat catchment areas in the coat form. Such a complex can be regarded as morphologic and hydrologic homologue of a sufficiently developed group of continental raised bogs of the interriver area. The surface of such a complex can be distinctly convex in relation to its margins and can correspond with the ground water table suspended in the interriver area. The above phenomenon depends in this case not on the rise of peat deposit, but on the rise of the mineral subsoil. The small peat thickness is evidence of this situation.

DEVELOPMENT OF THE KULCZYŃSKI'S THEORY IN THE CONCEPT OF HYDROLOGICAL CLASSIFICATION OF WETLANDS

It follows from the above presentation of the Kulczyński's theory that the problem of biology of peatlands has been considered by the author in the aspect of causal-consecutive relations. The cause constituted widely conceived hydrological conditions, the consequence — plant communities and peat formations. In such a way the genetical division of peatlands based upon hydrologico-ecological criteria has been developed. The Kulczyński's theory presented in his work concerning Polesie peatlands is creative and up-to-now till actual. The studies carried out in the last 50 years confirmed, namely, rightness of its principal assumptions (Okruszkó 1964, Oświt 1973, 1977).

To the Kulczyński's theory the hydrological classification of wetlands refers (Okruszkó 1977, Okruszkó 1983), constituting its development in the sense of consideration not only of peatlands, but also of sites of other kinds. This classification is taking into consideration those sites, which are alimented depending on the water inflow (underground or surface one) at higher rates than its losses. In the concept of the above classification two basic elements of the Kulczyński's theory responsible for differentiation of water conditions of wetlands are taken into consideration (Okruszkó 1984) and viz:

- way of in- and outflow to and from the site defined as a type of hydrological alimentation,

- hydration state of the site expressed by the water amount contained in it and the time of its occurrence as well as the soil oxidation degree defined as hydroecological conditions.

On the basis of the hydrological alimentation type four wetland types have been distinguished. Within the types differences occur following from hydroecological conditions constituting a basis of division of wetlands into nine kinds.

1. TYPES OF WETLANDS DISTINGUISHED DEPENDING ON THEIR ALIMENTATION WAY

The water alimentation way of wetlands constitutes a basis for distinguishing four types differing with the character of hydrological conditions. They are ombrogenous, topogenous, soligenous and fluviogenous wetlands. The notion of the used names as defined below at discussion of water conditions of the given wetland type.

Ombrogenous wetlands

They occur, as a rule, at watersheds in places fully deprived of underground outflow and covering their water requirements directly from precipitation.

The sites of their occurrence are most often flowless depressions upholstered with impermeable formations and therefore totally isolated from ground waters of the catchment area. In case of a lack of such an isolation, they are deposited in places of stagnant ground waters, poor in mineral elements, especially in calcium. The calcium deficiency in water causes occurrence in the soil solution of free acids forming from the plant matter decomposition, what makes that the solution acidity value (pH) is 3.5–4.5. Oligotrophic vegetation connected with the formation of raised or transitional bogs is developing under such conditions.

Topogenous wetlands

They occur mainly in interriver regions, most often in gradientless depressions connected with plains. Their characteristic feature is almost horizontal ground water table. They are fed with water by means of the contact with the table of subterranean water reservoir formed under these conditions and by the precipitation water infiltrating into the peatland surface. If the deposit growth and rise of its surface are not correlated with the simultaneous rise of ground waters above the whole area the oligotrophisation connected with an increase of the role of precipitation water in the development of these wetlands occurs. In the deposit stratigraphy it is marked by occurrence of transitional peat and even of raised bog-peat on fen-peat.

Soligenous wetlands

They occur on areas with differentiated ground water table formed by the complicated geological structure and occurrence of layers with different gradient and permeability. They are formed mainly under conditions of more or less constant inflow of ground water. They develop usually in places of ground water occurrence above the area surface. The ground waters flow can be under the effect of gravity only or also under the effect of hydrostatic pressure. The latter occurs also on plain areas at places with locally high ground water table connected with springs. In wetlands as such the action of forces affecting water

inflow vanishes and therefore they constitute the place of relief of ground water pressure. Their paludification degree is connected both with the amount of inflowing water and with its outflow conditions. The outflow is, as a rule, checked by plant cover and accumulation of organic material formed in the site. It causes a permanent impoundment of waters and the accumulation of peat of the same kind, very often of considerable depth. The water inflow depends to a considerable degree on permeability of the water-bearing layer. A low permeability of this layer causes a uniform inflow and stabilized paludification of the site, what leads to deposition of weakly decomposed, most often sedge-moss peat. On the other hand, at a high permeability of the water-bearing layer the water inflow occurs in pulsatory way, changing in time. In consequence changes in aerobic conditions of the peat-forming layer occur and peats of medium or high decomposition degree are formed.

Fluviogenous wetlands

These wetlands are forming mainly in valleys under the effect of surface waters causing floods. They occupy places of accumulation of river waters or waters coming from surface runoff, and represent the sites, in which flood waters are relieved, what is connected with sedimentation of silts carried by water. While being inundated periodically, they can fulfil the task of periodical water reservoir.

The presence of silts is connected with a reduction of the flow energy causing sedimentation of fine suspension. The typical fluviogenous wetlands are, beside peatlands, silted formations forming under conditions of small paludification at a certain growth of the kinematic energy of floods. This is reflected both in distinct differentiation of the microrelief of sites and in the character of formed muds, i.e. formations containing humus connected with fine mineral suspension in complex organic-mineral substances.

2. WETLAND KINDS DEPENDING ON HYDROECOLOGICAL CONDITIONS

The hydration state of wetlands is very different. This differentiation is reflected in the occurrence of high amount of various plant communities as well as different soil formations and soils (Okruszkó 1969, Oświtt 1978). These plant communities and soils develop and occur under hydroecological conditions forming by:

- water maintenance way in the site,
- existing air-water conditions and soil aeration connected therewith,
- the water maintenance way affecting, first of all, the vegetation character, differentiates the wetland sites into:
 - not flooded or episodically flooded (semiterrestrial),
 - periodically flooded (telmatic) with log-term, non-episodic flood,

- submerged (limnetic), being permanently or almost permanently under water.

To each the mentioned sites definite plant communities correspond, which after their exact recognition can deliver a detailed information about water conditions of the site.

The air-water conditions responsible for intensification of the biological decomposition process of the produced organic matter and its content in accumulated soil formations constitute an expression of paludification state of the site. Basing on this criterion the following soils and sites can be distinguished:

- humous, well-oxidated, forming under the aerobic conditions,
- muddy, periodically oxidated, forming under aerobic-anaerobic conditions,
- peaty, oxidated very weakly and connected with conditions of a strong anaerobiosis.

On the basis of water maintenance way in the site with reference to the soil surface as well as soil oxidation degree the wetlands can be divided into nine kinds (Table 1).

Table 1

Classification of wetlands into kinds in accordance with hydroecological conditions

Formation of air-water conditions in the soil	Water occurrence in the site		
	without surface flood (semiterrestrial)	with periodical surface flood (telmatic)	with permanent surface flood (limnetic)
With aerobiosis predominance	1. periodically waterlogged wetlands accumulating humus in mineral soil	4. telmatic wetlands accumulating humus and silt	7. limnetic wetlands accumulating gyttia
Aerobic-anaerobic conditions	2. permanently waterlogged wetlands accumulating peaty material	5. telmatic wetlands accumulating mud	8. limnetic wetlands accumulating mud
With anaerobiosis predominance	3. emerged peatlands	6. flooded peatlands	9. submerged peatlands

This division allows to distinguish in the **semiterrestrial sites**:

- Periodically waterlogged wetlands, submerged only in wet periods, with labile character of water conditions, not disposing of a continuous alimentation system. Accumulation of organic matter in soil amounting to about 10% occurs in consequence of the sod development in the meadow ecosystem or forming of forest humus in wooded stands.
- Permanently waterlogged wetlands of more stable hydration, occurring most often in the neighbourhood of peatlands, connected often with ground water

impoundment within their reach. They are characterized by accumulation of organic matter in the form of endohumus saturating the mineral formation in 10–20%, what leads to the development of a peaty formation. In the forest ecosystems of the character of very moist forests, the forest litter (ectohumus) transforms into humus of the hydro kind (hydromull, hydromoder, hydromor).

- Emerged peatlands developing on the areas permanently paludified by ground or precipitation water and comprising sedge-moss fens and raised bogs as well as their forest facies, i.e. birch-alder swamps, spruce and bog pine stands. In the group of **intensively flooded sites** there occur:
 - Telmatic wetlands accumulating sedimentary formations, comprising fluvio-genous sites, in which silts are sedimented by surface waters. They are characterized by a considerable amplitude of oscillations of ground water levels. This usually correlates with a considerable kinetic energy of flows and consequently with sedimentation of silts and formation of alluvials. The meadow vegetation of these sites is characterized by predomination of grasses. With these sites there is connected, prior to deforestation of the valley, the occurrence of osier thickets and poplar-osier forests.
 - Telmatic wetlands accumulating mud formations comprising the sites (marshes) in which long-term floods occur, beside the periodical distinct ground water level drops. In such condition the intensification of the decomposition processes occurs. The accumulated organic matter is well humified and has a character of mud. At a certain growth of paludification of the site the peaty-muddy material is formed. At a growth of kinetic energy of floods a silted mud is deposited. In the plant cover sedges (mainly *Carex gracilis*) and mannagras (*Glyceria aquatica*) predominate. The forest vegetation is composed mainly of ash-alder marshy community.
 - Telmatic peatlands occurring under conditions of a distinct valley water impoundment connected with intensive river floods. Vegetation consists of reed-sedge and sedge communities as well as of osier and alder in case of forest facies. Peats are characterized usually with high ash content due to an admixture of mineral sediments.

In the group of **submerged sites** there occur:

- Limnetic wetlands accumulating gyttia in overgrown parts of lakes. Organic matter of gyttja is developed from plankton and lacustrine vegetation at a certain share of the benthos fauna in well-aerated water milieu. Gyttja contains moreover in different per cent the mineral substance precipitated from water mechanically (sediments) or chemically, mostly in the form of calcium carbonate. The water reservoirs shallowed by gyttja are overgrown usually with reeds, what leads to transformation of lakes into submerged peatlands.
- Limnetic wetlands accumulating mud occurring usually in the form of shallow water reservoirs. Most often they occupy abandoned river beds overgrown by

the reedswamp and megaplankton communities. High oxidation of water by aquatic plants favours the plant matter humification and transformation into amorphous mud. In deeper places with still more aerated water, limnetic muds vanish and are replaced by gyttja.

- Limnetic peatlands lying mainly in river valleys and deltas, in places of whole-year river floods and in shallow lacustrine bays. Vegetation consists mostly of reedswamp communities. A weak water flow and high amount of accumulating organic matter causes deficiency of oxygen in water, what leads to formation of peat containing frequently an admixture of gyttja.

The classification of wetlands as presented above, including also peatlands, referring in its basic assumptions to the concept of Kulczyński, is applied in the practice at determination of water conditions of hydrogenic sites. As the respective experiments have proved, it is useful also at formulation of the principles of control of water conditions in managed and agriculturally utilized areas as well as in protected areas in view of their high natural value (Oświt 1978).

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Teoria Kulczyńskiego hydrologicznego podziału torfowisk w świetle współczesnych badań

Streszczenie

W pracy omówiono w sposób syntetyczny podstawowe założenia teorii torfoznawczej Kulczyńskiego szeroko rozwiniętej przez niego w dziele „Torfowiska Polesia”, ze szczególnym uwzględnieniem wpływu zjawisk hydrologicznych na rozwój i różnicowanie się torfowisk. Rozwijając teorię Kulczyńskiego przedstawiono własną koncepcję hydrologicznego podziału mokradeł wyróżniając cztery typy i 9 rodzajów. Ze względu na sposób realizacji dopływu wody do siedliska wyróżniono mokradła: fluwiogeniczne, soligeniczne, topogeniczne i ombrogeniczne. Uwzględniając zaś różnice w stanie ich uwodnienia wyróżniono następujące rodzaje mokradeł: podmokliska, namuliska, mułowiska (zalewane i zatopione), torfowiska wynurzone, torfowiska zalewane, torfowiska zatopione i jeziorzyska.