Contemporary Problems of Management and Environmental Protection
Vol. 1, 2009. Soils of Chosen Landscapes: 5-19

Chapter I

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Soil Environment in the Landscape

The term 'landscape' first appeared as '*Landschaft'* in an Old German language in 8th century and it has been used in this form till nowadays [BERNINGER 1975]. However, several ways of its interpretation are distinguished, depending on the criteria of classification, and each definition is tinged with a professional point of view. It is defined as a geographical, natural, esthetic or socio-cultural term as well as from a geochemical point of view [PERELMAN 1971; SZCZĘSNY 1982]. Ambiguity of its definitions makes it a replacement for the terms like: geographical environment, geosystem, geocomplex, geosphere, ecosystem WOLSKI 1988].

In a colloquial speech, landscape is understood as an area of earth's surface seen from a particular position or a view of an area of land with all its technical elements [KOWALKOWSKI 1998]. The landscape components include natural environment with its geological bed, soil, water, vegetation, animals and air as well as anthropogenic elements like buildings and sets of buildings (settlements, cities), technical elements related to industry, transport, power industry, water management, etc. [SZCZĘSNY 1982; STARKEL 1989].

Definition of landscape from a socio-cultural point of view describes current state of space-time consciousness of a particular society [WOLSKI 1988]. SAUER [1986] defines landscape as a region with typical connections between natural and cultural elements which are a certificate of a human activity over the centuries. Similarly, SERAFIN [1958] developing the term of landscape, defines it as 'a junction of natural and human-induced elements in a particular geographical environment'. Landscapes reflect the culture [WAGNER 1986] recording simultaneously the history of natural evolution and human activity [PATOCZKA 1987]. Within them BOGDANOWSKI [1973] distinguishes modern landscapes, landscapes of early Middle Ages, renaissance, baroque, classicism and of industrialization.

In the aesthetical sense, typical for the disciplines similar to architecture and theory of art, landscape is defined as a visual aspect of an object. It is an observable world [HOUSTON 1964], an external expression of natural elements [CIOŁEK 1964], a physiognomy of environment [BOGDANOWSKI 1973, PATOCZKA 1987], particular external esthetical-visual features

[SZCZĘSNY 1982], the overall of spatial phenomena occurring on the Earth's surface [ŁUCZYŃSKA-BRUZDA 1978] and it is associated with a view of surroundings [PATOCZKA 1987]. The above definitions in their expanded form indicate that the landscape-forming factors are both natural conditions and cultural human activity and that their evaluation are the beauty criteria based on the theory of aesthetics i.e. harmony, profundity, grandeur and balance. According to GOŁASZEWSKA [quoted in BAJEROWSKI et al. 2000], people usually prefer landscapes of typical scenery, for example landscape of rocky mountains, streams and gorges, sea, forest, lake.

The term of landscape defined by geographers was introduced in the literature by von Humboldt at the beginning of 19th century as 'a complete set of features of one area of land' [quoted in KOWALKOWSKI 1998]. In its essence, the definition describes the landscape as the Earth's surface with mutual conditions and relations between phenomena (processes) and both natural and human-induced components of environment [TROLL 1971; RUŽICKA 1978; LANGER 1978]. It is related to the material layer simultaneously stressing its spatial character [WOLSKI 1988]. KONDRACKI [1967, 1991] defines landscape as territorial natural complex, i.e. geocomplex which comprises interrelaion of land relief and lithological composition, water relations, local climate relations, biocenotic and soil relations. The author distinguishes marine landscape, young glacial landscape, old glacial landscape, landscape of valleys and water accumulation plains and the landscape of uplands and mountains.

From a geochemical point of view, landscape is a part of Earth's surface, where migration of chemical compounds of atmosphere, hydrosphere and lithosphere occurs due to solar energy [PERELMAN 1971]. Depending on the direction of the flow of solid and liquid material in the soil, eluvial landscape (autonomic, superior) super-aqual landscape (aquatic, subordinate) and sub-aqual landscape (underwater, subordinate) are distinguished. Beside main types of landscapes, in a case of lack of a dominant, GŁAZOWSKA [quoted in POKOJSKA, PRUSINKIEWICZ 1982] introduces a combination of the types of landscapes depending on the element of the relief. She specifies transitional landscapes such as: transeluvial landscape (upper parts of the slope), eluvial-accumulative landscape (bottom parts of the slope), accumulative-eluvial landscape (local, closed depressions with low groundwater level), super-aqual proper landscape (closed depressions with weak exchange of groundwaters) and trans-super-aqual landscape (with the exchange of groundwaters). MARCINEK [1976] adds particular soil units to the above classification and names it a physio-geographical-soil landscape.

In natural sciences, first definition of landscape was presented by Rozenkranz [quoted in SCHMITHÜSEN 1978] paying attention to its biological part. Polish definition was first presented by SMOLEŃSKI in 1912 [quoted in

BAJEROWSKI et al. 2000]. The author defined landscape as “a set of interrelated phenomena representing natural environment, formed during long evolution as a result of free activity of nature”. Similar depiction of landscape was presented by Wodziczko in 1946, who points to “an overall of nature on the limited area of Earth, in which a balance is reached due to self-regulating processes” and by Prieobrażeński who defines landscape as “a set of interrelated components of nature as a unity of lower order forming the entirety” [quoted in BARTKOWSKI 1986].

BOGDANOWSKI [1973] and SZCZĘSNY [1982] made a division of landscapes basing on the gradient of transformation under anthropogenic factors and the state of evolution of civilization. The authors distinguish four main states of landscape, i.e.: primeval, natural, cultural and devastated. Primeval landscape is defined as preserved only in some areas, extremely rare in our geographical conditions. This kind of landscape has intact biological balance and therefore it is naturally sustainable with unaltered ability of self-regulation. It was formed by exclusively natural factors without human interference.

Natural landscape occurs in the areas under human impact which does not cause significant changes in the ability of self-regulation. This type of landscape lacks spatial elements introduced by man. It is the first stage of landscape transformation, however, with the lowest intensity, so that the natural forms prevail over human ones.

Cultural landscape, very common nowadays, is characteristic for the areas of intensive human production which changes configuration of natural conditions and spatial elements introduced by man. In cultural landscape, destruction of the ability of self-regulation draws the necessity of applying proper conservation-cultivation treatments, essential to maintain the balance.

Devastated landscape occurs in strongly invested areas as a result of industrial development and urbanization. These are the areas of human activity which exploits the nature and contributes to the destruction of natural configuration of conditions. It is usually expressed by very advanced quantitative and qualitative deformation of one or more natural components of the landscape, in which the elements introduced by man play a dominant role. It can be regarded as a subtype of cultural landscape in which devastation and degradation was caused by human activity.

The definition of cultural landscape was developed by NAVEH [1982] on a spatial structure model. The author distinguishes cultural agricultural open landscape (field, plantation, fish pond) and cultural built-up landscape: rural (farm, village), suburban and urban-industrial (city). BAJEROWSKI et al. [2000], determining the functional role, distinguish cultural forest landscape, agricultural landscape (cultivation and breeding), urban, industrial and recreational landscape (Fig. 1). Urban landscape, as a complex and dynamic

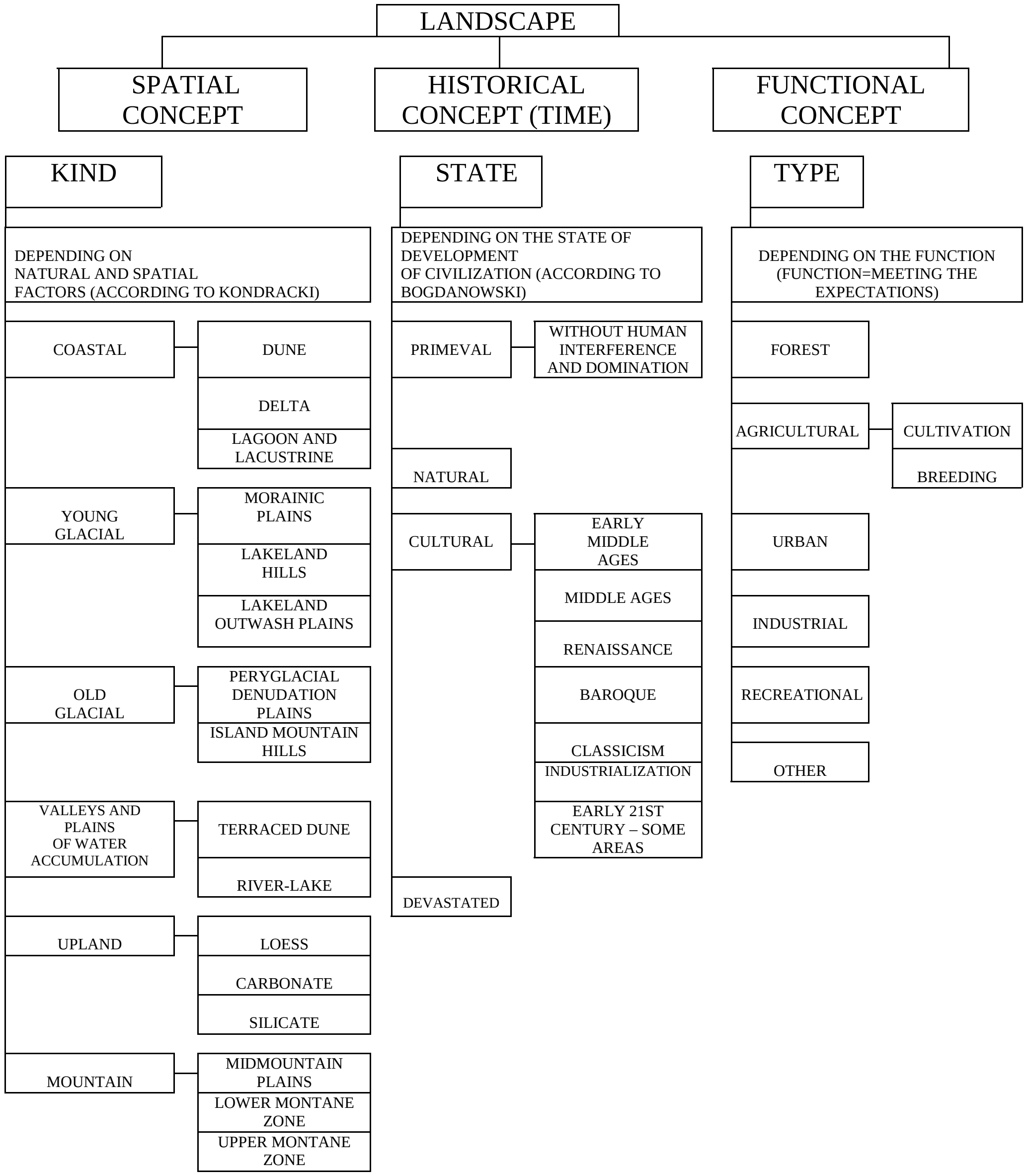

Fig. 1. Classification of landscape definitions [quoted in BAJEROWSKI et al. 2000]

anthropogenic system, causes reductive and destructive changes of natural environment, in which and at the expense of which the landscape is functioning and existing [PRZEWOŹNIAK 1989]. Nowadays, as a result of expansion of urbano-cultural elements, a tendency to transformations of biodiversified natural landscapes into more and more monotonous cultural landscapes occurs. Cultural landscape is therefore a modification of agricultural natural bioecosystems into agricultural-techno and urban-techno ecosystems with a significant domination of anthropogenic artifacts. Usually, primeval landscape is transformed into natural, then into cultural an at last into degraded.

CYMERMAN and HOPFER [1998] noted that, with some restrictions, inverse sequence of transformations is also possible. According to RICHLING and SOLON [1998], a transition of cultural rural landscape into suburban and urban causes a decrease of its stability features (self-regulation, intensity of interspecies bonds) and an increase of exchange of species as well as pollution with ash and gas.

The sequence of landscapes has its historical roots. In Europe, man appeared in a period of Central Polish Glaciation together with a primeval landscape, which began its transformation into natural [KOWALKOWSKI 1976; STASIAK 1978; STARKEL 1988]. At the beginning, human activity, i.e. hunting, destroying forests, grazing and cultivation of small fields was obliterated by nature in a relatively short time. Hydrotechnical works (dikes, dams, artificial reservoirs) contributed to the drainage of land and expansion of agricultural land which led to the formation of first cultural landscapes in Poland in XV century. Together with a development of industry in 19th and 20th century (steam machine, mining, transport), devastated landscapes were formed. These changes were described by STASIAK [1978] as difficult to reverse or threatening to the biosphere.

According to BLUM (1998, 1999], soil is the most important component of the landscape. The author distinguishes its six functions:

- it is an area of agricultural and forestry production
- plays a role in infrastructure
- it is a gene pool and protects genetic resources
- it is a buffer and a filter for transformation processes
- it is a source of natural materials
- it is a geogene and cultural heritage of landscape forms.

These functions as well as their threats derive mainly from the soil chemical composition which in unaltered conditions depends on the type of soil parent material, soil-forming processes and texture [SKŁODOWSKI, SAPEK 1977; KABATA-PENDIAS 1981; DUDKA 1992; CZARNOWSKA 1996; BIENIEK 1997]. From a variety of chemical elements in the soil, attention is paid to high amounts of iron, aluminum, calcium, natrium, manganese and potassium, i.e. elements important in plant nutrition. KONECKA-BETLEY [1968] and JANOWSKA et al. [2002] indicate that the forms of iron and aluminum are a good indicator of soil-forming processes. For *sideric* horizon, the amount of amorphous forms of iron (Feo) and aluminum (Alo) may be a distinguishing criterion. In *cambic* horizon of brown soils, a tendency to accumulate chemical elements, also heavy metals, occurs [GWOREK 1985]. Lower amounts are found in *luvic* horizons of lessive soils and the highest were reported for *argillic* horizon. In pseudeogley soils, the highest concentration of iron and aluminum was reported for gley horizons, which are typical for these soils. A highly significant correlation between the amount of chemical elements and clay fraction in the soils was found. Heavy soils are generally abundant in macroelements [PONDEL, TERELAK 1994] and heavy metals [CZARNOWSKA 1996].

PRUSINKIEWICZ et al. [1983] presented a cycle of chemical elements in exploited forest ecosystem. The chemical elements entering the ecosystem are differentiated into natural which include in-soil elements (from surface and side inflow), deriving from the atmosphere and anthropogenic ones (fertilization and industrial emissions). The elements leaving the ecosystem are also divided into natural and anthropogenic. Natural ones refer to the surface and in-soil outflow to groundwaters. Anthropogenic ones derive from the exploitation of timber, forest fruits, herbages and forest floor.

A concern in the state of the environment contributed to numerous studies of heavy metals content in the soils [KABATA-PENDIAS 1999; CZARNOWSKA 1999]. As a result of various human activity, the content of heavy metals in the soils increases, especially in surface layers. Excessive amounts of heavy metals affect the growth and development of plants, animals, and indirectly also of a man. In some parts of Poland the contents of zinc, lead, copper, cadmium, manganese, chromium and iron are increased [DUDKA 1992; TERELAK et al. 1995] However, according to CZARNOWSKA [1996], the parent material which is a geochemical background not under anthropogenic impact, ought to be the basis for the estimation of the content of heavy metals in surface soil horizons. For the city of Warsaw, the enrichment factor for surface layers, in relation to geochemical background of soils, amounts to 3.7 for copper, 4.0 for zinc, 11.7 for cadmium and 19.1 for lead [CZARNOWSKA 1994, 1999].

Urban and suburban soils are particularly threatened with the contamination due to multiple sources of pollution. Industry and car transport are the main emitters of heavy metals to environment [GAMBUŚ, GORLACH 1995]. Moreover, pollution with carbon oxide, aromatic hydrocarbons, nitrogen and sulfur oxides as well as with aldehydes is referred to car transport [CURZYDŁO 1995; GAŁKA, SZERSZEŃ 1996; GORLACH et al. 1993; MACIEJEWSKA, SKŁODOWSKI 1995]. It is believed that the amount of heavy metals decreases with the increasing distance from roads and the pollution disappears approximately 50 meters from the road [CZARNOWSKA 1994]. The obtained results suggest a 7-8-time increase of heavy metals in a roadside area during a 10-year period (1980-1990). MALCZYK and KĘDZIA [1996] noted that the content of heavy metals may be higher than the natural even in the distance of 150 m from the road. Moreover, the authors recorded a significant accumulation of cadmium, nickel and chromium at a depth of 30-40 cm in the soil. SKŁODOWSKI and ZARZYCKA [1997] prove that the amount of heavy metals in forest soils is the highest in the forest floor, decreases with depth and is similar to the amounts reported in arable soils.

According to KOWALKOWSKI [1976] and STARKEL [1989], human activity irreversibly affects the differentiation of the soils. The modifications are recorded in the relief and natural environment as a sequence of soils and changes in vegetation. The result of human activity is soil degradation, not always and not necessarily equal to the diminishing ability of biomass production. As a result of direct human activity, anthropogenic forms of relief are formed. PODGÓRSKI [1997] divides them into convex forms (embankments), concave forms (road and rail embeddings) and plain forms (a result of building airports and car parks).

PRUSINKIEWICZ et al. [1983] grouped the factors of degradation of forest soils environment according to their influence on physical, chemical and biological processes. The factors degrading soil physical properties include water, wind and skidding erosion, negative changes of soil structure, soil compaction due to pressing by vehicles and machines, overgrazing of domestic animals and trampling by tourists, negative changes of the soil profile due to wrong deep tillage treatments, negative changes of soil water and soil thermal conditions due to wrong drainage treatments or drainages carried out within the area of depression funnels influence, etc. The processes of chemical degradation include the decrease of humus stock and nutrients due to raking of the forest floor and grazing of domestic animals, negative changes of soil reaction and in the composition in the soil sorption complex as well as accumulation of surplus amounts of toxic compounds from industrial emissions. According to the authors, introduction of the forest stand composed of monocultural coniferous species (without brushwood) does not provide balanced circulation of chemical elements, negatively affects the composition of soil microflora and fauna and contributes to surplus concentration of pests and pathogens.

In forestry tourism, according to RÓG et al. [1980], trampling and mechanical pressure negatively affects the soil. The use of heavy machinery also contributes to the soil compaction. Plants and soil structure are destroyed under mechanical pressure [CURDT 1958; SMORODIN, PARSZIKOW 1968; SŁOWIŃSKA-JURKIEWICZ 1998]. Soil permeability [SŁOWIK 1970], porosity and water storage capacity decreases [ONISZCZENKO, MICZURIN 1971; RÓG 1985], soil density increases [FEUERLEIN 1961; SŁOWIK 1970; KHANN et al. 1973; DOMŻAŁ 1977] and the soil micromorphology is changed [RÓG et al. 1980]. Soil compaction restricts root growth, weakens water and nutrients (especially nitrogen) uptake by plants [SŁOWIK 1970]. Loosening the soil has an opposite impact [SŁOWIŃSKA-JURKIEWICZ 1998]. According to HEWELKE [1992], soil moisture can be effectively regulated by economic irrigation systems which ensure stressless plant growth.

Soil organic matter (natural and applied with the fertilizers) and especially the products of biochemical transformations of organic matter, determine favorable soil properties affecting soil fertility and productivity. Soil organic matter has an impact on the circulation of bioelements, positively affects soil water management and its phytosanitary state. When high doses of mineral fertilizers are applied, soil organic matter plays a role as a buffer for surplus concentrations of salts, pesticides and heavy metals [MYŚKÓW et al. 1986].

The manner of soil use has an impact on accumulation and transformation of soil organic matter. NIEDŹWIEDZKI [1984] and SIUTA [1995] reported that arable cropping systems cause a decline whereas forestry practices cause an increase of organic matter content. However, human activity such as raking of forest floor may affect this regularity [PRUSINKIEWICZ et al. 1983]. DOMŻAŁ et al. [1992] noted that, as a consequence of transition of post-forestry land into agricultural use, humus content in arable humus horizons decreased. According to MYŚKÓW et al. [1986] high yearly doses of organic fertilizers (straw, manure) under arable cultivation contributed to the maintenance of organic matter content on an initial level or even to a 2-3-time increase. Also, long-term mineral fertilization enables to maintain the initial content of organic matter or even its slight increase when neutral soil reaction is maintained. As reported by GOTKIEWICZ and BIENIEK [1996], erosion, high share of grains and root plants in the structure of sowing as well as improper management of organic fertilizers cause a decline of humus in cultivated, arable soils. SKŁODOWSKI [1994] proved that qualitative composition of humus in arable humus horizons is different in cultivated and forest soils. In cultivated soils, organic matter is bound with mineral soil fraction, has higher degree of humification, contains more humic acids and humins, i.e. stable mineral-organic complexes.

Application of mineral fertilizers on cultivated soils, especially soil liming, contributes to a deacidification, a decrease of exchangeable aluminum and hydrogen and an increase of base saturation in arable humus horizons [NIEDŹWIECKI 1984; DOMŻAŁ et al. 1992]. As compared to forest soils, cultivated soils contain more potassium, natrium and plant-available forms of phosphorus and iron, but less magnesium [CZERWIŃSKI, PRACZ 1977; SKŁODOWSKI, ZARZYCKA 1995]. According to MYŚKÓW et al. [1986], the content of N, P, K, Mg and Ca increases under systematic manure fertilization, whereas during long-term mineral fertilization the content of the mentioned elements decreases.

Deforestation, grazing and arable cultivation enhance soil erosion on the slopes and contribute to the surface gravitation movements [STARKEL 1989, LICZNAR 1995]. On the slopes, deluvium and colluvium are formed. Deforestation enhances the formation of eluvium and activates the formation of soil matter susceptible to eolian processes.

On arable land, surface flows are much more intense than in forests. Chemical erosion affecting up to ¼ of soil substrate is equally threatening the environment [CHUDECKI, NIEDŹWIECKI 1983]. A yearly flow of mineral compounds from a hectare of arable fields in Poland is estimated as high as 2-12 kg N-NO_3, 0.2-0.6 kg N-NH_4, 0.06-0.6 kg P-PO_4, 4-10 kg K, 40-230 kg Ca, 10-60 kg Mg and 10-40 kg Na [SOLARSKI, SOLARSKA 1986; POKOJSKA 1988]. According to RYSZKOWSKI et al. [1990], landscape saturation with biogeochemical barriers, which include mid-field shelterbelts, mid-field enclaves of grasslands and ponds, considerably reduces the transport and migration of chemical elements. According to POKOJSKA [1988], soils with unsaturated sorption complex, which have reserve exchange capacity play an important role in binding of biophilous ions. In diversified morainic landscape such role is largely played by deluvial soils [BIENIEK 1997].

In north-eastern Poland, on the hills of front moraine, from 3^{rd} to 5^{th} degree of water erosion was reported [UGGLA et al. 1968]. In the areas of high erosion threat, proper arrangement of arable land, grasslands and forests is advisable [NIEWIADOMSKI, SKRODZKI 1964].

According to SIUTA [1990, 1995], nowadays in Poland, we have to deal with surplus agricultural land use. Especially light soils have been chemically and biologically sterilized by agricultural land use and bad water conditions and are successively increasing the share of wastelands and ineffective arable lands called marginal lands [KUKUŁA 1998]. In order to protect the lands against degradation, they ought to be afforested. However, frequently for economic and organizational reasons, land with soils of good quality is lain fallow. They are then subject to agrotechnical degradation [KUTYNA, NIEDŹWIECKI 1996; KRASOWICZ, FILIPIAK 1998]. The land which is lain fallow should be covered with perennials, extensively cultivated. This will reduce the development of uncontrolled succession of weeds [CZARNECKI et al. 1994]. The cover plants include *Trifolium pratense* L. with grass species, *Phacelia tanacetifolia* Benth. and *Raphanus sativus* L. var. *Oleiformis Pers.* [DZIENIA 1998]. As KOŚCIK and KALITA [1998] reported, perennials (for example *Urtica dioica* L.) are the forage and habitat for many beneficial animal species as well as protect soil against erosion simultaneously diminishing the rate of soil degradation.

Lying fallow of organic soils is a particularly negative phenomenon. On drained peatlands, as a result of ceasing human activity, existing drainage facilities are devastated, floristic composition of the green growth is impoverished, a fire threat occurs and the muck-forming process has unfavorable effects [NIEDŹWIECKI et al. 1998; KARWOWSKA 2002].

It is generally believed that any reclamation treatments on peatland are an ecenomic necessity. They destroy existing ecosystems, impoverish both biodiversity and productivity of water vegetation and animals [ILNICKI 1987;

LIPIŃSKI 1997; OKRUSZKO 1997]. Under the conditions of permanent high moisture content and with little air content, an accumulation of organic matter in the peatland occurs. It is an accumulation phase of wetland development [OKRUSZKO 1988]. Atlantic period was particularly favorable for the accumulation of peat (2.5 mm·year^{-1}), [STASIAK 1971].

When a peat soil is drained, muck-forming process occurs. It considerably changes the properties and the morphology of the soil profile. Humification and mineralization of organic matter leads to a decline of organic matter. This process is called a decession phase of peatland development [OKRUSZKO 1981; GOTKIEWICZ 1983]. As an effect, peatland surface level is systematically lowered and contributes to the shallowing of muck soils and their evolution towards mineral-organic and mineral soils [PIAŚCIK et al. 1990; PIAŚCIK, GOTKIEWICZ 1995; GOTKIEWICZ 1996; ŁACHACZ 2001]. The level of drained peatland surface is lowered by approximately 1 cm yearly. However, it can reach a value of 3 cm yearly [OKRUSZKO 1991; SZUNIEWICZ 1996] or sometimes 7 cm·year^{-1}, depending on the land use, depth and period of drainage [FRĄCKOWIAK, FELIŃSKI 1994]. Lowering of peat soil surface may lead to the secondary swamping of the soil and to a compensation phase in which the input and output of organic matter is balanced [OKRUSZKO 1996].

As a result of muck-forming process, water retention properties and capillary rise are diminished whereas the water outflow and water permeability increase [GAWLIK 1994; PIAŚCIK, BIENIEK 1998]. As a result of organic matter mineralization, an accumulation of phosphorus, potassium, aluminum and iron occurs in surface muck horizons. The process of decalcification leads to a decline of calcium and an increase of hydrogen content [PIAŚCIK, BIENIEK 2000]. Cation exchange capacity is decreased and high amounts of nitrogen are released [GOTKIEWICZ 1996].

The rate of mineralization of organic matter in organic soils is enhanced by cultivation requiring intensive drainage and by aeration tillage of surface layers [GOTKIEWICZ 1996]. The research carried out at Biebrza Experimental Station proved that cultivated soils released 20% more inorganic nitrogen during growing season than grassland soils. Forest land use does not protect organic soils against surplus mineralization of organic matter. Forests are drying the soil and worsening soil retention properties therefore the processes of mineralization of organic matter in forest soils are enhanced.

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