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3. CHARACTERISTICS OF SOIL COVER IN POLAND WITH SPECIAL ATTENTION PAID TO THE ŁÓDŹ REGION

3.1. Introduction

In this work, the basis for the analysis of soil cover in Poland was the concept of bioclimatic zonation of soil in its contemporary form. The occurrence of regularities in the distribution of basic systematic units of soil resulting from geophysical regionalisation was described, and in particular the consistent soil forming conditions. The factors determining the origins and development of soil formations resulting from the variability of geological base and geomorphologic processes were presented. The commonly used division of soil types into zonal, azonal, intrazonal and extrazonal units was assumed *a priori*.

The presented approach is based on the new taxonomy of soil in Poland developed by the Polish Society of Soil Science (2011), which in turn is based on the classification of soil resources found in the *World Reference Base for Soil Resources 2006* (2007). While

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describing the soil characteristics of Poland, the authors referred to the classification and taxonomy of soil formations, taking into consideration the issues of quality, which are the development of the classical soil-genetic approach as well as ecological features resulting from the functioning of soil in specific conditions of natural and anthropogenic environment. Attention was paid to issues which influence soil resources in the most dynamic manner, i.e. the major threats, the value of croplands and the need to protect the assets.

3.2. Features of the soil cover in Poland against the background of soil forming factors

As regards the soil, climate and vegetation taxonomy, Poland is located in the Central European, humid zone of the sub-boreal belt. The climate is moderately warm with oceanic influences, which lessen considerably eastwards. Mean annual temperature varies from 6.0 to 8.5°C, and the average long-term precipitation sum oscillates around 600 mm with more precipitation in summer months. The vast majority of the area of Poland, except for Kujawy, is characterised by positive water balance. As compared with the neighbouring countries, the hydrologic resources of Poland are low and result from low average annual runoff coefficient, which conditions the water balance (Kołodziej 2008). Varied height above sea level and land relief also contribute to the diversification of soil cover. This concerns above all grain size, morphology and chemical properties of soils. Lowland and upland areas, which constitute around 92% of soil resources of the country, are characterised by relative homogeneity conditioned mainly by bedrock types. Soils of the mountain areas (approximately 8% of soil area in Poland) have a distinct character, which results from significant variability of landform features, diversity of bedrock types, changeability of climatic conditions, water balance type and altitudinal zonation of vegetation (Jones et al. 2005, Ostaszewska 2008).

Most soils in Poland were formed after the latest glaciation period – Vistula (115 thousand – 11.7 thousand b2k) (Ber 2005). Formations from earlier glaciations were transformed or covered with deluvial, alluvial and eolian deposits from interglacial periods but also with periglacial, organic and, locally, alluvial Holocene deposits. Bedrocks of the vast majority of Poland's soils are various types of Pleistocene post-glacial deposits (of which the most important are glacial till, fluvioglacial and eolian formations), characterised by high variation of basic features: mineralogical composition, grain size distribution and arrangement of horizons. An important part is played by alluvial formations from contemporary rivers and bog and post-bog soils built from organogenic formations. In some areas of Poland, particularly in the Lesser Poland, Silesian and Cracow-Częstochowa uplands and in some mountain areas, bedrocks of contemporary soils are made of formations from earlier geological periods – mostly Mesozoic ones (Bednarek et al. 2004). An interesting aspect is the resistance of rocks to weathering, which contributes to the diversification of soil cover in the mountain areas. High mountains are built from solid magmatic and metamorphic formations, whereas low mountains were formed from deposit structures called flysch (clastic rocks from the Cretaceous and Tertiary periods, mostly schists, sandstones, siltstones and conglomerates) (Bednarek et al. 2004).

Taking into account the criterion of granulometric composition of bedrocks, the soil resources of Poland are as follows: soils made up of gravels and sands of various origins constitute nearly 46% of all soil formations, soils built of clays – about 25.5%, and soils made up of silts – nearly 8%. The remaining are soils formed from alluvial deposits (about 5%), organogenic structures (8.5%), carbonate rocks (approx. 1%) and massive rocks of various origins (about 6%) (Lekan and Terelak 1997).

Soil age is important while characterising soils in Poland. In the process of soil formation, a set of soil-forming factors acts upon the bedrock, which, with time, shape the soil profile, and, more precisely, its thickness and degree of development of individual genetic levels. Older post-glacial material, occurring near surface in the central and southern parts of the country (Nida, San, Krzna and Warta glaciations), is definitely more weathered and deeply decalcified than the younger materials deposited by ice-sheet in Northern Poland. Moreover, warm periods between glaciations saw intensive development of eolian processes, which had significant influence on the rising share of sands among soil-forming soils. Loesses, which constitute a scarce percentage of soil bedrocks, are a genetically similar material, though allochtonic for the area of Poland.

Land relief has a diverse influence on the character, properties and degree of development of soil cover. Although a significant part of the area of Poland is relatively flat, even small depressions are a source of irregularities in proper functioning of soils in the given area. Surface relief influences the variability of moisture, insolation conditions and development of vegetation. Poland is characterised by belt-like system of relief in latitudinal layout, typical of areas where ice-sheet formed several times. The lowest portions of the country, with diverse microrelief, covered with post-glacial deposits include: coastal belt, lake districts, Central Poland lowlands, uplands and sub-Carpathian basins. The mountain belt has its own specificity (Bednarek et al. 2004, Ostaszewska 2008).

Another important factor is the climate. Its main components which influence the formation, development and functioning of soils are: temperature, atmospheric precipitation, air humidity and winds. The average values of some parameters, mentioned at the beginning of this chapter, undergo changes in regional scale. One of the main climatic features is the increasingly continental character towards the east. It causes the average annual amplitude of temperatures to differ by about 4–5°C between the west and east of Poland (Degórski 1985). Mountain areas stand out as regards precipitation volume in comparison with lowlands and uplands. The average annual precipitation sum of 600 mm in most parts of the country is three times lower than that of the Sudetes or Tatra Mountains (Niedźwiedź 1992). It has a significant impact on the characteristics and intensity of biological and physicochemical processes in soils. Apart from the average annual precipitation sum, its distribution in individual seasons is of importance for the moisture content of soils in Poland. For example, in vast majority of soil formations, there occurs rinsing type of water balance, resulting from intensity of precipitation in spring and summer months, conditioned also by bedrock types.

Vegetation in the described area includes mainly post-Holocene remnants of deciduous and mixed forests, once typical, currently under considerable pressure owing to dynamic and progressive increase of coniferous stands (about 50% of all forest areas in Poland) dominated by such species as pine and spruce. It is a result of the past use of a large portion of the best quality soils of deciduous forests for agricultural purposes. The current afforestation rate of the country is 29.3% and is strongly diversified regionally. Forests occupy the genetically weakest and lowest quality soils, composed of easily-permeable sands, not suitable for the introduction of old-growth deciduous species and much less for agricultural use. Additional problems related to the impossibility of their use include diversified land relief and still frequent unregulated water regimes. Deciduous forests (broadleaved, beech, riparian and black alder forests) constitute an increasingly smaller share of Polish forests, which has an adverse impact on soil conditions in afforested areas (Bednarek et al. 2004, Lekan and Terelak 1997).

Apart from vegetation, it is necessary to take into account the participation of living organisms in the functioning of soils. Their diversity depends on the kind of development and use of the given area, intensity of biological and biochemical processes and efforts to provide proper conditions for the development of soil fauna. Considering the transformation of a considerable area of usable soils, disturbed ionic balance and other issues related to soil degradation in Poland, one must be aware of the pressure exerted on the living organisms responsible for: decomposition of dead organic matter and creation of humus, release of biogenic components, aeration of soil and formation of symbiotic relationships such as rhizospheres or ecto- or endomycorrhizas (Slankis 1974, Brundrett 1991). These phenomena occur locally, particularly in agricultural areas.

3.3. Diversification of soil cover on Poland

Taking into account all the characterised elements of the environment, it is possible to introduce a division of soils into formations typical of the given conditions, called zonal soils, often described as geochemically “independent” (Bednarek and Prusinkiewicz 1999). They border on intrazonal soils. Modifications in their distribution over the area of Poland result from changeability of moisture content, mostly due to proximity of groundwater, constant or periodical enrichment with foreign rock material, e.g. of fluvial origin, or, possibly, the occurrence of special kinds of bedrock, different than those that occur locally. Extrazonal soils, which constitute a small portion of the soil area in Poland, are characterised by their insular distribution and their share is highlighted in many classifications due to their exceptional quality and value in use. The whole is supplemented by locally conditioned azonal soils, which cannot be assigned any specific factors which determine their formation and development, as they include all surface formations in their initial stage of development. A feature of soil structure in Poland which is often stressed because of its high typological diversity is its mosaicity (Bednarek and Prusinkiewicz 1999, Lekan and Terelak 1997).

Having considered the above aspects, a clear domination of zonal soils is observed in Poland, but the characteristic feature, due to high diversification of bedrocks, moisture content and vegetation, is the occurrence of several soil types. They include mainly brown earth (brown soils and lessive soils covering about 51.5% of the area of the country) and podzols (podzolic soils, podzols and rusty soils covering about 26% of the area of the country) (Bednarek et al. 2004, Bednarek and Prusinkiewicz 1999). Brown earth soils originated in areas taken by multi-species deciduous and mixed woodlands. The main bedrocks of these soils include post-glacial formations (clays, sands), formations of water accumulation (mainly silts), and locally eolian accumulation (loesses and loess-like formations). Among these soils we can distinguish: Eutric Cambisols, Dystric Cambisols, Albic- and Glossalbic Luvisols. Podzolic formations

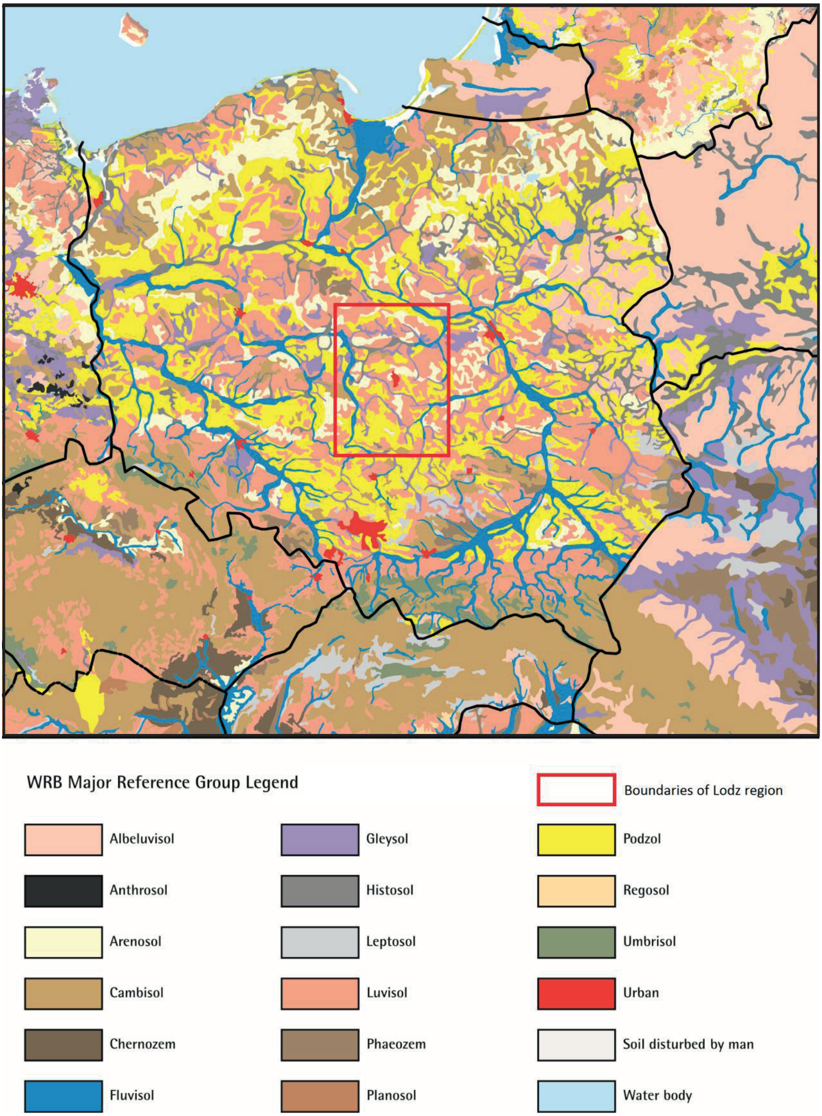

Figure 3.1. Distribution of main soil units in Poland

Source: elaboration based on *Fertilizer Use by Crop in Poland* (2003) originated in areas taken by coniferous woodlands with rare additions of other tree species. Bedrocks of these soils include first of all poor, easily-permeable sand formations of various origins, and in mountain areas – eluvium of acidic magmatic and metamorphic rocks and non-carbonate sedimentary rocks. This series includes: Dystric Arenosols, Haplic and Densic Podzols.

Intrazonal soils cover about 20% of the area of Poland and include:

- Fluvisols – covering about 5% of the area of soil resources, built mainly from formations of alluvial accumulation;
- Gleysols, Phaeozems, Gleyic Podzols, Mollic and Arenic Gleysols – originated in the conditions of periodic or constant excess moisture content related to high level of groundwater or stagnation of water upon poorly permeable formations;
- Histosols – typical of waterlogged areas, concentrated especially in the northern part of the country;
- Rendzic Leptosols – covering about 0.9% of the area of Poland and formed on carbonate bedrock (mainly limestone, marl and lacustrine chalk) and sulphate bedrock (gypsum);
- Pelli-Grumic Vertisols – created in the process of vertilisation from carbonate-rich marginal lake silts. They occur locally in the area of the Pomeranian Lakeland and Warmia;
- Salt-affected soils – occurring locally in the Nida Basin and Kujawy. Formed thanks to saline groundwater co-occurring with rock-salt diapirs and salt mines.

Extrazonal soils include mainly soils made of loess and loess-like formations – Chernozems (the best quality and usability soils in Poland, covering about 1% of the area of the country) and formations similar to soils of the Mediterranean areas of Calcaric and Chromic Cambisol type, formed with the participation of xerothermic plants in areas with evaporation type of water balance (Bednarek and Prusinkiewicz 1999).

The remaining part of the country is covered with azonal formations, which do not have a fully formed profile or are an effect of human activity. They include: Regosols, Pelosols, Lithic and Umbric Leptosols, Ochric Arenosols, Anthrosols, Urbisols, Technosols, Industrisols. Initial and poorly formed soils constitute about 2% of the area of the country (Bednarek and Prusinkiewicz 1999, Jones et al. 2005). Soils of anthropogenic origins are related to the occurrence of large urban units, industrial plants and they can also be the result of agrotechnological procedures that are highly invasive for the ground surface.

Soils of the mountain areas (Carpathians and Sudetes) are characterised by specific difference resulting from variability of vegetation and climatic conditions, of which only some show features analogous to soils of lowland and upland areas. The prevailing part are azonal soils. A characteristic feature of mountain areas is the vertical zonation of soil distribution. Bedrock type conditions soil diversification in lower zones, and bioclimatic factors determine the development of soils in the higher zones. Zonal soils are analogous with soils of lowland and upland areas, occurring in mountain basins and lower parts of individual massifs. Similarly as in the case of intrazonal soils in relation to Histosols, Gleysols and Rendzic Leptosols. Lithic and Umbric Leptosols have much more share than in lower areas. Distinctive features of mountain soils are their properties related to the genesis and age of rocks, high variability of moisture content, land relief and others (Bednarek and Prusinkiewicz 1999, Lekan and Terelak 1997, Ostaszewska 2008).

3.4. Ecological value and utility of soils in Poland

Soils of the highest ecological value are the ones included in protected areas and forests and used in agriculture. According to data from the Central Statistical Office, at the end of 2012 protected areas covered a total of 101 494.8 km^2, which accounts for 32.5% of the area of Poland. Of them, 3.1% were national parks, 25.7% were landscape parks, 1.6% were nature reserves, 69.7% were areas of protected landscape and 0.5% were ecological farmlands. The remaining 0.9% were nature and landscape complexes and documentation stations. As regards agricultural lands, they covered the area of 150.5 thousand km^2, which accounts for 48.1% of the area of the country (Table 3.1). Of them, 72.2% were arable lands, and 29.6% were grasslands. The area of forest lands was 93.7 thousand km^2, which accounts for 30% of the area of the country. Forests make up 97.8% of this area.

Table 3.1. Agricultural lands in Poland by voivodships at the end of the year 2012

Voivodship	Total agricultural lands	Arable lands	Grasslands
	occupied area in [thousands km^2]		
Dolnośląskie	9.6	7.5	1.4
Kujawsko-pomorskie	10.1	8.7	1.2
Lubelskie	14.1	10.6	2.3
Lubuskie	4.9	3.6	1.1
Łódzkie	9.9	7.7	1.6
Małopolskie	5.8	3.1	2.3
Mazowieckie	20.2	13.4	4.9
Opolskie	5.2	4.5	0.5
Podkarpackie	6.3	3.4	2.0
Podlaskie	10.8	6.5	4.1
Pomorskie	7.5	5.9	1.3
Śląskie	3.9	2.8	0.8
Świętokrzyskie	5.0	3.4	1.1
Warmińsko-mazurskie	10.4	6.3	3.5
Wielkopolskie	18.0	15.0	2.5
Zachodniopomorskie	8.7	6.4	1.4
Polska	150.5	108.7	32.1

Source: Local Data Bank of the Central Statistical Office, www.stat.gov.pl/bdl (21.09.2013).

As follows from the above, soils in Poland exhibit a wide variety of usage and development forms, which allows for their ecological value to be assumed as very high. High plant species diversity occurring on the soils, even in agricultural areas, is exceptionally valuable. Despite an increased share of monoculture in agriculture and particularly in forestry, biodiversity is much higher than in other Central European countries owing to considerable area segmentation resulting from ownership structure of farms (large portion of baulks, irrigation canals, domination of small farms – up to 20 ha and medium-size farms – between 20 and 50 ha). In regulations of the Minister of Environment (*Regulation*… 2004a, b) the list of wild species of plants and fungi includes: 428 items of species, families, and even entire classes of strictly protected plants, 51 items of partially protected plant species, 109 species of strictly protected fungi and 10 species of partially protected ones.

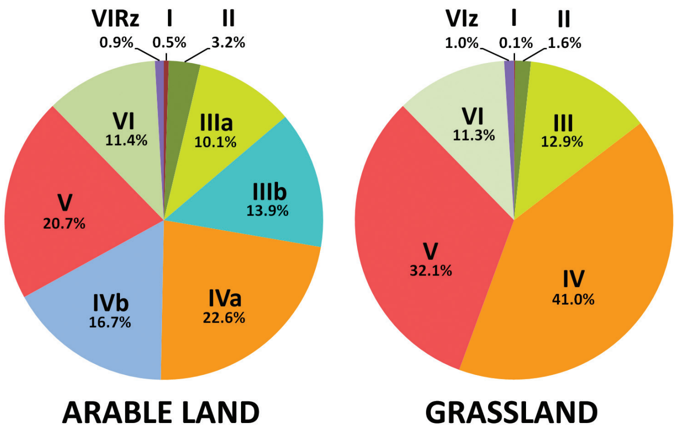

Figure 3.2. Percentages of soil-valuation classes in main groups of agricultural lands

(I – best quality soils, II – very good quality, IIIa-IIIb – good quality, IVa–IVb – medium quality, V – poor quality, VIRz–VIz – poorest quality)

Source: elaboration based on A. Mocek and S. Drzymała (2010)

Ecological value and utility of soil formations depend on numerous features of the environment and properties of soils themselves.

In Poland, the index which reflects the agricultural value of soils is the soil-valuation classes. Its basis is a precise determination of location with detailed characteristics and conditions which determine the fertility of soil. The main criteria for classifying soil into the given valuation class are: grain-size composition, thickness of the humus horizon and humus contents, hydrological properties of the soil, reaction and calcium carbonate contents, structure and usage of the area. Agricultural lands are divided for tillage into arable lands and grasslands (meadows and pastures) (Figure 3.2).

The utility of soils, understood as agricultural usefulness, is determined on the basis of allocating utility complexes. They group soil ranges which represent the same site types of agricultural production area in strict connection with the cultivated plants, mostly winter crops, as the best indicative plants, from which names of individual units are derived. The main features which provide the basis for inclusion in the given complex are: soil properties (type, kind, grain-size distribution, richness in plant nutrients, reaction, amount of humus and degree of agricultural conditions), moisture content, land relief and agroclimate. In arable soils, 14 complexes of agricultural utility are allocated (9 for lowland and upland areas, 4 for mountain areas and 1 which occurs in all these areas but which groups soils for grasslands), whereas in agricultural lands – 3. Wheat complexes (numbers 1–3) account for 26.3% of all arable lands, rye complexes (4–7) – 60.4%, cereal and fodder complexes (8–9) – 8.3%, mountain complexes (10–13) – 4.8%, arable lands for grasslands (complex 14) account for 0.2% of the area of arable lands. In grasslands, complex 1z covers 1.8% of their area, 2z – 60.5%, whereas 3z covers 37.7% of the total area of meadows and pastures (Skłodowski and Bielska 2009).

3.5. Soils of Poland in comparison with the soil cover of Central Europe

Soils in Europe are mostly conditioned by their location in the northern hemisphere, complex geological composition and diverse climatic conditions. Central Europe is an area which almost entirely lies in the subboreal belt. The continental index, which grows eastwards, modifies the variability of soils in the area to the largest degree, though, at first glance, soils in this part of Europe show homogeneity (Jones et al. 2005).

Despite a considerable production potential, the soils of Poland, compared with the neighbouring countries, rank as poor in the European context. The main problem is not, as one might assume, the genetic poverty of soils but issues which result from inappropriate soil management. The basic problem is the high acidification of soils and very low renewability index of organic matter resources in soil (Skłodowski and Bielska 2009). Additionally, in Poland there is a significant threat of erosion (particularly of agricultural lands) and compaction in reference to soils from young glacial formations (Krasowicz et al. 2011, Wawer et al. 2010). Comparing zonal soils of Poland with areas of the neighbouring countries, it is easily noticeable that the share of brown earth soils increases to the west of national borders, similarly to the share of podzols in the eastern and northern directions. Also typical in this part of Europe are albeluvisols (Figure 3.1). It is an effect of increased continentalism towards the east, which corresponds to more severe climatic conditions and decreased amount of deciduous forest stands (Degórski 1985). Not far from the south-eastern part of Poland, there is a quite clear boundary of cohesive range of Chernozems and grey soils, which are typical for steppe plant formations (Bednarek et al. 2004).

3.6. Threats and degradation of the soil cover

The vast majority of soil resources in Poland has been transformed as a result of anthropopressure. It is only in areas which are environmentally precious (national parks, selected forest, floristic and soil reserves) that we can observe quasi-natural soil covers. The Central Statistical Office reports that at the end of 2012, there were 643.4 km^2 of soils and lands that required recultivation, which is a nearly 10% decrease in comparison with the year 2003. Degraded lands within this area covered 88.6% (of which more than a half as a result of mining), whereas devastated lands covered 11.4%.

The main aspects of soil transformation include: impoverishment or elimination of ectohumus, inappropriate hydrological improvement (in almost the entire area of Poland, there has been a lowering of groundwater level, locally considerable), degradation of natural vegetation (primarily, by numerous deforestations for agricultural purposes) and improper agricultural management (mainly due to the use of invasive agrotechnological procedures and improper fertilisation which caused disturbance of the natural ionic balance) (Baran and Oleszczuk 2003, Degórski 1987, 1995, 1997, Jankowski and Bednarek 2000, Kabała and Chodak 2000, Krasowicz et al. 2011, Tołoczko et al. 2009).

Wind erosion poses a threat to over 25% of the area of the country and is the most troublesome in areas with scarcity of water in the regions of Central Poland, East-Baltic Lakeland, and in areas where loess and loess-like rocks occur. In turn, water erosion threatens around 30% of the area of Poland. The highest intensity of this threat concerns the areas of mountains, foothills and lake districts (Krasowicz et al. 2011, Wawer et al. 2010).

Geomechanical transformations of the soil cover are related to areas where underground and surface mining are present, water reservoirs are built, landfill sites operate and infrastructure is constructed. A repercussion of geomechanical transformations are hydrological transformations. The biggest problems in this respect include excessive drying of soils in areas influenced by surface and underground mines and improper land drainage (Degórski 1995). There are areas in Poland, where hydrogenic soil formations have been transformed into semi-hydrogenic ones, and semi-hydrogenic formations into autogenic ones. It was related to changes in water balance of soils as a result of lowered level of groundwater in almost the entire area of Poland after heavy land drainage. Effects include a decrease of ecological value and utility of soils. Locally, water inflow occurs for the following reasons: infiltration of water from newly built artificial reservoirs, construction of liquid waste reservoirs and creation of subsiding troughs in mining areas. As a result of agrotechnological procedures, convex landforms with arable farming are exposed to the risk of humus layers being washed away. Polish soils did not manage to avoid this phenomenon, which locally led to slight erosive soil degradation (Degórski 1995). Another significant problem is the compacting of top soil horizons caused by mechanical soil packing with heavy machinery. A decrease in the biological activity is observed in this respect, particularly in soils with high water content, of up to 50–70% (Mocek and Drzymała 2010).

The main problems of chemical degradation of soils in Poland include: acidification, loss of organic material, excessive accumulation of heavy metals and organic xenobiotics (mainly PAHs). Whereas soil acidification is a natural phenomenon, in certain areas of Poland this phenomenon is intensively stimulated by humans (Degórski 1987). The so-called acid rains play the biggest part in this respect. Emission of carbon, sulphur and nitrogen compounds from industrial plants of Upper and Lower Silesia and from areas of large urban centres is responsible for this phenomenon to the largest extent (Degórski 1995, Jones et al. 2005). Acidification of soils in Poland results in a number of other adverse phenomena, such as decreased sorption capacity of the already poor soils, reduced assimilability of some nutrients, decreased activity of microorganisms and general deterioration of fertility (Degórski 1987). Loss of organic material in soils is a more complex issue. It results above all from the use of increasingly smaller amounts of natural fertilizers (particularly of manure, which is very beneficial) and increasingly deeper ploughing in arable lands. An additional aspect is incorrect land improvement.

Heavy metals in the soil environment occur primarily, similar to the rest of Europe, in highly industrialised and urbanised areas. The problem concerns a small part of soil resources in Poland (mainly in the Silesian and Lesser Poland voivodships) and is burdensome mainly for people who run agricultural activity, particularly in the cities in residential or allotment gardens (Degórski 1997, 1998, Degórski and Gworek 1997, Oleszek et al. 2003).

The issue of PAH concentration in soils is even more marginal. About 80% of soils in the country are not polluted with these compounds at all, and high degradation is only reported in isolated spots (mainly around landfills, industrial plants and agricultural areas where sewage sludge is used as a fertilizer) (Baran and Oleszczuk 2003, Kaszubkiewicz et al. 2010, Maliszewska-Kordybach et al. 2008, Oleszczuk 2006, Oleszek et al. 2003). It is worth noticing that with time the compounds undergo fast biodegradation, which is why PAHs are not currently considered as an important threat to soils in Poland.

Protection of soils and reclamation treatment do a lot of good in this respect. Taking into account the advance of reclamation treatment, in the last decade an average of 1754 ha of soils of various forms of use were rehabilitated annually (data obtained from Central Statistical Office). The annual average area of rehabilitated lands in the last decade were 791 ha in agriculture and 533 ha in forestry. Current soil protection is an attempt at preventing numerous threats and is executed in a more and more effective way.

3.7. Characteristics of the soil cover in the Łódź region

Boundaries of the Łódź region were assumed according to the distinction, proposed by K. Turkowska (2006) and often used in physical geography, of an area located in the central part of Poland, stretching between the maximum extent of the Vistula glaciation in the north and the Warta stage of the Odra glaciation in the west, the Warta valley in the west and valleys of the Pilica and Rawka rivers in the east. Extent of the region defined in this way is a result of numerous geomorphologic and palaeographic studies.

The Łódź region is characterised by relatively flat surface, with only several highlands reaching more than 50 m above terrain level. The flat surface is an effect of the action of Scandinavian ice-sheets, which left behind a considerable amount of sediments, most of which are bedrocks for contemporary soils today. However, the area is not completely homogenous in this respect. Some locally occurring bedrocks include deluvial, fluvial and dune formations, as well as contemporary organogenic and alluvial material of some rivers. There are not many rocks that originated before the Pleistocene and Holocene, e.g. from the Mesozoic, whose outcrops in the Łódź region are not numerous and are found mostly in the southern part of the area. Their vast majority includes carbonate rocks which form rendzinas and calcareous initial soils with poorly developed profile (Laskowski 1993).

Taking into consideration the grain size distribution of rocks that build soils, similarly to the rest of Poland, the dominating type are sands (about 62% of all formations) of fluvioglacial and eolian origin (inland dunes are common here) and sands of fluvial accumulation (Laskowski 1993). High concentration of the sandy fraction is also an effect of geomorphologic processes, in which the leading role was played by the periglacial conditions, and more precisely, climatic conditions (especially dry, frosty and strong winds) in the foreground of the latest glaciation in Poland (Manikowska 1998, 2001). The second position (24%) is occupied by clayey formations with the remains of ice-sheets. Silt formations constitute a small percentage (8%) and are mostly admixtures in the sandy fraction in the structure of soil profiles. Organogenic formations (about 6%) are related to the occurrence of local wetlands in the form of marshes, peat-bogs, peat and silt soils and rendzinas (Laskowski 1993).

The climatic conditions of this area do not differ much from average values for the entire country. Absence of large water reservoirs, mountain areas, small geographic extent and relative surface flatness do not contribute to typological diversity of soils in the region as regards climatic conditions. It is only the microclimate, in connection with local environmental conditions, that can play a role in the process of forming different soil units than the ones that are typical for this area (Laskowski 1993, Manikowska 2001).

The potential flora in this region used to be forests, which at present constitute 4.2% of the forest resources of the country, which is a very low value with 16 voivodships in total. Small area is compensated with a large number and high diversity of species in tree stands. The described region includes many protected areas in the form of nature reserves, landscape parks, protected landscape areas et cetera. A significant number of protected plant species occur in the forests of the region. Soils of the forest areas include mostly formations built of eolian and fluvioglacial sands.

The Łódź region is characterised by scarcity of surface and underground waters. There are no large river valleys, and a large part of the region lies in the watershed area of the main Polish rivers, i.e. the Vistula and Odra. Contemporary hydrographical network of the characterised region is an effect of interactions of the Odra glaciation, overlaid with the Holocenic transformations of river valleys and human activity. The impact of bedrock is visible in the dominating direction of water flow being from the south-east to the north-west (Laskowski 1993).

As regards soil types, brown earth and podzolic formations clearly prevail, covering 75% of the area of the region. The share of hydrogenic and semi-hydrogenic soils is relatively small and they include mostly sandy and sandy-clayey formations or, less frequently – sandy-silty ones.

The occurrence of brown earth soils is limited due to the fact that a considerable portion of postglacial rocks was covered by sandy sediments of eolian origin. They constitute about 45% of soils in the region. They were formed upon the richer and more diverse (as regards grain-size distribution) bed rocks, mainly clays. Individual types do not differ much in morphology, but rather in chemical properties. In Poland, we distinguish proper, acidic and alkaline brown soils, whose names perfectly correspond to the characteristic features of these formations.

Rusty soils, podzolic soils, podzols, which cover 30% of the area of the Łódź region, were formed in the conditions of harsh climate and were mostly covered with coniferous forests. The effect is their acidic or strongly acidic reaction, locally neutralised by the presence of clay inserts, mostly in the form of glacial till. Podzolic soils and podzols occupy the genetically weakest positions and are very poor sites of mostly forest soils. In agricultural areas, they are less and less frequently cultivated, mainly due to their very low utility. Rusty soils are also poor in nutrients and often very strongly acidized (Laskowski 1993).

Black earths (15%) occur in areas of high hydration and mainly on clays, whose characteristic feature is a high content of calcium carbonate. They have the thickest humus horizon of all soils in the region, reaching 30–40 cm, of black colour and with good agricultural properties. A limitation of their use in the past was high groundwater level. Currently, with the advances of land improvement techniques, they are the most fertile soils in the Łódź region, and as a result of improper use, they often undergo agricultural degradation.

Peat soils and muck-peat soils (2%) originated mostly from peats of low peat bogs. Muck-mineral soils (3%) formed from shallow and medium-depth peat bogs lying over sands which became drained for some reason. Silt-peat soils (1%) are present in valleys of small rivers and minor flows as a result of co-occurrence of the peat-forming and aggradation/silting processes.

Absence of large river valleys limited the development of Fluvisols, whose share in the region is scarce and amounts to about 3%. Despite accompanying many small flows they do not present high value in use. They are of ecological importance, providing refuge for many species of plants, particularly within the characteristic formation of riparian forest. These soils were created mainly in floodplains, i.e. places where there were no favourable conditions for peat development. Their use in agriculture is limited mainly to meadows and pastures (Laskowski et al. 2006).

The southern part of the region is where shallow rendzinas occur (1%), in which solid bedrock appears at the depth of several dozen centimetres from the surface. In comparison with sandy soils, they are still good and very good quality soil formations due to their alkaline reaction along the entire profile and cloddy structure, which is a result of calcium compounds interacting with the substrate (Laskowski 1993).

Acidification of soils in the Łódź region is the basic symptom of soil degradation. This problem concerns over 80% of all soils in the region, and locally in smaller geophysical units, it reaches up to 90% (Laskowski and Tołoczko 1998, 2001, Niewiadomski and Tołoczko 2005). The commonly used calcium fertilisers are supposed to prevent this phenomenon, but the genetic poverty of soils, resulting from sandy grain-size distribution and low sorption capacity do not favour improvement of soil condition. Soils of the Łódź region, apart from deacidification, also require fertilisation with basic microelements necessary for proper growth of plants. Low chemicalisation index and extensive agriculture are another problem of the soil environment, which is permanently deprived of organic matter and other components (Laskowski 1993, Laskowski and Tołoczko 2001, Laskowski et al. 2006).

In the years 1957–1964, soil-valuation was performed in Poland. In this classification poor quality soils prevail in the Łódź region. In the case of arable land, classes IV, V, and VI altogether cover about 80% of the area. The entire region lacks soils of class I (highest quality soils), and the share of class II (very good quality soils) is only about 1%. The remaining soils belong to quality class III. The situation is even worse for permanent grasslands. Here, better quality classes (I–III) constitute less than 5% of all soils. It proves their low utility, and the only advantage is their higher biodiversity than that of arable areas (Laskowski 1993).

As regards agricultural utility complexes of soils, the percentage of wheat (1–3) is about 10%, rye (4–7) about 80%, cereal and fodder – about 10%. Complex 14 occurs sporadically (Laskowski 1993). The low utility of soils is to some extent an effect of their genetic conditions and reflects the condition of agriculture in the region, which has always been evaluated below average in comparison with other regions of the country.

The Łódź region is currently an intensely developing area, in which numerous infrastructural, mining and urban investments are concentrated. An important aspect of threats and degradation, and even devastation of soils in the region is the development of brown coal mining concentrated in the area of Bełchatów and Konin and the planned similar investments near Sieradz and Poddębice. In these areas, thousands of hectares of biologically active soils have been excluded from use. Owing to the location in the central part of Poland, the development of the road and motorway network is particularly intensive here. Because of this, in the last decade several hundred hectares of soils were excluded from use each year. On the other hand, after finishing mining exploitation, significant areas were restored to agricultural and forest use in the area of Bełchatów. Soil reclamation also includes former military grounds and communal and industrial landfill sites. Works are performed in the area of over 1200 ha of soils which used to be military ranges.

Among chemical impurities, the main problems, though marginal, are sulphur (Laskowski and Tołoczko 1998, Trawczyńska and Tołoczko 2006), heavy metals, whose deposition is concentrated in the area of Łódź and other bigger urban centres of the region (Laskowski et al. 2001, Trawczyńska and Tołoczko 2005a, b, Tołoczko et al. 2009), as well as a small share of PAHs in soils which neighbour communication areas (Laskowski and Tołoczko 2003, Laskowski et al. 2005).

3.8. Conclusions

The vast majority (as much as 92%) of soil resources in Poland occur in lowlands and uplands, and only 8% of the area of Poland has the characteristics of mountain soils. Nearly a half (46%) of soils in Poland is created of sandy formations of various origins – usually with a slightly acidic pH.

Soils of the Łódź region were mainly formed from sands, and to a lesser degree from clays, silts and organogenic formations. Brown, lessive, podzolic and rusty soils dominate here. Chernozems, fen soils, organogenic soils (peat, muck and silt soils) and rendzinas are also present. Owing to their sandy grain-size composition, they are most often light and very light for cultivation. Most soils are acidified.

Socioeconomic and natural conditions have determined the utilisation structure of soils in the Łódź region, where arable lands constitute 60% of the area and grasslands – less than 10%.

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