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The soils of the South Central Planning Region in Bulgaria – distribution, characteristics, limiting degradation factors

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Abstract

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The paper presents a brief description of the soils in the South Central Planning Region of Bulgaria. Soil differences and their distribution are indicated through analysis of printed and digital map material. The established information is supplemented with a graphic representation of the soils using a geographic information system (GIS). Some of the morphological features of soils, as well as several of their chemical and physicochemical characteristics, are highlighted. A few fundamental natural and anthropogenic factors related to the influence of degradation processes leading to a decrease in soil fertility are presented.

Keywords: soil units; GIS; soil characteristics; degradation processes; soil fertility

Introduction

The soil provides both material and spiritual benefits to humanity (Teoharov and Hristov, 2016). It provides an environment conducive to natural plant growth and crop cultivation, and is crucial for regulating the water cycle (Rousseva, 2015). This property of soil depends on its fertility, related to the supply of nutrients (Gyurov and Artinova, 2015). Another important factor is soil organic matter, which determines the quality of soils (MOEW, 2024) and provides important information about their genesis, ongoing processes, and monitoring (Filcheva et al., 2018).

It is known the tendency for decreasing of soil organic matter in arable lands due to the removal of the surface soil layer as a result of water and wind erosion, as well as the implementation of intensive tillage (Rousseva, 2015), which determines the main task, related to the optimal maintenance of the soil's physical state (Nenov et al., 2015). Therefore, determining changes in soils under the influence of various agrotechnical activities is a subject of extensive research (Nedyalkova et al., 2015).

Acidification is another soil process that can occur under natural conditions, depending on the soil-forming parent materials and the growing vegetation, or under anthropogenic impacts related to the unbalanced use of nitrogen fertilizers (Teoharov, 2015). Here, in the second case, especially with insufficient use of organic fertilizers, this can lead to the degradation of soil humus (Penkov et al., 2008).

The above illustrates that the irrational use of soil resources can lead to physical disturbance, degradation, or pollution of soils (Penkov et al., 2008).

The paper aims to present briefly the soils of the South Central Planning Region in Bulgaria and some factors related to the influence of natural and anthropogenic soil degradation processes.

Materials and Methods

The research is carried out by determining the soils in the studied region and surveying literary sources related to basic soil properties and characteristics.

The soil units are indicated in accordance with the Soil Map of Bulgaria in scale 1:400 000 (Koynov et al., 1968a) and its digital version (ISSAPP "N. Poushkarov", map archive).

The determined FAO soil names in the digital map are synchronized with the latest edition of the World Reference Base for Soil Resources – WRB (IUSS Working Group WRB, 2022).

Map data for spatial localization and visualization of the region are based on OpenStreetMap (OpenStreetMap contributors, https://www.openstreetmap.org/copyright).

The digital processing and graphic representation of the soil map is carried out through the geographic information system QGIS, 3.22.

Results and Discussion

Soil units

The South Central Planning Region (SCPR) covers approximately 22,365 km^2, encompassing the districts of Plovdiv, Pazardzhik, Smolyan, Kardzhali, and Haskovo in Bulgaria. The majority of the area is characterized by agricultural (48.1%) and forest (45.1%) areas (National Statistical Institute, 2024; Sapundzhiev and Mitreva, 2016; Regional Administration Plovdiv, 2024). SCPR is characterized by diversity in terms of soil types and soil varieties (Figure 1).

Brown forest soils (Cambisols)

Brown forest soils cover almost the entire territory of Smolyan District and the southern half of Pazardzhik District. Separate areas are observed in the northern part of Plovdiv and Pazardzhik districts, as well as the southernmost part of Kardzhali district. In their most extensive area of SCPR, these soils are determined along with Humus calcareous soils, secondary grassed, and Mountain meadow soils. Together, they are spread over an approximate area of 7,590 km^2 in different parts of the SCPR (Koynov et al., 1968a;

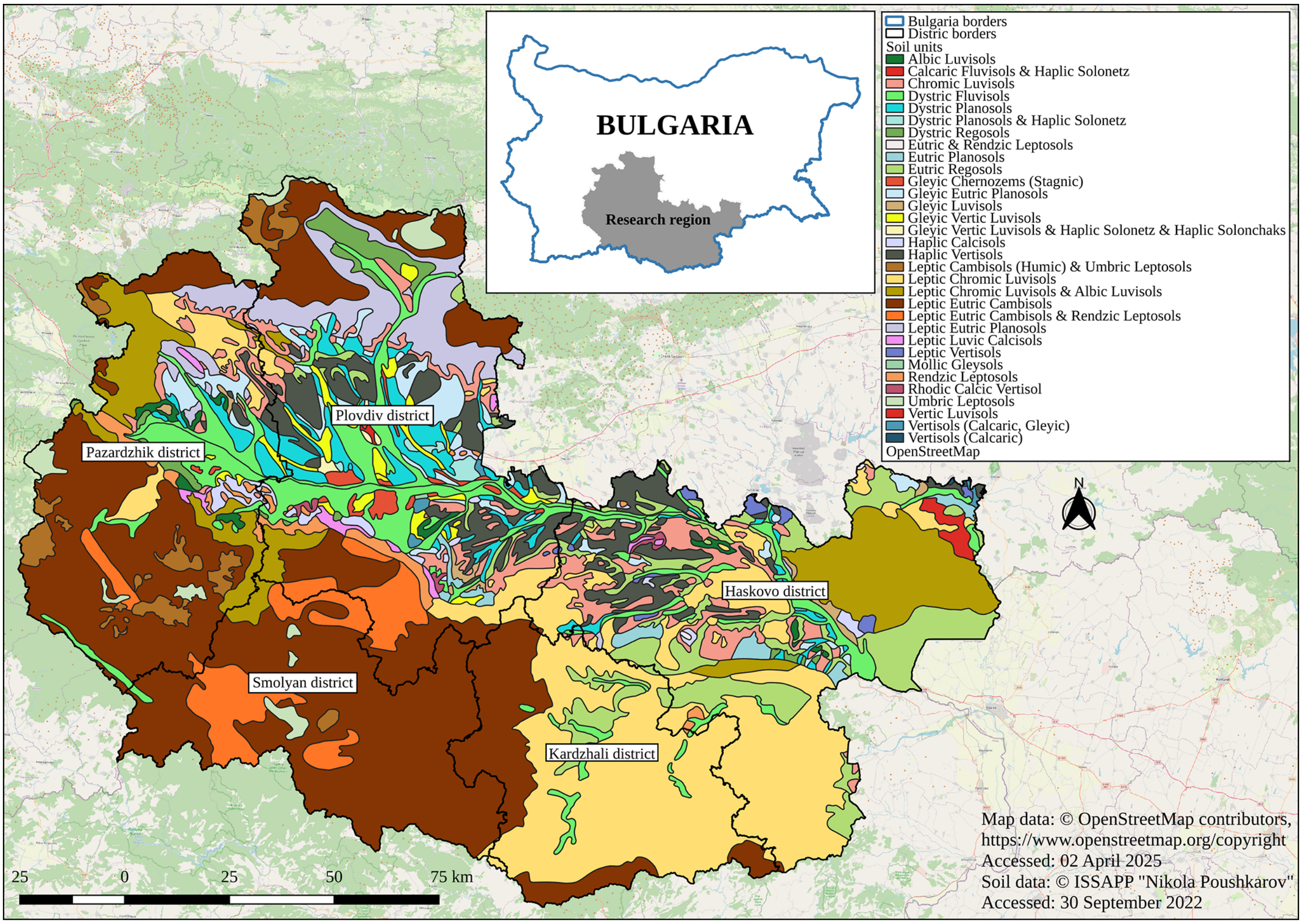

Fig. 1. Soil map of the South Central Planning Region in Bulgaria

Figure 1). Brown forest soils belong to the forest fund, and a small part of them is used in agriculture (Penkov et al., 1992).

The thickness of the soil profile at the development of forest vegetation reaches 60–80 cm and is characterized by a large content of coarse fragments, which increase in depth (Koynov et al., 1998). The humus horizon in different soil varieties ranges from 5–6 cm to 26–30 cm (Penkov et al., 1992).

In natural conditions, the humus content is above 3%, but in agricultural soils, it is lower (below 2%) (Koynov et al., 1998). Likewise, in cultivated soils, the amounts of nitrogen and phosphorus decrease; however, under natural conditions, the content of total nitrogen ranges from 0.1% to 0.50%, and that of total phosphorus from 0.02% to 0.04%. The pH activity is acidic throughout the soil profile (pH H_2O 4.5–5). The sorption capacity is low in the subsurface metamorphic horizon (10–15 cmol/kg^{-1}). In the composition of exchangeable cations, calcium prevails (Gyurov and Artinova, 2015).

Degradation processes

The relief is highly fragmented, which creates the prerequisite for the natural development of erosion processes. This factor, together with strong acidification and the decline in humus content, is primarily related to the decrease in fertility of the Brown forest soils (Gyurov and Artinova, 2015). In some cases, deep ploughing can also lead to increased erosion processes (Koynov et al., 1968b).

Leached cinnamon forest soils (Chromic Luvisols)

The Leached cinnamon forest soils are typical throughout almost all areas of the Kardzhali district and parts of the Haskovo district in the SCPR. Separate areas are located in the central and northern parts of Pazardzhik District and the southeastern part of Plovdiv District. In the northeastern part of Haskovo district and areas of Pazardzhik district, these soils are highly leached to slightly podzolic. In the remaining administrative districts in SCPR, the distribution of cinnamon soils is represented by their various soil varieties (Koynov et al., 1968a; Figure 1). These soils occupy low-hilly and submountainous areas, where, under natural conditions, not only forest but also herbaceous vegetation develops (Koynov et al., 1998). In SCRP, the cinnamon soils are located in sites with a total area of around 7,371 km^2 (Figure 1).

Morphologically, the Leached cinnamon forest soils in the main agricultural areas are usually well-developed, whereas in the semi-mountainous areas, they are shallow. Some of these soils are highly leached to slightly podzolic. The humus-accumulative horizon is well-structured and reaches a depth of 25-35 cm. Below follows a compact illuvial horizon with a thickness of between 60 and 80 cm (Koynov et al., 1968b).

The humus content in the surface horizon is between 4% and 5% in natural conditions and decreases to 2.5% in cultivated soils (Gyurov and Artinova, 2015). pH activity is slightly acidic (pH 6–6.5). The sorption capacity ranges from 17 to 47 cmol/kg^{-1}, with higher values in the illuvial horizon. Similar to Brown forest soils, the composition of exchangeable cations is dominated by calcium (Koynov et al., 1968b). In the cultivated soil layer, the average content of total nitrogen is 0.2%, and that of total phosphorus ranges between 0.15% and 0.5%. Likewise, the available forms of these elements in soils are insufficient, unlike potassium, with which the soils have a favourable quantity (Gyurov and Artinova, 2015).

Degradation processes

The main factors limiting the fertility of Leached cinnamon forest soils are related to the reduction of humus content in arable soils, destruction of the cultivated soil layer, and the development of erosion processes (Gyurov and Artinova, 2015). On the other hand, the disturbed soil structure contributes to the deterioration of the water-air regime and physico-chemical properties of the surface arable soil layer (Penkov et al., 1992).

Pseudopodzolic soils (Planosols)

Pseudopodzolic soils include the light grey forest soils of northern Bulgaria and the podzolic cinnamon forest soils of southern Bulgaria (Penkov et al., 1992). In SCPR, they occupy a total area of approximately 2,194 km^2 (Figure 1). Pseudopodzolic soils are distributed as different soil varieties adjacent to the varieties of Cinnamon forest soils and meadow cinnamon soils, mainly in the Plovdiv district. These soils are also found in areas of the Haskovo district and the northern part of the Pazardzhik district. In small areas of the Plovdiv district, they are located near saline soils (Koynov et al., 1968a; Figure 1). Pseudopodzolic soils are formed on flat, undrained relief and have texture-differentiated profiles because of the processes of leaching and clay movement within the depth of the soil profile (Penkov et al., 1992).

Cinnamon podzolic soils are characterized by a 25–30 cm humus-eluvial horizon, below which follows a dense, clayey, illuvial horizon with a thickness of 80–100 cm. In semi-mountainous areas, the soils are shallow, with a soil profile thickness of up to 50 cm (Koynov et al., 1968b). A characteristic feature of Pseudopodzolic soils is the occurrence of surface gleyic processes, which depend on the periodic waterlogging and drying of the soil (Gyurov and Artinova, 2015).

These soils are among the poorest in Bulgaria and are characterized by an acid to very acid reaction (pH KCl 3.5–5.0). Cultivated areas contain approximately 1%–1.5% humus, whereas in natural conditions, this amount reaches 2.0%–2.5% (Koynov et al., 1968b). The soils have a low content of total nitrogen and total phosphorus, as well as an insufficient amount of total potassium, which affects their supply with available forms of these elements. The sorption capacity is low in the surface horizon (8–10 cmol/kg^{-1}). In the illuvial horizon, it reaches 35 to 45 cmol/kg^{-1} (Gyurov and Artinova, 2015).

Degradation processes

Unfavourable soil properties (surface waterlogging, very acid reaction) and low natural fertility are the main factors limiting the use of Pseudopodzolic soils in agriculture (Gyurov and Artinova, 2015). The unstable soil structure contributes to its easy destruction during tillage (Penkov et al., 1992). In addition, agricultural areas in hilly regions, where the Pseudopodzolic soils are shallow, are susceptible to erosion processes (Koynov et al., 1968b).

Alluvial-meadow soils (Fluvisols)

Alluvial-meadow soils are widespread in Plovdiv and Pazardzhik districts, where they are close to the various varieties of Pseudopodzolc soils and Leached cinnamon forest soils. They are less common in the Haskovo and Kardzhali districts. In a small area in the central part of the Plovdiv district, soils are established alongside saline soils (Koynov et al., 1968a; Figure 1). The approximate area of Alluvial-meadow soils in SCPR is 1,504 km^2 (Figure 1). These soils occupy the central part of the river valleys, following the Alluvial soils, and are located further away from the river bed, where the deposited sediments are finer and the groundwater is at a depth of 1.5 m from the soil surface (Gyurov and Artinova, 2015).

Morphologically, the soils have a humus horizon up to 40 cm thick, below which alluvial sediments are present. In virgin soils, its structure is granular (Koynov et al., 1968b). In the individual layers with alluvial materials below the humus horizon, gleyic processes can be observed at depths of more than 100 cm (Gyurov and Artinova, 2015).

The content of humus in natural conditions is between 1% and 5%, and in cultivated soils from 1 % to 2 % (Koynov et al., 1968b). The pH values range from weakly alkaline to weakly acidic, and the sorption capacity is between 20 and 30 cmol/kg^{-1}. The content of total and available forms of nitrogen and phosphorus in Alluvial-meadow soils is low, in contrast to potassium, which is in better quantity (Gyurov and Artinova, 2015).

Degradation processes

The main factors limiting fertility in Alluvial-meadow soils are related to the reduction of humus content due to long-term tillage, insufficient moisture in the surface layer during summer, and the possibility of erosion processes occurring during intense river floods (Gyurov and Artinova, 2015).

Smolnitsas (Vertisols)

Smolnitsas in SCPR are primarily distributed in Plovdiv and Haskovo districts, where, along with Pseudopodzolic soils and cinnamon soils, they contribute to the varied soil cover of the studied region. The different varieties of these soils are spread over a total area of around 1,208 km^2 of SCRP (Koynov et al., 1968a; Figure 1). Smolnitsas have high clay content and are found in lowland and plain fields. They are distinguished by their substantial shrinkage in the dry state, in which cracks form, and swelling in the wet state (Penkov et al., 1992).

Smolnitsas have a thick humus horizon that reaches 60–80 cm in depth. It divides into 25–30 cm of loose surface and sub-surface soil horizons and passes into a transitional horizon, which, below 80–100 cm, transitions into carbonate-rich soil-forming parent materials with carbonate nodules (Koynov et al., 1998; Gyurov and Artinova, 2015).

The humus content is between 5% and 6% in virgin soils and lower in arable soils, ranging from 2.5% to 4%. In depth of the soil profile, this amount decreases gradually. The pH activity in surface horizons is neutral to slightly alkaline in typical Smolnitsas and slightly acid to neutral in the leached soils (Penkov et al., 1992). The sorption capacity ranges from 30 to 66 cmol/kg^{-1}, with a predominance of calcium in the composition of exchangeable cations (Koynov et al., 1968b). Soils have a favourable quantity of total nitrogen, which decreases with depth in the soil profile. The amount of phosphorus is insufficient in contrast to the favourable potassium regime (Penkov et al., 1992).

Degradation processes

Due to their heavy mechanical composition, Smolnitsas have unfavourable physico-mechanical properties related to plasticity and stickiness in a moist state and high solidity in a dry state, which makes their tillage difficult in the absence of optimal soil moisture (Gyurov and Artinova, 2015).

Humus calcareous soils – Rendzinas (Rendzic Leptosols)

Rendzinas are found in various parts of Bulgaria, with the majority located in the semi-mountainous and mountainous regions (Penkov et al., 1992). In SCPR, they occupy larger sites with a total approximate area of 900 km^2, along with Brown forest soils, as stated above. Here, we will note that this area is also discussed in the context of the properties and characteristics of the Brown forest soils. Smaller sites with Rendzinas (approximately 226 km^2) have also been identified, typically located near Alluvial-meadow soils in the central part of Pazardzhik District and the southern part of Plovdiv District (Koynov et al., 1968a; Figure 1).

Rendzinas are formed on calcareous rocks. The thickness of the soil profile in typically developed soils exceeds 50 cm, but in shallow soils, it is typically 15–20 cm. The surface horizon is loose, characterized by a granular structure and varying thickness (Koynov et al., 1998).

The humus content in virgin soils varies widely (from 5% to 13.5%), depending on altitude, and decreases to 3% in cultivated areas (Koynov et al., 1968b). The pH values in different soil varieties range from neutral (pH 7.0) to slightly alkaline (pH 8.2–8.5). Sorption capacity varies depending on the humus content and is above 30 cmol/kg^{-1}. Calcium is predominant in the composition of exchangeable cations. Despite the high amount of total nitrogen, Rendzinas are poor in the available form of this element. Available phosphorus also has a lower content (Gyurov and Artinova, 2015).

Degradation processes

Soils that are common in mountainous and sub-mountainous areas can be affected to varying degrees by erosion processes (Koynov et al., 1968b).

Mountain meadow soils (Umbric Leptolols)

The Mountain meadow soils occupy mixed sites alongside Brown forest soils on a total area of approximately 391 km^2. Like in Rendzinas, these sites are calculated in the discussion of Brown forest soils distribution. Mountain meadow soils are also found on small, separate territories with a total area of approximately 243 km^2, adjacent to the Brown forest soils in Pazardzhik district, the southern parts of Smolyan district, as well as in the northern parts of Plovdiv district (Koynov et al., 1968a; Figure 1). These soils are located in the high mountain zone and are characterized by meadow grass vegetation (Penkov et al., 1992; Gyurov and Artinova, 2015).

The thickness of the soil profile is typically 20–40 cm to 80 cm, and almost all of it is represented by a humus horizon that is abundant with the roots of herbaceous vegetation (Koynov et al., 1968b). Some soils may have up to 10 cm of weak metamorphic horizon (Penkov et al., 1992).

The pH activity of Mountain meadow soils is acidic (pH H_2O 4–5) with high exchange acidity. Humus content is high and varies widely depending on the nature of humus formation, which can result in soils with chernozem-like properties (5–10% humus), sod (10–20% humus), or peat (20–30% humus). The sorption capacity ranges from 10 to 50 cmol/kg^{-1}. Soils are well stocked with total nitrogen (0.3% – 0.4%), in contrast to their available form (Gyurov and Artinova, 2015).

Degradation processes

Regardless of the specific conditions under which Mountain meadow soils are distributed (altitude, climate, relief) (Koynov et al., 1968b), the factors related to the limitation of their fertility are connected with high soil acidity and the possibility of erosion processes occurring when the areas are overloaded by grazing (Penkov et al., 1992). Another factor that can affect water erosion is the clearing of brush areas by burning, which hurts grass vegetation (Gyurov and Artinova, 2015).

Regosols

Regosols in SCPR are distributed over approximately 1,636 km^2 in areas with eroded cinnamon soils, mainly in the Haskovo district and partly in the Kardzhali and Plovdiv districts (Koynov et al., 1968a; Figure 1). These soils develop on rugged relief that favours erosion processes (Gyurov and Artinova, 2015).

Regosols are formed on loose or loosely bound soil-forming materials (Gyurov and Artinova, 2015). Their profile consists of a humus horizon that is poor in organic matter (Penkov et al., 1992). Regosols are formed over highly eroded zonal soils, where only regolith remains (Gyurov and Artinova, 2015).

The thickness of the soil profile depends on the consistency of the soil-forming materials, and that of the humus horizon corresponds to the arable layer. The humus content in this layer is less than 1%, and plant nutrients are insufficient. The pH and sorption capacity also depend on the composition of the soil-forming materials (Gyurov and Artinova, 2015).

Degradation processes

Limiting factors in Regosols are related to erosion processes, low humus content, and acidity in soil varieties developed on acid rocks (Gyurov and Artinova, 2015).

Other less widespread soils in SCPR include deluvial and deluvial meadow, meadow chernozem-like, meadow-boggy, meadow cinnamon, and saline soils (Koynov et al., 1968a; ISSAPP "N. Poushkarov", map archive).

Conclusion

The literature review and map analysis of the soil resources in the South Central Planning Region of Bulgaria reveal a wide diversity of soil types and varieties. This diversity is also found in terms of morphological features, composition, properties, and characteristics of soils.

The analysis found that in natural conditions, certain soils are influenced by relief features, which, together with high soil acidity, contribute to part of the degradation processes, thereby limiting and reducing soil fertility.

The influence of anthropogenic factors related to soil degradation processes in the studied region is primarily linked to soil tillage, which results in a decrease in humus content and creates favourable conditions for erosion processes in soils with poor structure, particularly those prevalent in hilly areas.

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