Criteria for Identification and Diagnostics of Sandy Soils in Bulgaria

Ivaylo Kirilov*, Metodi Teoharov**

**N. Poushkarov Institute of Soil Science, Agrotechnologies and Plant Protection*
1331 Sofia, 7 Shosse Bankya str.
*** President of Bulgarian Soil Science Society*
Corresponding Author: Ivaylo Kirilov, e-mail: stingra@abv.bg

Abstract

The present article considers the criteria for diagnostics and identification of sandy soils in Bulgaria. The research so far has proved that they have a soil profile structure of the type A-AC-C, sand content over 75% in the surface horizon and of 80-90% in the soil formation rock. With some exceptions they are non-fragmented soils. The humus content most often varies from very low to low and average by way of exception. The total content of iron is most often low and in isolated cases it is higher, which could be considered as an exception, too. The soil reaction is slightly acidic to slightly alkaline. The relative and volumetric density are high and very high and the general porosity vary from low to average. According to the water-physical indicators these soils are hydrophilic and very rarely - hydrophobic. The carbonate variation determines to a greatest extent the Sandy soil classification on a lower taxonomic level. The sorption capacity is low to average while the base saturation is high. The content of primary minerals is inherited and is determined by quartz and feldspars. This defines sandy soils as primitive ones with underdeveloped soil-formation process.

Keywords: Sandy soils, origin, diagnostics, criteria for identification, classification.

Introduction

In recent years Sandy soils in our country have been an object of research for some Bulgarian scientists (Teoharov, 2003, 2004; Ninov, 2009), who have provided information about their definition, diagnostic evaluation and classification . New data have been obtained from additional research of (Teoharov, Kirilov, 2011, 2012, 2013) about the morphogenetic characteristics of Sandy soils and about their physical, physico-chemical and general chemical indicators as well. Both research scientists note that these soils have been formed on soft rocks of marine origin from natural grass and shrub vegetation. A substantial part of the soils have been subjected to cultivation due to the fact that they are suitable for growing agricultural crops. Active resort tourism is developing in regions where Sandy soils are spread, which is why they are often sealed by new construction of buildings, roads, highways and railway tracks.

Materials and Methods

Data from different stages of research along the Danube river and the Bulgarian Black Sea coast have been used to establish the criteria and diagnostics for identification of Sandy soils. Besides the thorough geo-morphological and morphological, research analytical results of different diagnostic indicators have been provided.

Analyzing the soil samples was performed according to the following indicators, criteria and methods:

Morphological description and characteristics (Penkov et al., 1992), Guidelines for Soil Description); Mechanical content (Kachinski, 1958); Soil Colour (according to the Munsell color scale, Soil Color Charts, 1975); Volumetric Density (Kachinski, 1965); General Porosity by Calculation (described by Penkov et al., 1981); Hydrophobisity and Hydrophilicity of Soils (Doerr, 1998); Total Carbon by Turin (Kononova, 1963); Humus by Calculation %C. 1,724; Total Nitrogen by Keldal (described by Penkov et al., 1981); Composition of Humus by Kononova-Belchikova (Kononova, 1963; Filcheva&Tsadilas, 2002); Carbonates by the Method of Sheibler (described by Penkov et al., 1981); Sorption Capacity, Exchange Cations and Degree of Base Saturation (Ganev, Arsova, 1990); Microbiological Characteristics (Mishustin, Emtsev, 1989).

Indicators and Criteria for Definition of Sandy Soils

For the first time in Bulgaria Sandy soils were correlated by FAO and were called Arenosols by Mihailov, Teoharov (1985) and these soils were later mentioned in the monograph "Geography of Bulgaria" by Ninov (1997). In the recent years the current problems in the classification of Bulgarian soils have been thoroughly analyzed by Teoharov (2003). He has pointed out the lack of data about Sandy soils as a disadvantage of Bulgarian classification - (Arenosols, WRBSR, 2014) and he has also emphasized that Sandy soils do not have their position in the classification as a separate soil type. Kirilov, Teoharov (2011) clarified the morphogenetic diagnostics of Sandy soils along the Bulgarian Black Sea coast. The processes of humus formation on modern and older marine terraces in regions along the Black sea coast have been described in detail (Kirilov et al., 2012). The sorption, acidic-neutralizing and hydrophobic properties of Sandy soils have been proved and their physic-chemical characteristics have been established (Atanasova et al., 2013). Land evaluation of Sandy soils in the region of the northern and southern Black sea coast has also been made with regard to the needs of basic agricultural crops and reference to climatic conditions. The land evaluation was accomplished by using "Methods for Relative Evaluation of Agricultural Lands in Bulgaria" (Krasteva et al., 2013).

The research so far shows that in the first detailed study of Sandy soils, performed by Mihailov, Teoharov (1985) there are analytical data of the genesis and diagnostics of these soils in the Gamza area (the region of Vidin). The authors pointed out the basic diagnostic criteria, which include the structure of the soil profile of the type A-AC-C, the high content of sand, the low humus content and the comparatively low sorption properties. These soils were described on sand sediments in the region along the Danube river and were defined as underdeveloped Sandy soils (Arenosols). The authors provide their basic characteristics and soil-morphological description as follows: the soils under research were formed on loess-like

alluviums of very light (sandy and clayey-sandy) mechanical composition. The lightest and most coarse-graduate are the materials (gravel) composing the lower sections of the "C"-horizon. Mihailov (1988) noted that on different-age terraces mainly soils of underdeveloped profile - profile A-C, A-AC-C and A-(B)-C - have been formed and in morphological terms these soils show certain similarity as follows: they are characterized by a thin surface "A" horizon (20 to 25 cm), which in the lower part of the relief turns into a "aC" horizon (up to about 40 cm) and on the hump and the comparatively leveled parts it passes into a "C' horizon, then, with a distinct transition or abruptly, turns into the slightly distinct 'B' horizon. This fact shows that Sandy soils pass into carbonate Chernozems or into the two other carbonate soil types. Carbonates are found on the surface or they are deposited at different depths in the "Ck" horizon. The data of the composition of the primary minerals show that the type composition of the primary mineral association is identical. The observed minerals, the morphological characteristics, the intensity of the marked weathering process, the quantitative distribution of the separate profile depths representatives are identical, too. All this is an indicator of the similar conditions of development of the soil formation process of the Sandy soils and the carbonate Chernozems in spite of the differences of the terrace levels, which is a proof that the differences in time of formation are minimal and not having any crucial importance.

However, in one case a soil of a primitive profile has developed and in the other the soil is characterized by a well-developed profile and "B" horizon. The soils have slightly acidic to slightly alkaline reaction and non-washing water regime. Under such conditions mineral phases are stable, especially quartz. The lack of differentiation in the profile of the studied soils is virtually connected with the lack of clay-formation, for which there are no conditions and the quantitative presence of primary mineral components, which are most rapidly disintegrated to secondary minerals is rather scarce. This is another indication that from a genetic point of view these are relatively modern soils. The soils under research are very slightly stocked with organic substance (about and less than 1%). As far as the humus is concerned they fall into the fulvic-humatic type of humus. The humic acids are entirely connected with calcium. The content of mobile iron increases with the increase of soil dispersion, which is related to the increasing content of iron-containing minerals and it is in close relation to the content of organic substance. Mihailov, Teoharov (1985) suggest that on the basis of the entire information from the accomplished research, in relation to genesis, physic-chemical characteristics and the justified diagnostic criteria, it is appropriate to differentiate Sandy soils on a separate taxonomic level.

In the region of the town of Varna Teoharov's research of the geomorphology of two catenas of second order has provided new results and has contributed to the previous research performed of almost the same indicators of Sandy soils, which has simultaneously confirmed the criteria pointed out for identification of the studied soils.

A newer problem development of Primitive soils concerns the diagnostics and classification of Primitive soils in Bulgaria (Boyadziev, Teoharov, 2005). This study has analyzed and described all groups of Primitive soils, which are characterized by profile depth of 2 to 30 (40) cm; more than 15 % of fine earth, more than 40% of $CaCO_3$ in the surface 30 cm, a light humus horizon and different composition (sandy, sandy-clayey, clayey).

For the physic-chemical diagnostics of Sandy (underdeveloped) soils (Arenosols) done on the northern Black Sea coast (Teoharov, 2004) profiles from the land of the village of Vinitza and the Botanical garden of "St. St. Kliment Ochridski" University of Sofia near Varna were used. The morphological and physic-chemical properties were described with an evaluation that uses the degree of base saturation according to FAO (1988). In this respect they were classified as Calcaric (carbonate) Arenosols.

Kirilov, Teoharov (2013) have presented their diagnostics arguments for the introduction of Sandy soils as an independent soil type in the National Soil Classification. For that purpose the authors use some soil indicators and criteria, as follows: the soils of research are formed on soft, unconsolidated Palaeogene, Miocene and modern marine depositions with a sandy texture and composition and surfaces of flat, sloping and hilly relief. The soil-formation rocks have a direct impact on the processes of weathering, soil formation and soil diversity, but always within the limits of the studied Primitive sandy soils. Anthropogenic influences on soils directly affect the processes of their formation and degradation. The authors emphasize that in some areas of the Black Sea coast the soil formation has taken place in conditions of afforestation with different ornamental and natural forest plant species, while another substantial part of the soils has been conserved under asphalt, concrete and buildings. Some profiles from villa and garden areas have been investigated in conditions of soil cultivation by applying sustainable agricultural practices.

According to the research done by Kirilov and Teoharov Sandy soils contain more than 75% of sand in their surface horizon and over 80-90% of sand in the soil-formation rock. As a class of mechanical composition sandy and sandy-clayey soils have been evaluated. Soils formed on more modern marine (off-coast) depositions appear to be of lower class while soils formed on Miocene depositions are of a higher class.

It has been established that Sandy soils have comparatively poor general physical properties. According to the water-physical indicators they are hydrophilic. The sandy soils from the land of Aksakovo and Primorsko on the Black Sea coast are an exception due to dominant hydrophobic organic compounds such as alkanes and fatty alcohols, which determine the soils as less water-permeable and as having deteriorated water and air properties.

The humus content most often varies from very low to low and rarely to average, which is why the processes of humus formation and humus accumulation are at an early stage. The soils have similar values of the type of organic substance which proves the direct dependence of the soil-formation rock on the accumulated high-quality (of the mull type) humus. The correlation C:N and the humus content of the type humatic, fulvic-humatic and humatic-fulvic also confirm the potential opportunities of forming organic substances of high molecular weight and high-quality humus of the type calcium mull humus as well as the opportunity of structuring.

The iron content also proves incipient and modern processes of soil formation. The general and exchange iron is low and it is accumulated in the surface horizons as a result mostly of the increase of the yl- fraction in the "A" humus horizon. In the soils around and in near proximity to the coast and the lowering terrains due to the processes of increased humidification and weathering the content of general and exchange forms of iron is

substantially increased and iron, as well as the increased amount of water-soluble alkaline salts, cause a harder internal structure of soils.

The soil reaction is slightly acidic to slightly alkaline (from 6 to 8.6). As far as the carbonate content is concerned these soils are non-carbonate, poor carbonates, average carbonates and rich and very rich carbonates – from 0 to 32% (in the C horizon). The sorption capacity varies from low to average (4 – 23,2 $cmol_e kg$ /100g soil). The soils are from slightly to moderately colloidal, saturated with a high degree of bases, but incorrectly structured.

Sodium cation and water-soluble salt content has been found out in the region of Bourgas salt-pans, where the data show that it is higher. The degree of salinification does not exceed 20% and it often reaches 5%. The studied soils are defined as slightly salinificated.

The composition of the primary minerals is determined by quartz and feldspars. The formation of non-clayey minerals from the calcite group in some profiles proves the formation of non-clayey minerals and weak soil-formation (clay-formation) and the ability of these soils to structure in natural conditions. Primary materials have been inherited from sandy marine depositions. Quartz is a dominant mineral in all profiles and horizons and that fact defines the primary character of the soil-formation process.

The micro-flora is poorly developed and its amount is typical of Primitive soils. There is a higher amount of bacteria and oligonitrophils in the surface horizons, which is directly proportional to the higher humus content. The values of the microbiological indicators are dependent on the exposition of the micro-slope in soils formed on some southern micro-slopes and lower parts of the micro-catenas, and there is a definite tendency of the increase of values in the surface horizon. A tendency of higher biogenicity of the soils from the southern Black Sea coast is noticed in comparison with soils from the northern Black Sea coast. Land evaluation shows that in regard to the crops it was made for, the differences are substantial when the soils are compared to zonal Chernozems. Sandy soils are absolutely unsuitable for soya, less suitable for sunflowers, tobacco, apples and plums whereas in regard to vines the soil suitability is almost equalized.

According to the determined peculiarities of soil formation, the accomplished characteristics and diagnostics of the studied soils, they are classified as follows: Azonal, Sand, Underdeveloped soils of the following subtypes: carbonate, saturated, hydrophobic and slightly saturated. Under the FAO classification they are classified as Arenosols, with a subclass prefix Hydrophobic and Haplic and suffix subclass as follows: Hydrophobic eutric, Hydrophobic calcaric, Haplic eutric, Haplic calcaric, Haplic Hyposalic (Kirilov, 2013).

Conclusion

Based on complex field, geo-morphological, morphological, laboratory and analytical investigation and research the criteria for diagnostics and identification of Sandy soils can be characterized as follows:

1. Primitive and underdeveloped profile of 20-30 to 50 and rarely 60 cm of the type A-C and an initial degree of soil-formation (clay-formation).
2. Soft modern and old soil-formation rocks, most often of marine origin.
3. Content of sandy fraction over 75% in the A horizon and over 80-90% in the soil-formation rock.

4. Incipient processes of humus formation and humus accumulation and low content of humus substances of not more than 2 %.
5. Slightly acidic to slightly alkaline reaction (from 6 to 8.6).
6. High volumetric and relative density, respectively over 1.4 and 2.6.
7. General porosity – slightly or averagely porous (from 30 to 60%).
8. High content of inherited soils and low content of secondary (clayey) minerals.
9. High content of secondary (non-clayey) minerals from the calcite group in some varieties.
10. High salinification (up to 20%) in some varieties.
11. Availability of high hydrophobicity and rarely of high hydrophilicity, which is due to hydrophobic organic compounds of the type of alkanas and fatty alcohols.
12. Low to average sorption capacity (4 – 23,2 $cmol_e kg$ /100g soil and high to very high base saturation (75-100%).
13. Calcium mull humus, humatic, fulvic-humatic and humatic-fulvic type of humus.
14. Low degree of feritization and absence of processes of rubification.

References

Atanasova, I., Metodi Teoharov, Ivailo Krastev. 2013. Sorption, Alkaline-neutralizing and Hydrophobic Properties of Sandy Soils (Arenosols). Scientific Reports. ISBN 978-954-353-206-3, Sofia, pp 50-54; 2013. (in Bulgarian)

Baize, D., ; Girard C-M, 1992. Referentel pedologique. Paris, p. 222 .

Boyadzhiev, T., M. Teoharov. 2005. "Diagnostics and Classification of Primitive Soils in Bulgaria". Soil Science, Agro-chemistry and Ecology, issue 2-3-12. (in Bulgarian)

Deribeeva, D., M. Teoharov, I. Kirilov. 2013. Microbiological Characteristics of Sandy Soils (Arenosols) from the Region of the Black Sea Coast. Soil Science, Agro-chemistry and Ecology, issue 3. (in Bulgarian)

Doerr, S.H. 1998. On Standardising the "Water Drop Penetration Time" and the "Molarity of an Ethanol Droplet" Techniques to Classify Soil Hydrophobicity: a Case Study Using Medium Textured Soils. Earth Surface Processes and Landforms. 23, 663-668.

FAO. 2006. World Reference Base for Soil Resources 2006. FAO, Rome, p. 132 .

Filcheva, E., C. Tsadilas. 2002. Influence of Cliniptilolite and Compost on Soil Properties. Commun. of Soil Sci. and Plant Analysis, 33, 3-4, 595-607.

Ganev, C., A. Arsova, R. Sechkova, T. Kolchakova, A. Gateva, H. Tarpanova. 1990. "Physic-chemical Properties of Soils in Bulgaria and in Different Geographic Regions of the World". Publishing House to Nikola Pushkarov Institute of Soil Science, Sofia. p. 54 . (in Bulgarian)

Kachinski, N. A., Physics of Soil, part.I., 1965, part I I.,M.,1970. (in Russian)

Kirilov, I., M. Teoharov. 2011. Morphogenetic Diagnostics of Sandy Soils from the Black Sea Coast, Soil Science, Agro-chemistry and Ecology, issue № 3, 3-9. (in Bulgarian)

Kirilov, I., M, Teoharov. 2011. Indicators and Criteria for Defining Sandy Soils According to the National and World Classifications; Soil Science, Agro-chemistry and Ecology, issue № 1-4, pp 135-140. (in Bulgarian)

Kirilov, I., Teoharov M, Filcheva E. 2012. Humus Formation Processes in Modern and Old Marine Terraces of Bulgarian Black Sea Coast. Science Reports. ISBN 978-954-749-096-3, PSSE, Sofia, pp. 75-80. 2012. (in Bulgarian)

Kirilov, I. 2013. Peculiarities of Soil Formation on Sandy Materials in the Region of the Black Sea Coast. Dissertation for Acquisition of PhD Degree. Academy of Agriculture, Nikola Pushkarov Institute of Soil Science, Agro-technologies and Plant Protection, p. 165. 2013. (in Bulgarian)

Kononova, M. 1963. Soil Organic Substance. Its Nature, Properties and Research Methods. ASSU, Moscow, p. 314. (in Russian)

Krasteva, V., Metodi Teoharov, Ivailo Kirilov. 2013. "Agronomic Suitability of Sandy Soils from the Region of the Black Sea Coast for Growing Agricultural Crops". Soil Science, Agro-chemistry and Ecology, issue № 2. (in Bulgarian)

Mihailov, M., M. Teoharov. 1985. About the Genesis, Diagnostics and Classification Status of Underdeveloped Soils in the Black Sea Coast Region of North-West Bulgaria. Ecologization of Agriculture, Yambol, pp. 239-248. (in Bulgarian)

Mihailov, M. 1988. Genesis, Diagnostics and Classification of Soils, Developed on Sand Sediments in the Danube River lowlands. Dissertation for Acquisition of the D. Sc Degree, AA, N. Pushkarov ISS, p. 170. (in Bulgarian)

Mishustin, F., Emtsev N. 1989. Microbiology, Moscow, Kolos Publ., Колос, MAF, Information Bulletin 27, 1994, p. 367. (in Russian)

Munsell, Soil Color Charts, 1975.

Ninov, N., T. Andonov, I. Kolchakov, M. Teoharov. 1985. Classification, Diagnostics and Problems of Mountain Soils in Bulgaria. International Conference on Classification and Use of Soils in the Mountain Soils. Sofia, pp. 40 -52. (in Bulgarian)

Ninov, N. 1997. New Classification System of Soils in Bulgaria with a Soil Map in 1:1 Scale. Geography of Bulgaria, Prof. M. Drinov Publishing. (in Bulgarian)

Ninov, N. 1997. Soils. Geography of Bulgaria. Prof. M. Drinov Publ., Sofia, pp. 225-259. (in Bulgarian)

Ninov, N. 2002. Soil Types and Subtypes (in Bulgaria). Map in 1:1,5 mln. scale. Geography of Bulgaria. ForCom Publishing. (in Bulgarian)

Ninov, N. 2009. Sandy Soils (Arenosols) in Bulgaria. Problems of Geography, 1, BAS, pp. 16-26. (in Bulgarian)

Penkov, M., Y. Dimitrova, I. Hristov, Y. Kozarev. 1981. Guidebook in Soil Science. Tehnika Publishing, Sofia, p. 204. (in Bulgarian)

Penkov, M. 1992. Classification and Diagnostics of Soils in Bulgaria with Reference to Land Division. Sofia, p. 151. (in Bulgarian)

Teoharov, M. 2003. New Research and Results of the Genesis and Diagnostics of Sandy Soils (Arenosols) from the Northern Black Sea Coast. International Science Conference "70-th Anniversary of the Forestry University", Science Reports. Lotos Publ., Sofia, pp. 5-7. (in Bulgarian)

Teoharov, M. 2004. Physic-chemical Diagnostics of Sandy Underdeveloped Soils (Arenosols) from the Northern Black Sea Coast. Soil Science, Agro-chemistry and Ecology, issue № 1, pp. 32 – 35. (in Bulgarian)