General and Applied Plant Physiology – 2009, Volume 35 (3–4), pp. 188–194
©2009 ISSN 1312-8183 Published by the Institute of Plant Physiology – Bulgarian Academy of Sciences
Available online at http://www.bio21.bas.bg/ipp/

Special Issue (Part I) – Proceedings of the XI National Conference on Plant Physiology
18–19 November 2009, Sofia, Bulgaria

ECOLOGICAL GENESIS AND FORMATION OF REGOSOLS FROM THE HILLY PART OF THE DANUBE PLANE

Teoharov M.**, *B. Hristov, N. Zhivkova

N. Poushkarov Institute of Soil Science, 7 Shosse Bankya str., 1080 Sofia, Bulgaria

Received: *11 March 2010* Accepted: *26 March 2010*

Summary. In the hilly part of the Danube plain, Regosols are widespread on soft rocks mainly on loess. These soils are developed mainly on slopes and other eroded terrains. Regosols are extensive in arid and semi-arid areas. This research was carried out to determine ecological genesis and formation of the Regosols developed on loess and colluviums calcareous material. Ecological factors were examined in this research for soil definition, genesis and formation.

Key words: Soil genesis, soil formation, Regosols, loess, vegetation, soil ecology.

INTRODUCTION

Weak developed soils are spread over regolits from the hilly part of the Danube plain occupying an area of 485 000 ha (Koinov et al., 1972). The area is increasing, mainly due to improper use and degradation processes in this part of the plane. Regosols are spread in areas where natural vegetation is poorly developed; this shows that the soils are not suitable for agriculture. The remaining natural vegetation suggests that in the past the Danube hilly plane was almost entirely occupied by large forests and steppes. Ancient use of the plane gives a significant impact on the state of the soils and environment. Especially active are the processes of degradation (mainly landslides and erosion) in Lom-Svishtov agro-ecological region, where research was accomplished on three catenae from first order and six catenae from second order (Modrokovich, et al. 1985). To achieve that objective we have discussed pedogenetics environmental conditions and factors of soil formation and their influence and formation of researched weak developed soils defined as Regosols (Hristov and Teoharov, 2008).

MATERIALS AND METHODS

The choice of profiles is based on geomorphologic and topographic features of the Lom - Svishtov Region, in which

*Corresponding author: mteoharov@abv.bg

the studied soils were distributed and compared to zonal and azonal soils with known morphological features and physico-chemical and mineralogical indices. The Catena method was used during the field research (Modrokovich et al., 1985). Content of carbonates in the studied profiles was determined using the method of Scheibler (Penkov et al., 1981). A glass electrode (potentiometric) was used to determine pH in H_2O.

RESULTS AND DISCUSSION

Lom - Svishtov region occupies a central position in the Danube valley. The average altitude of the research area is 138 m. This region is characterized by the Lowland plain-hilly and undulating terrain. In northern and western parts Danube alluvium sediments formed lowlands that are spread anywhere. These areas are well drained and conducive to formation of primitive soils like Regosols. In Table 1 are presented some soil properties, the location and slope degree of profiles. According to FAO (2006), profiles № 8, 17 and 24 have *Slope gradient class* - *Sloping* (5° to 10°). All other profiles have *Slope gradient class* - *Strongly sloping* (between 10° to 15°). In these parts of the hilly-plain soil formation processes are slow; this is one of the reasons for Regosols development and the physical-mechanical degradation has highest degree. Despite the low slope terrain this is the major ecological-genetic factor that gives influence over soil structure. All these various processes of degradation like translocation, geochemical and physical soil migration from that area will be investigated in this paper. The formation of primitive soils on the uneven relief is closely related to topographical features and particularly with the sloping terrain (over 6°). The studied area is covered with loess and similar formations. With the exception of profile (4), all other profiles are on loess parent material. Profile № 4 is on a river terrace, where the geological material is Pliocene, Gath-Pontic type. Parent rock and relief create specific morpho-structural forms that are undergone to active processes of erosion and drainage. However, due to good cation exchange properties and slightly alkaline pH of the geological substratum, soil parent material is maintaing soil absorption complex and enhances soil development processes. Loess in the Danube plain has expressed alkalinity. $pH_{(H_2O)}$ typicaly reaches 9.5, but for the deep loess sediments it is 7.0. Reaction of the environment in loess sediments is a proof for the diversity of the geochemical conditions in which soil formation takes place (Stoilov, 1984). The main components that determine the soil reaction are carbonates ($CaCO_3$ and $MgCO_3$). Danube plain loess contains 18 - 25% carbonates and their distribution in vertical depth is uneven (Stoilov, 1984). The content of carbonates varies across the Danube plain in a wide range. From the studied profiles it can be seen that they have levels from 0 to 21.36% carbonates in the soils. Where the values of carbonates are close to zero, probably this is the result from the high degree of evapotranspiration, washing out and removal of part of them because of the hilly terrain of the studied profiles (like profile 16) or because of their spending to neutralize the acid products formed in the process of weathering. An opposite process is observed in places with high content of carbonates. There is a low degree of evapotranspiration

Table 1. Soil profile properties, location and slope

Profile-location	Altitude	Slope	Horizon [cm]	$pH_{(H_2O)}$	Carbonates %	Classification FAO (2006)
Profile № 4, Yakimovo, Montana District	130 m	12.5º	$A_{(h)}$ 0 - 20	6.0	0.0	Non-calcareous
			C_1 20 - 40	5.8	0.0	Non-calcareous
Profile № 8, Kovachtitza, Montana District	135 m	7º	$A_{(h)k}$ 0 - 21	7.6	11.60	Strongly calcareous
			AC_k 21 - 36	7.9	14.52	Strongly calcareous
			C_{1k} 36 - 45	7.9	20.42	Strongly calcareous
Profile № 10, Stanevo, Montana District	77 m	10º	$A_{(h)k}$ 0 - 22	7.8	12.92	Strongly calcareous
			AC_k 22 - 33	8.0	19.86	Strongly calcareous
			C_{k1} 33 - 50	8.2	10.88	Strongly calcareous
Profile № 11, Muselievo, Pleven district	64 m	12º	$A_{(h)k}$ 0 - 18	7.9	15.2	Strongly calcareous
			C_k 18 - 35	8.3	18.7	Strongly calcareous
Profile № 14, Milkovitsa, Pleven district	53 m	10º	$A_{(h)k}$ 0 - 16	7.5	0 .26	Slightly calcareous
			AC_k 16 - 32	7.8	2.62	Moderately calcareous
			C_k 32 - 50	7.9	11.68	Strongly calcareous
Profile № 16, Milkovitsa, Pleven district	73 m	10º	$A_{(h)}$ 0 - 15	6.0	0.0	Non-calcareous
			C_1 15 - 30	6.5	0.0	Non-calcareous
Profile № 17, Opanets, Pleven district	100 m	9º	$A_{(h)k}$ 0 -2 1	8. 0	4.02	Moderately calcareous
			AC_k 21 - 40	8.1	14.78	Strongly calcareous
			C_{2k} 40 - 55	8.2	10.78	Strongly calcareous
Profile № 18, Opanets, Pleven district	113.5 m	10º	$A_{(h)k}$ 0 - 14	8.1	8.36	Moderately calcareous
			C_k 14 - 30	8.0	3.62	Moderately calcareous
Profile № 19, Opanets, Pleven district	132 m	10º	$A_{(h)k}$ 0 - 15	8.1	16.96	Strongly calcareous
			C_k 15 - 30	8.3	13.24	Strongly calcareous
Profile № 24, Trastenik, Ruse Region	120 m	6º	$C_{(h)k}$ 0 - 19	7.9	14.82	Strongly calcareous
			C_k19-38	8.2	21.36	Strongly calcareous

during the summer months and areas with high drought regime. The presence of carbonates is indicative for low degree of soil moisture. The formation of aggregates of colloidal and larger particles under the influence of carbonates is part of soil formation. Increased content of carbonates in the soil is conditioned by the geographical location of the area.

This is the reason for the active role of the carbonates in the formation of the modern face of soil types. By its geographical position Bulgaria is located in the southern temperate zone and it is in close proximity to the subtropical Mediterranean climatic area. It is proved that the climate is a major ecological-genetic factors of soil formation. In the U.S. Soil Taxonomy (1999) this factor of soil formation is included in the soil classification. Summarized climatic data by Boyadjiev (1986), shows that the territory of Lom - Svishtov region is characterized by warm - mesic temperature regime. This regime is defined with an average annual temperature of 9.2 to 15°C at 50 cm depth and contrast winter and summer temperatures of 11.2 to 15.4°C. Regimes of water levels are characteristic of two types-dry (Xeric) and semi dry (Ustic). Xeric regime is when the soil is constantly dry after the summer sun standing for period of 45-90 days. Soils are constantly wet during the winter sun standing for 105-120 days and for 99-154 days during the period with temperatures above 8°C 50 cm depth. The total number of days in the period with soil temperatures above 5°C (in 50 cm depth) when soil is wet, ranging from 85 to 156 days. Semi ustic regime is in which the soil is constantly dry after the summer standing in the sun for less than 45 days (from 0 to 41). The total number of dry days during the period with temperatures above 5°C is from 0 to 42 days (Boyadjiev, 1986).

The combination of temperature and water regime of soils in Lom-Svishtov region makes it possible to outline the temperature of the following water regimes: meso - xeric (warm and dry) and meso - ustic (warm and semi-dry). The determination of both species under climate is the reason for the evolution of primitive soil process for studied and other types of soils in the region. Meso – xeric regime covers areas like Silistra - Ruse, Oryahovo - Svishtov, Vidin - Lomska. Meso – ustic regime covers districts like Pleven, Lovech - Tarnovo, Razgrad - Shumen region. Lom-Svishtov region is characterized by a negative annual hydrothermal regime and low index of soil moisture and evapotrnaspiration. The results of the hydrothermal regime (Ivanov, 1958) (Fig. 1) show that Lom - Svishtov region has unwashing water regime, which is the predominant type.

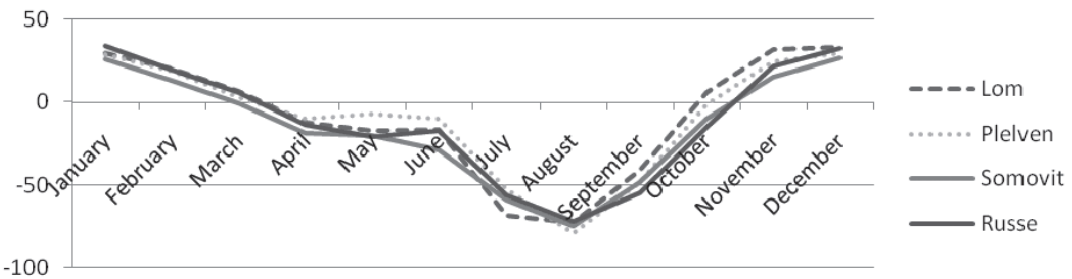

Fig.1. Hydrothermal regime in Lome-Svistov district. Humidity balance in mm.

This regime has the annual amount of precipitation less than the amount of evapotranspiration. Therefore, the typical soil formation process is severely delayed, especially in the hilly ridges of the plane. According to hydrothermal data, Lom-Svishtov area belongs to the semiarid zone. In this zone rainfall, temperature and potential transpiration are insufficient and this is limited factor for soil development process more than 200 days of the year. It should be noted that the surveyed regions are among the lowest temperatures in winter, with moderate continental climate - hot summers and cold winters with spring maximum precipitation and annual amount of precipitation is below average for Bulgaria. The region is characterized by communities of xerothermic vegetation like steppe grasses, shrubs and perennial vegetation (Tsonev et al., 2005). Natural vegetation occupies limited area manly in the hilly section and in places unsuitable for agriculture. Natural vegetation in the residual suggests that the studied regions in the past were almost entirely occupied by large forests and meadow steppes. Today most tree species are some common types of oak (*Q. cerris L.*and less *Quercus frainettoTen.*), elm, hornbeam, lime, hazel and others. (Bondev, 1982). From the steppe species the most common are grass steppe - *Chrysopogon gryllus L*, esparto, caragan, iris, and etc. Grassy steppe vegetation is one that is most actively involved in the processes of sod formation and organic carbon accumulation (soil formation) of the studied primitive soils. Widely spread species in research area are herbaceous formations, among which are those of the dominants *Chrysopogon gryllus L, Dichanthium ischaemum Roberty., Festuca valesiaca Schleich. Ex Gaud*. and *Poa Bulbosa L.* . Degradation of forests and bush cenoses, xeric vegetation gradually diluted enters in these forests and creates respective cenoses form grass and weakly developed soils. There are many combinations and complexes transition between forest, bush and grass vegetation, which in most cases have been referred to the appropriate forest or shrub formations, depending on the predominant components. These grass formations in the hilly plane of Northern Bulgaria are called ”Pannonia loess steppe grasslands” (Tsonev et al., 2005). These formations are dominated by Poaceae grasses of the loess hills, where the thickness of loess reaches 30-50 m and is covered with primitive soils and less frequently with Chernozems with varying degrees of degradation. Xeric processes are reinforced by well-draining carbonate terrain and high cliffs. Therefore, some artificially planted species such as locust, are almost declined. Cenoses of *Chrysopogon gryllus L.* that are most actively involved in soil formation in the Cheroznem zone in northern Bulgaria are found in most areas eroded pastures or severely eroded lands, where are researched soils. They are also heavily partite and tufts territories. Soil development process of such lands is more advanced, but the degree of development is still early. Phytocenoses of *Chrysopogon gryllus L.* normally are open or half-open. In their populations have also appeared other perennial and annual grass species. Some scientists separate formations of *Chrysopogon gryllus L,* and *Dichanthium ischaemum Roberty.,* as a type of anthropogenic grassland vegetation, although in our country it has a secondary origin (Bondev, 1982). Natural phytocenoses are anthropogenically

modified in agricultural areas. In the past this area was Forest-steppe zone and mixed forests of *Q. cerris L. and Q. Virgiliana Ten*., often mixed with *Q. Peduculiflora C. Koch.* The main agricultural crops in the research area are wheat, maize and vineyards. On hilly terrain with less inclination farming is abandoned, and there is a secondary recovery process with ephemeral vegetation. On the steep terrain vegetation retain its original status, as it was in the early stages of development tufted with segmented nature of the distribution and development. Millennial use of the territory of the Danube plain has a significant impact on the current state of the studied soils. Forests and steppes areas have been turned into farmlands. One part of the hilly land was arable land but now there are abandoned places. Another part has never been cultivated due to steep terrain, but humans did not make the necessary improvements. It can be concluded that human activity, directly or indirectly, has a significant impact on the degradation processes of soil and its recovery. All this directly affects the image of the modern landscape. Forest-steppe vegetation in the studied territories almost everywhere is deforested or highly diluted. Deforestation process have led to increasing degradation of the soil profile and usage of the surface (A) horizon especially in hilly terrain where was the intensive cultivation of lands. All this determines the formation of Regosols. As a result of irrigation, wind and rainwater erosion particles have accumulated in the lower parts of the plane, where are the rivers Vit, Tsibaritsa, Iskar, Ogosta, Ruse Lom, Yantra, and others. Meanwhile, Northern Bulgaria remained the region with the most intensive agriculture, but it is monoculture in recent years. In the end, it can be underlined that the soils in the hilly parts of Lom - Svishtov region are under strong anthropogenic influence for ages. This obviously has affected the soil formation processes, as a result some soils even changed their original appearance and they have changed from one type to another.

Conclusion

Weakly developed soils are formed mainly on sandy soft loess and other unconsolidated rocks (Regolith) with relatively sandy-loam texture. Their genesis is influenced by the properties of the parent material. They are located in the hilly part of the Danube plain with split relief and gentle slopes. Pedogenetic environmental factors suggest that soil formation processes, especially in the hill-ridges part of the plane are severely weakened. The annual moisture balance is negative. The temperature/water regime is warm and dry or semi-dry and warm. The little rainfall, temperature and potential transpiration appear to be the limiting factors for soil development process more than 200 days of the year, and limiting processes for clay formation. Natural phytocenoses are anthropogenically altered due to intensive use in the past. Steppe xeric and meso xeric vegetation is highly declined and it has tuft-partite grass nature of development and trees, artificial and natural afforested. These conditions and factors severely hampered soil formation processes and they are responsible for the formation of Primitive soils. In the diagnosis and classification of FAO (2006) and Bulgarian soil classification (Penkov et al., 1992) these soils are defined as

Regosols (Hristov and Teoharov, 2008). According to the Bulgarian classification (Penkov et al., 1992), profiles 4, 16 are Haplic Regosols, while all others are Calcaric Regosols.

REFERENCES

Bondev I, 1982. The vegetation of Bulgaria. Zemizdat, Sofia, 364 (In Bulg.).

Boyadjiev T, 1986. Temperature and soil water regime in Bulgaria. Fourth National Conference on Soil Science, Sofia. 207-214 (In Bulg.).

Hristov B, M Teoharov, 2008. Genetics - Diagnostic characteristics of soils, defined as strongly eroded Chernozem. Soil Sci Agrochem Ecol, 2: 37- 43 (In Bulg.).

Ivanov I, 1958. The atmospheric moisture from the tropical countries of the world. Moscow, 143 (In Ru).

Koinov V, C Trashlieva, M Jolevski, N Ninov, D Gurov, 1972. Bulgaria's soil resources and their utilization. First National Congress of Soil Science, ed. BAS, Sofia, 476 (In Bulg.).

Modrokovich DC, NG Shatonina, AA Tityanova, 1985. Steppe catena. Novosibirsk, ed. Science, 115 (In Ru).

Penkov M, S Dimitrov, I Hristov, J Kozarev, 1981. Guidelines for Soil Description. Technika, Sofia, 204 (In Bulg.).

Penkov M, C Donov, T Boyadjiev, T Andonov, N Ninov, M Jolevski, D Andonov, S Gencheva, 1992. Classification and diagnosis of the soils in Bulgaria in connection with land partition. Sofia, 151 (In Bulg.).

Stoilov K, 1984. Loess formation in Bulgaria. BAS, Sofia, 351 (In Bulg.).

Tsonev R, A Ganeva, M Rusakova, M Dimitrov, P Ivanov, P Zhelev, T Ivanova, T Belev, Ch Gusev, 2005. Guidance for identifying the habitats with European importance in Bulgaria. MEW, Sofia, 129 (In Bulg.).

FAO, 2006. World reference base for soil resources FAO, Rome, 132.

Soil Taxonomy, Second Edition. 1999. Washington, DC USDA, 870.