THE SOIL RESOURCES OF MOLDOVA AND THEIR CURRENT STATE

Ursu A., Overcenco A.,
Curcubăt Stela, Marcov I.

Summary

The soil is the main from the limited natural resources of Moldova. The zonal spectrum of soils consist of the brown, grey and chernozem types, in which are included fragmentary different types of intra-zonal soils – Rendzina, Vertisol, Gleysol, Solonetz, Solonchak, Deluvial, Aluvial, Anthropic. The soil resources of Moldova were overused and are the subject now to various degradation processes. The most dangerous destructive process is surface and linear soil erosion. To improve the current state of soil resources, it is necessary to implement a complex system of urgent measures, including adoption of the Soil Law and establishment of State agency "Solurile Moldovei".

The key words: soil resources, Chernozem, land fund, erosion, degradation.

Introduction

The Republic of Moldova does not have considerable mineral resources, the forest area is only 10.8%, and the water reserves are minimal. The main natural resource is soil, which is unique by the genetic composition.

From a geomorphological point of view, the territory of Moldova is a gently undulating plain, in which the relatively flat surfaces intersect with hilly regions. Codrii are highlighted in the central part of Moldova – an original geomorphological formation with a maximum altitude of 430 m. Some authors consider Codrii as a "low mountains" of erosional origin (Горбунов, 1961), where the neotectonical activity reaches up to 10 mm annually (Билинкис, 1971).

The North Plateau, Prenistrian Hills and Balti Steppe are highlighted in the Northern part of the country, the Tigheci Hills are highlighted in the South Plain (Degradarea solurilor, 2000).

The relief of the hilly regions is an alternation of hills with long, partly steep slopes with narrow and deep valleys. Average altitudes range from 300 to 400 m (maximum 430 m, minimum 5 m).

The geological construction of the territory consists of layers of sedimentary rocks – deposits of the Sarmatian seas (clays, siltstones, sands, limestones) and loess of quaternary age (Stratigraphy, 1964). The predominant hills are formed of tertiary rocks – clays and siltstones, low lands and river terraces – from loess. The limestone blocks stand out in the North-Western part of the country (the so-called *Toltre)* and in the valleys of the Prut, Nistru rivers and their tributaries, mostly at the base of the slopes.

Tertiary and quaternary sedimentary deposits serve as soil parent material, which constitute their mineral composition. Attaching and alternating rocks condition the territorial spread, texture, physical-chemical properties of soil varieties. The mineral composition of some rocks determines the specifics of the genesis of Rendzina and Vertisols (Ursu, 2011).

The hilly relief conditions the territorial variability of climate, characteristic of the temperate zone (Atlas, 2013). On the territory of the Republic of Moldova, the annual average temperature is 7,7°C to the North and 9,9°C to the South, the sum of precipitation, respectively, is 550 and 425 mm, with high annual variability (Degradarea solurilor, 2000). The average annual temperature decreases by 0.5-0.7°C at each 100 m altitude, the sum of precipitation increases by 50-60 mm (Guidebook on climate, 1965). Climate conditions create the specific hydrothermal regimes of soils, their productive potential. Under the natural conditions, the climate determines specific composition of spontaneous biocoenosis and terrestrial ecosystems.

Depending on the climate, the biocoenosis of deciduous forests, pastures and hair-grass steppes and the hydrophilic associations were formed, and which determined the soil processes and the formation of different soils on this territory.

In the Northern part of the country, the hilly regions formed the forest-steppe area with oak forests on the hills, meadows and steppes on the slopes and terraces. In the upper part of Raut River Basin, including Ciuluc River Basin, dominated the hair-grass steppe with a fragments of hydrophyte and halophyte associations (Postolache, 1995).

The Codrii is an island forest formation, with beech and oak on the predominant central plateau and oak – on the peripheries. These forests are considered as the Eastern part of the Central European forest area.

The Southern plain is a xerophyte hair-grass steppe with a fragments of oak forests.

During the prehistoric period, the grassy vegetation occupied about 80 percent of the country's territory, and the forests – 20% (Ursu, Cuza, 2014).

Materials and comments

Depending on the specifics of geological rocks, geomorphological construction, relief, climatic conditions and the specific composition of biocoenosis, it was formed the soil cover, the zonal spectrum of Moldovan soils.

The Brown soils (Cambisols) were formed on the predominant heights of Codrii (altitude 380-430 m) under the beech and oak forests, on siltstone and sandy rocks , represented by two subtypes – Haplic and Luvic. These soils constitute the upper level of the soil spectrum, conditioned by the legitimacy of the vertical zonality (Урсу, 1977).

The Grey soils (Luvisols), represented by 4 subtypes – Albic, Haplic, Luvic, Vertic, were formed on adjacent areas of Codrii on altitudes of 240-300 m, as well as on the predominant hills of the North Plateau, the Prenistrian Hills and Tigheci, under the oak forests with various deciduous mixtures (maple, hornbeam, lime, ash etc.) on different parental rocks (clays, siltstones, sands). The territorial distribution of these soils is conditioned by the legitimacy of the vertical zonality (Albic > Haplic/Typical > Luvic) as a consequence of the intensity of water regime, or the composition of the parental rocks (Vertic).

Chernozem – is a predominant soil on the territory of Moldova, formed under the former meadows, steppes and fluffy oak forests. From the North

to the South, depending on the intensity of the humidity regime (from percolative to non-percolative), there are Argillic Chernozem (Phaeozems), formed under the common oak forests with grassy cover, to the South replaced by Levigated Chernozem (Haplic), formed under the grassy vegetation of the meadows (Balti Steppe) or fluffy oak forests (South Plain).

The subtype that characteristics the type – is Typical Chernozem (Cernic, Haplic), formed in the hair-grass steppe conditions. This "steppe soil" prevails in the Balti Steppe (moderately humiferous) and in the Southern Plain (low humiferous or ordinary), where it also predominates under the fluffy oak forests.

The Carbonate Chernozem was formed in the Southern part of the chernozem zone, under the xerophyte steppes, with participation of wormwood. The Vertic Chernozem, that contact with vertisol, was formed on heavy clay rocks.

The Brown, Grey and Chernozem soils form the zonal spectrum of Moldova's soil cover – the automorphic soil class.

In the areas of Grey soils and, especially, of Chernozems, there are fragmentary small areas of intrazonal soils: litomorphic soils, the formation of which is conditioned by the specifics of parental rocks; hydromorphic soils – conditioned by the surplus of humidity; and halomorphic soils – which contains soluble salts.

Lithomorphic soils are represented by Rendzinas, formed on limestone (Rendzinic Leptosols), and Vertisols, formed on heavy clays.

The class of hydromorphic soils is represented by 3 soil types – Chernozemoid (Phaezems), Gleysol and Histosol.

The class of halomorphic soils is represented by Solonetzs and Soloncheaks.

The areas of zonal soils are crossed by soils of *dynamomorphic* class, which are formed in the valleys of rivers on the current deposits – alluvial and delluvial deposits (Fluvisols), as well as a result of anthropic activity (Anthrosols).

The current soil classification of Moldova (Clasificarea, 1999) includes 5 classes, 13 types and 37 subtypes. Types and subtypes can be compared with the World Reference Base for Soil Resources (2006) as is shown below (Table 1).

Table 1. Correlation of Moldova's major soil taxonomic units with the World Reference Base for Soil Resources

Classification of Moldova's soils (Clasificarea, 1999)			World Reference Base for Soil Resources, 2006)	
Class	**Type**	**Subtype**	**Higher level (Reference Soil Group)**	**Lower level (Qualifiers)**
Automorphic	Sol brun	tipic	Cambisol	Haplic
		luvic		Luvic
	Sol cenuşiu	albic	Luvisol	Albic
		tipic		Luvic
		molic	Phaeoziom	Haplic
		vertic	Luvisol	Vertic
	Cernoziom	argiloiluvial	Chernoziom (Phaeoziom)	Luvic
		levigat		Haplic (cernic?)
		tipic: moderat humifer		
		tipic: slab humifer		
		carbonatic		Calcic
		vertic		Vertic
Litomorphic	Rendzină	tipică	Leptosol	Rendzinic
		levigată		Eutric
		marnoasă		(Pelic?)
	Vertisol	molic	Vertisol	Haplic
		ocric		Eutric
Hydromorphic	Sol cernoziomoid	levigat	Phaeoziom	Haplic
		tipic		
	Mocirlă	tipică	Gleysol	Molic
		gleică		Haplic
		turbică		Histic
	Sol turbos	tipic	Histosol	Haplic
		gleic		Gleic
Halomorphic	Soloneţ	molic	Solonetz	Molic
		hidric		Gleic
	Solonceac	molic	Soloncheak	Molic
		hidric		Gleic

Dynamo-morphic	Sol deluvial	molic	Fluvisol	Halpic
		ocric		Eutric
	Sol aluvial	molic		Molic, cernic (?)
		stratificat		Abruptic
		hidric		Stagnic
		turbic		Histic
		vertic		Vertic
	Sol antropic	molic	Anthrosol	Hortic (?)
		ocric		Eutric (?)

The soil cover, actually, is very complicated, being represented by multiple lower level units – species, families, genus, variants, depending on the thickness of the profile, humus content, texture, erosion degree, salinization, etc. Moldova's systematic list includes more than 700 soil units.

Historically, the soil resources of Moldova have been overused. The high productive potential of chernozems and the relatively simple process of use contributed to the development of agriculture. At the present time, 2,499,585 hectares (78%) are agricultural land out of the total area of 3,381,620 hectares, according to the State Land Cadastre (Cadastrul, 2016). The arable land is 1,822,912 hectares, vineyards and orchards occupy 288,900 hectares, pastures – 345,034 hectares, and the forest area (including forest plantations) occupy 465,253 hectares.

Systematic utilization of soils has contributed to the activation of erosion, deflation, landslides and others destructive processes (Eroziunea solurilor, 2004). Eighty percent of the arable land is located on slopes with inclination of over 2°, and, therefore, could be subjected to surface and linear (deep) erosion. In the last years, the monitoring of erosion processes has not been carried out; according to the latest official data, the total area of eroded soils is 898,653 hectares. 24,098 ha are affected by landslides. The linear forms of erosion (gullies, ravines) occupy 12,031 ha and their activation continue.

The geological construction of some territories, including for agricultural purposes, represents an alternation of the layers of different

rocks – clays, siltstone, fine sands. Permeable rocks are often supported by waterproof clays, which condition the formation of aquifer layers and "*coastal springs*". These lands may periodically be subject to landslides, during which the soil cover is destroyed, and the water regime of the slopes deformed. Landslides radically change the soil suitability and the possibility of using them.

The agricultural fund is susceptible to various degradation processes, which reduce the productive potential of soils. The arable layer is permanently susceptible to de-structuring, compaction, dehumification, pollution. The systematic utilization of soil contributed to the destruction of the texture elements created during the long pedogenetic process. In dependence of the degree of humidity, the arable layer is compacting, it can become stony, compact, and with a crust on the surface.

Overuse of soil and predominance of annual field crops conditioning the decomposition processes of soil organic matter and lead to lack of humus content. The humus content is reduced by approximately one tone per hectare (Degradarea solurilor, 2000). Soil without humus content is easily exposed to compaction.

The crop production without respecting crop rotation and without applying of fertilizers, leads to reduction of nutrient reserves in the soils.

In the last years, it has declined considerably the use of mineral and organic fertilizers, as well as pesticides. The potential for chemical pollution of soils has been reduced, but pollution with various wastes continues.

Conclusions

In order to improve the current state of the agricultural land, it is strongly recommended a system of measures, starting with change of the society's indifferent attitude towards the country's main natural wealth. The most dangerous form of soil degradation is erosion. At the present time, the necessary anti-erosion protection measures are not implemented in agricultural practice.

The agricultural fund is dispersed, the individual plots are often parcelled out and the works are carried out along the slopes.

A strictly necessary measure is the consolidation of the agricultural lands and its anti-erosional organizing. The protective measures should regulate the road network, the location of fields and soil works across the slopes, the implementation of agro-technical, crop rotation and hydro-technical measures to combat and eradicate the soil erosion.

Strongly eroded soils are need to be excluded from the crop production circuit and transferred to a special fund for regeneration. The less productive soils (Solonetzs, Soloncheaks, Chernoziomoid soils, Gleysols), which are not a subject to ameliorative technologies, could be also transferred to this fund.

In the soil-climatic conditions of Moldova, all agriculture fields need to be organized anti-erosionally. In order to minimize the negative effect, or to exclude the degradation processes, it is necessary to organize and implement the special crop rotation with inclusion of perennial grasses.

In order to maintain the humus content and regulate the nutritional balance, it is necessary to apply fertilizers, including organic, and promote to prepare and use the composts.

A special anti-erosion ecological network needs to be created within the country, that would include existing and new planted forest areas, anti-erosion strips and plots for soils recovering.

There is a need to develop and implement regional systems of measures to stabilize landslides. It is important to regulate grazing, excluding pasture and soil degradation.

A large part of meadows and alluvial soils, partially drained and with damaged water regimes are in an abnormal state. It needs to be restored the natural missions of the valleys, as a shallow drainage channels and marshes, for purifying the waters.

Local climate and frequent droughts condition the need for irrigation, which ensures the increase of soil productivity. However, irrigation involves ensuring certain ecological conditions, and first of all, the water quality. Irrigation should categorically exclude salinization or soil solonetzization, as the irreversible consequences of these degradational processes.

For the purpose of sustainable use and protection of soil resources, it is strictly necessary to organize the Agency "Solurile Moldovei", to adopt the "Soil Law", and to develop and implement a system of countrywide urgent measures.

References

1. Atlas. Resursele climatice ale Republicii Moldova. Chişinău, Ştiinţa, 2013. 76 p.
2. World Reference Base for Soil Resources 2006. World Soil Resources Reports No. 103. FAO, Rome.
3. Cadastrul funciar al Republicii Moldova conform situaţiei la 1 ianuarie 2016. Aprobat prin Hotărârea de Guvern nr. 971 din 12.08.2016. Publicat 19.08.2016 în Monitorul Oficial nr. 265-276.
4. Clasificarea solurilor Republicii Moldova. Chişinău, SNMŞS, 1999, 48 p.
5. Degradarea solurilor şi deşertificarea. Chişinău, Tip. AŞM, 2000. 308 p.
6. Eroziunea solului. Chişinău, Pontos, 2004. 476 p.
7. Postolache Gh. Vegetaţia Republicii Moldova. Chişinău, Ştiinţa, 1995. 340 p.
8. Ursu A. Solurile Moldovei. Chişinău, Ştiinţa, 2011. 324 p.
9. Ursu A., Cuza P. Cota pădurilor în ecosistemele naturale ale Republicii Moldova // Mediul ambiant, nr. 2(74). 2014, p.15–18.
10. Билинкис Г.С. Неотектоника Молдавии и смежных районов Украины. Кишинев, 1971. 151 с.
11. Горбунов И.Ф. Рельеф Молдавии и его количественные характеристики. Труды Докучаевской конф. Кишинев, 1961. С. 119-125.
12. Справочник по климату СССР. Вып. II, Молдавская ССР; Ч. II. Температура воздуха и почвы. Ленинград, 1965. 124 с.
13. Стратиграфия осадочных образований Молдавии. Кишинев, Картеа Молдовенеаскэ, 1964. 131 с.
14. Урсу А.Ф. Природные условия и география почв Молдавии. Кишинев, Штиинца, 1977. 138 с.