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ELEMENTS OF EVOLUTION OF THE RELATIONS BETWEEN THE SOILS AND THE CLIMATE IN THE TERRITORY BETWEEN PRUT AND NISTRU IN THE CONTEXT OF CLIMATIC CHANGES AND NATURAL - ANTROPIC PEDOGENESIS

Gheorghe Jigău[1], Anton Blidari[1], Natalia Borş[1], Ana Bîrsan[1]

Key words: soils, climate, climate change

Abstract. The evolution of climate during the seventy-year cycle (1946-2016) led to the shaping, in the region, of two parallel trends of the evolution of the soil cover: a) in the sense of aridization; b) in the sense of humidification. These are due to the contouring of an alternation of drought and humid and relatively damp years in the 11-year climate cycle. According to calculations, 5 of them are humid or relatively damp and 6 are dry or relatively dry. Research shows that the climatic environment in the phase of modification leads to the simultaneous development of processes of both aridization of several spaces and hydromorphism of other. This situation shows different stability of the soil cover components in the region to climate change under natural-anthropogenic chernozem conditions. This particularity of soil development is to be taken into account both in pedological studies and in the framework of Regional Strategies and Programs for Adaptation to Climate Change.

Introduction

The soil is in its own way a reservoir of mineral and organic substances that determine the direction, intensity (speed) and the degree of migration and transformation of these within natural ecosystems. These processes take place within a certain climatic environment and are largely formed by it. At the same time, reverse links are also attested. Pedobiological processes, for example, significantly influence the concentration of greenhouse gases and, in turn, of climate change (Callas, 2009).

[1] State University of Moldova, Republic of Moldova

There is no doubt that during the Pleistocene-Holocene evolution of soils and climate, the torrents of typomorph elements and substances had different direction and intensity, being subject to cyclicality. These are printed in the morphological features of the soils of the space between Prut and Nistru and in the functional profiles (organic, carbonate, saline, agrophysical, hydrophysical, etc.).

Climate changes are capable of increasing the probability of risks for soils, as the strategy stipulates. The European topic of soil protection or to intensify the degradation processes in action, referring to the space between the Prut and the Nistru.

According to paleontological analyzes in the second half of the Atlantic period - the beginning of the Subboreal period (6000-4200 years ago), optimal climatic conditions for the development of the cernoziomic type of solidification are determined. Maximal aridization is attested 4200-3700 years ago. About 3300-2800 years ago, at the end of the Subboreal-period, a significant improvement in the pedogenic environment was noted, onsetting the differentiation of chernozem subtypes, the incipient phase being the arbonatic chernozems (Lisiecki etc. 2013).

In this respect I. Krupenicov notes that the current evolutionary phase of the chernozems in the Carpathian-Danubian-Pontic space is characterized by a type of calcium-humic-stepic type of solidification oriented towards biogenic accumulation and elution of the products resulting from the geochemical processes. Of this, the slightly soluble salts (Na_2SO_4, NaCl) are alienated deep under 6m. Alkaline salts are found in some areas under 4.5m. Calcium carbonates in most cases are found in the 0-100cm layer (Krupenikov 1967).

Both in the realization of the calci-humus-stepical pedogenesis and in the process of eluviation there is a clear rhythmicity synchronized with the climatic cyclic. Regarding the eventual evolution of the geochemical processes in some possible processes of climate change E.I. Pankova and M.V. Konyuschkova believe that rising the climate temperature without increasing the degree of humidity will lead neither to an increase in the intensity of alteration processes of soil minerals, nor to the intensification of salt accumulation processes (Pankova, Konyuschkova 2013). At the same time, however, a number of elementary pedogenic processes, under the influence of climate change, are undergoing noticeable changes (Kudeyarov etc. 2009).

The purpose of this paper is to evaluate the possible changes of the elementary processes within the chernozem type of solification under the action of climate change.

1. THE CONCEPTUAL - METHODICAL FRAMEWORK

In terms of the concept of the central role of the soil (the pedosphere) in the mediation of the relations between the spheres of the Earth (lithosphere, atmosphere, hydrosphere, climatosphere, biosphere), a full information on the interaction of severe climatic conditions and soils in general and some processes in its realization can be obtained through the use of indexes of soil function performance in relation to the components of the environment in general and within the ecosystems in general.

According to the theory of pedogenic factors and the systemic approach of soil relations ← elementary processes ← pedogenetic factors (environment), whatever the changes in the latter, they are obligatory reflected on soils. Since the soil mediates the relations between environmental factors, the changes within one shall have an impact on the others. At the same time, since soils have responsiveness and reactivity, changes within soils, whatever their nature, inevitably lead to changes in environmental components. In addition, it is demonstrated that soil has the ability to mitigate the impact of changes within factors in the relations to other environmental components. Due to the enumerated features, the soil is constantly adapting not only to the natural changes but also to the artificial ones that occur in the environment, by recording and memorizing the main moments of evolution, thus reflecting the changes in the state and evolution of the environment (ecosystems) very useful in the quantitative and qualitative evaluation of the efficiency of the landscaping works or the method of use of the soil resources (Florea, 2000).

The listed theoretical aspects involve the idea of introducing the pedofunctional concept as a basic criterion for assessing the effects of the interconnections between the environment and human communities, not only from the point of view of the relationships between organisms and their lifestyle, but broader, also using the forecast of the changes in the territory under the influence of socio-economic factors and thus with all the consequent consequences thereof.

The climate-pedosphere relationships imply physical processes and phenomena and occur according to physical laws. In this respect, the physical factors of functioning of the soil ecosystem have the main role in the relations with the climatic agents in any bio-and pedoclimatic conditions, while the physical processes determine pedofunctional (pedogenetic) regimes: hydrothermal, aerohydric, hydric, of aeration, thermal, biological, oxido-reductive. These in turn determine the intensity and the degree of mineralization-humification in the organic substances circuit in pedogenesis, the coefficient of usage of nutritive elements reserves and the biological accumulation of these, migration and biogeopedogenesis (Jigău, 2004, Jigău, et al., 2005).

Based on previous analyzes it was established that, for the purpose of assessing the physical aspects of soil relations with more informative climatic agents, there are the physical parameters that characterize the soil in the role of collector, reservoir and supplier of precipitation water as well as surface that participates in the recycling of water in the environment (Jigău, 2005). In the context of the presented concept, the relationships between soil and water are examined not only from the perspective of the soil's capacity to insure plants with sufficient amounts of water. According to the energetic concept of soil physics, founded by A. D. Voronin (1984), of the liquid phase of soil, in particular the solid phase theorem is determinant of the polyphasic systems functioning. At the same time, the quoted author notes that the soil, depending on the quantity of water and its energetic state, passes through a series of critical states of which most of the physical characteristics of the soils are indispensable of: maximum cohesion of humid soil, plasticity limit, flux limit, optimal conditions for aggregation, minimum plowing resistance, optimal conditions for mechanical soil working, compaction limit, and so on.

2. RESULTS AND DISCUSSIONS

2.1. Current climate in the space between Prut and Nistru: observed trends and variability

Overall, Moldova is located in an area with insufficient humidity, which leads to a high frequency of droughts that adversely affect the functionality of soil resources and as such of agro-ecosystems (agro-landscapes).

Table 1, 2 provides information on the frequency of droughts and droughty periods during the period of 1945-2011, from which we conclude that, besides the fact that the frequency of droughts has significantly increased during this period, there is also evidence of an intensification of the catastrophic droughts that affect the entire studied space. In this respect, we find that during the years 1990-2016 here have been registered 12 droughty years (1990, 1992, 1994, 1996, 1999, 2000, 2001, 2003, 2007, 2011, 2015) and 4 years with long periods of drought 2005, 2006, 2010, 2016). In the years 1990, 1992, 2003, 2007, 2012 the droughts prolonged throughout the vegetation period. After 1990, the frequency of the years with catastrophic drought significantly increased (1994, 1996, 2000, 2003, 2007, 2012), which significantly affected the most important period for the functioning of chernozems in the region. In this context the research of one of the authors of the present paper showed that during the period of 01.04-20.06 in the chernozems of the region are created the most favorable conditions for the achievement of the humification process with the wide reproduction of the stable humus reserves and those of the organomineral phytonutrients that insure the crops with the necessary nitrogen and other nutrients during the vegetation period (Jigău, 2009).

Table 1. Drought and droughty period frequency during the period of 1945-2015

year	Spring		Summer		Autumn	
	Area %	Drought type	Area %	Drought type	Area %	Drought type
1945	-	-	60	Catastrophic	40	Extreme
1946	100	Catastrophic	33	Extreme	-	-
1947	39	Extreme	-	-	60	Catastrophic
1948	-	-	-	-	60	Catastrophic
1949	60	Catastrophic	-	-	20	Vast
1950	33	Extreme	-	-	20	Vast
1951	60	Catastrophic	40	Extreme	-	-
1953	-	-	40	Extreme	60	Catastrophic
1954	-	-	73	Catastrophic	25	Very vast
1960	-	-	53	Catastrophic	13	Vast
1963	40	Extreme	7	Local	93	Catastrophic
1965	-	-	47	Extreme	80	Catastrophic
1966	47	Extreme	7	Local	60	Catastrophic
1967	60	Catastrophic	40	Extreme	93	Catastrophic
1968	93	Catastrophic	7	Local	-	-
1969	7	Local	47	Extreme	73	Catastrophic
1970	-	-	-	-	93	Catastrophic
1973	20	Vast	53	Catastrophic	87	Catastrophic
1975	-	-	7	Local	87	Catastrophic
1981	7	Local	53	Catastrophic	-	-
1982	60	Catastrophic	-	-	93	Catastrophic
1983	20	Vast	13	Vast	93	Catastrophic
1985	27	Very vast	-	-	73	Catastrophic
1986	100	Catastrophic	13	Vast	100	Catastrophic
1990	7	Local	67	Catastrophic	60	Catastrophic
1992	27	Vast	60	Catastrophic	40	Extreme
1994	87	Catastrophic	40	Extreme	100	Catastrophic
1996	68	Catastrophic	79	Catastrophic	44	Extreme
2000	75	Catastrophic	55	Catastrophic	49	Extreme
2003	86	Catastrophic	61	Catastrophic	26	Very vast
2007	78	Catastrophic	77	Catastrophic	-	-
2011	-	-	-	-	80	Catastrophic

The strong droughts of this period disrupt the rhythmicity of the biochemical processes in the soil thus affecting the pedofunctional potential, not only for that year, but also for subsequent years. At the same time, from the tables presented we find that the teritory between Prut and Nistru the strong and moderate droughts predominate. Besides the direct impact on the functionality of the soil ecosystem and agroecosystem, drought causes hydronic and thermal stress on soil biota that has a longlasting impact. Moreover, the increased frequency of years with climatic anomalies causes the phenomenon of cumulative drought effect, materialized in the spatial diversification of the hydrothermal and aerohydric regimes of the soils.

Table 2. Characteristics of the droughty years of the 1946-2011-year period

Year	Precipitations, mm			CHT	Crops, kg/ha	
	Total	XI - III	IV - V		Autumn wheat	Maize
1946	365	130	224	0.5	460	640
1953	344	144	197	0.5	1330	950
1950,1957	410	105	316	0.6	1800	1650
1967	395	106	289	0.7	3200	2860
1983	419	67	352	0.8	2750	3740
1986	370	134	234	0.6	3310	3150
1990	385	103	273	0.5	3110	3440
1992	405	111	289	0.6	3480	2450
1994	389	95	307	0.6	2390	1570
2000	458	130	289	0.8	2100	2400
2003	439	179	330	0.8	680	2780
2007	479	122	306	0.7	1520	850
2011	400	-	-	0.6	3100	3700

The first 15 years of the 21st century are the warmest of the entire period of documenting, starting the nineteenth century. Based on multiple research and observations, there is the impression that changes in climate during the cold period of the year are insignificant; summer, however, seems to be droughtier. The nature of the changes observed in the evolution of the climate in the space between Prut and Nistru is identified by the tendencies and variability of individual climatic variables. Given that the baseline of climate change is usually taken to be the early1990s, the seasonal and annual temperatures and the precipitations recorded at the Chisinau meteorological station (the longest range of instrumental observations) were studied and compared for two periods: 1980 and 1981-2008. According to these, the increase of the annual air temperatures in Moldova (0.035 ºC per decade), recorded before 1990, is followed by a sudden increase (about 0.58 ºC per decade). Moreover, compared with the first period, the temperature tendencies in the last three decades are statistically significant for summer and annual temperatures - with a 95% confidence level, and for spring - with a 90% confidence level (National Report on Human Development in Moldova "Climatic Change in the Republic of Moldova – The Socio-Economic Impact and The Policy Options for Adaptation", 2009-2010).

Within the precipitation evolution there can be atteseted a tendency of decrease - towards growth in spring and from growth (about 6mm/decade) - towards decrease over the last thirty years (more than 13 mm/decade) - in the summer. Autumn - winter and annual precipitations indicate a tendency towards an insignificant growth. The annual and the middle seasonal (excluding autumn) temperatures of the last three decades differ from those of previous years. Changes in precipitation patterns are not significant in terms of quantity, increase, but it is obvious in the transitional seasons (National Report on Human Development in Moldova "Climatic Change in the Republic of Moldova – The Socio-Economic Impact and The Policy Options for Adaptation", 2009-2010). According to the same source, the climate change is regional by its manifestation, but not by its origin. In this context, the research demonstrates the existence of some relations between global air temperature abnormalities and those of the surface of the planet with a series of analogical data from the last 120 years for the space between the Prut and the Dniester. At the same time, studies show that the overwhelming part of regional climate variability is caused by local factors. The simple correlation coefficient (r) between global and regional anomalies is 0.405. The dependence of the climate of the space between Prut and Nistru on the large-scale circulation processes in the Northern Hemisphere ($r = 0.457$) is about 20.1%.

According to forecasting scenarios within a climate evolution, the assesed space will face warmer and weter winters, but also hotter and drier summers and autumns. The annual decrease of the precipitation, combined with the rise in temperatures, leads to a severe humidity deficit. Potential evaporation will increase by 15-20%.

Thus, if in the assessed territory the climate in the reference period was semiarid only at the end of the summer – beginning of autumn, in the future the dry periods will probably be considerably longer and more severe.

2.2. Elements of modification of basic pedogenic processes induced by climate change

According to genetic pedology, the climate is the main pedogenetic factor and the evolution of soils is closely synchronized with the evolution of climate. However, not all soil characteristics can undergo immediate changes with the change of climate, because many pedogenetic processes and soil characteristics have inertia (Table 3).

With regard to climate variations in the past and present, as well as of the natural phenomena (drought, floods, activation of landslides, etc.), the current importance is to study the soil and soil biota's response to stressful changes due to the increase in the frequency of natural phenomena. This reaction has to be examined at the hierarchical levels of the soil ecosystem and the natural geosystems. In this respect, a series of phenomena and processes can be attested, which can be used as indicators of the evolution trend of relations in the climate↔solar system climate↔geosystem.

Table 3. The speed of achieving the equilibrium of soil characteristics with the environment under conditions of its change (Cudeyeovidr., 2009)

Soil Characteristics	Speed, years
The temperature, humidity, air, heat, salt concentration, the chemistry of the salts regime	10^{-1}-10^{0}
Aerohydric, hydrothermal, biological, oxido-reduction, composition of retained cations, pH values regime	10^{0}-10^{1}
Biological parameters, litter parameters, organic matter content, cationic exchange capacity	10^{1}-10^{2}
Humification profile, content and distribution of carbonates, iron, aluminum and fine clay compounds	10^{2}-10^{4}
The content and distribution of poorly alterable minerals, the modification of the alteration type and of the alterated bark	10^{4}-10^{7}

Regarding the climate↔geosystem relations in the space between Prut and Nistru, a series of landscape changes can clearly be outlined, these being an indicator of the landscape reaction to climate change (Table 4).

In order to appreciate the short-term changes, the reaction of the intrazonal soils, the formation of which is indispensably related to the climate, is more appropriate. In this respect, more specific are the complexes of salinized soils, the dynamics of which are easily accessible to study.

In order to appreciate the medium-term changes, more appropriate are a series of elementary zonal processes, the sense and intensity of which are indispensably dependent on the dynamics and the evolution of climatic conditions. The process of forming and accumulation of humus is also part of these. In this respect, the research carried out by Yu. S. Kozun (2014) in environmental environmental conditions of the territory between Prut and Nistru showed that the humus content in the soil is very responsive to their climatic conditions and dynamics: the coefficient of correlation of the humus content with the de Martonne aridity index is 0.86.

As the degree of climate continentality increases, the humus content is reduced because, in this respect, the activity of the microorganisms, especially of the bacteria - which are an important source of nitrogen in the process of humus formation, is reduced.

The humus content is strongly dependent on the annual amount of precipitation (correlation coefficient r = 0.98). A 100 mm increase in the amount of precipitation contributes to a 0.96% increase in the humus content. The dependence is nonlinear between the humus content and the air temperature, and within it the increase of the temperature amplitude by 1°C leads to the reduction of the humus content by 0.80%. The optimal conditions for the accumulation of a maximal quantity of humus in the space between Prut and Nistru are created under the conditions of an annual average temperature of 9-10ºC and humidity coefficient of about 1. At higher or lower temperatures, the humus content is reduced.

Table 4. Terrestrial biological systems affected by climate change in the territory between Prut and Nistru

Aridization indicators	Humidification indicators
Earlier greening of vegetation associated with a longer vegetation season, caused by recent heating	The accelerated expansion of seasonally overwetted areas over the past 30-38 years
Northward shift (invasion) of the plant species specific to the southern area	The abundant growth of early meso-hygrophite legumes: shamrock, vetch, trefoil and others., early spring
The shift towards higher altitudes (especially in Central Coders) of species adapted to lower altitudes	The abundant growth of white and, especially yellow, melilot during the summer
The abundant development of Elaeagnus angustifolia in the southern and center areas	Reducing the number of absinthe species within phytocenoses as a result of the increase in humidity in the superficial soil layer between April and June
The abundant development of sage and thyme in the southern area	The increase in the number of hydro and mesophytes (reed, coltsfoot, plantain, dandelion) and the decrease in the number of xerophyte species in the northern and central area

Elements of evolution of soil relations with the climate in conditions of natural-anthropogenic pedogenesis. The most important form of impact of natural-anthropogenic pedogenesis on the agrolandshaft is the substitution of natural vegetation with agrocenoses. This leads to the modification of two components with a decisive importance in pedogenesis and soil evolution: a) the biogeochemical circuit of substances; b) hydrothermal regime of soils (Jigău, 2009).

The evolution of the biogeochemical circuit of substances within the natural anthropogenic pedogenesis is determined by:

– the radical change in the aerial/root biomass ratio in favour of the aerial in comparison with the 80-90% of the radicular biomass in steppe ecosystems.

– the decrease in the amount of nitrogen involved in the process of humus formation as a result of the export of nitrogen from soil with the crops. As a result, the role of the humus formation process in the functioning and evolution of chernozems in the region is reducing. This is reflected primarily on the stability of the soil ecosystem under conditions of changes in the environmental factors.

– reducing the degree and the role of biological accumulation under the conditions of intensification of the technogenic fluxes of chemical elements.

Thus, the natural-anthropogenic pedogenic process is detaching from the natural one by the fact that the processes of substance and energy exchange are occurring otherwise, namely the flux and the exchange of information in the agrolandscape (the steppe ecosystem in the modification phase). The speed of the elementary typogenetic processes is significantly reduceding, which implies the need for a longer period of time for the realization of some of the pedogenetic effects corresponding to the newly created pedogenic environment.

Under the conditions of increased erosion with water and deflation, the intensity of the pedogenesis process is less than that of the destructive processes. As a result, slowly, the thickness of the humiferous layer is reducing.

The dehumidification processes acquire a new outline, a decrease in the content and the simplification of the composition of the humus is attested, the degradation of the structure. The substitution of biocenoses with agrocenoses inevitably leads to the modification of the soil climate due to the change in the soil surface and humidity regime and physical evaporation.

This leads to the increase of the arable soil sensitivity towards climatic conditions. Therefore, in arable soils, the changes in the soil climate are more pronounced than in the natural analogues (up to 1.5m). The soil climate becomes more continental in a larger thickness of the profile than in natural conditions, the sum of active temperatures increases on the whole profile, the depth of freezing increases as well, the soil thaws slower, the arable layer heats more in the summer, the monthly temperature and humidity amplitude increases, the ratio of water categories changes (Jigău, 2009).

The contrasting conditions of humidification and heating lead to an increase in the variability of the values of the oxidoreduction potential and the intensity of the physico-chemical processes of dissolution-precipitation (sedimentation) etc.

Plowing work leads to changes in hydrological regime. The latter is determined by two completely opposing components: a) the decrease in the thickness of the active water circulation layer, as a result of the decrease in the amount of water stored in the soil, and the humidification depth, caused by a decrease of water permeability and hydric conductivity; b) the cumulative-residual accumulation effect of water in the lower horizons of the soil due to a lower consumption through evapo-sweating.

The multiple researches carried out in the years 2003-2016 showed that within the current phase of natural – anthropogenic pedogenesis three types of hydrothermal regime has formed in the space between the Prut and the Nistru:

– Modal of steppe – annual humidification layer of 100 cm, presence for a prolonged time period of free water in the segment immediately underlying the active root. Slow water consumption during spring-summer that ensures the upward flow of water from the lower layers of the profile to the upper ones for a long period of time. In the 100-200 cm layer at the beginning of vegetation the water content is about 60-70% of the field capacity for water (FC).

– Antro-aridized – the depth of annual humidification aproximatively 50-70 cm. As temperature increases, accelerated drying and humidity reduction occur to the level of wilting humidity. During the vegetation period the upward flow of water from the lower layers to the upper ones is absent. At the beginning of the vegetation period in the lower levels of the soil the humidity is 50-60% of the field capacity. During the dry period of the year it is closer to the wilting humidity, 0.2-0.3 FC. The formation of the antro-aridized hydrological regime is favored by the intensification in the processes of physical degradation of the soil presented in Table 5.

– Bati-functional – water content corresponding to the field capacity for water (FC) and periodic compensation (once every 2-3 years) of the water reserves up to a depth of 2-3 m with accelerated (ephemeral batiactive), moderate (seasonally batiactive), slow (annually compensating) consumption of water.

– A separate subtype is the residual-cumulative subtype, which is characterized by an annual flow of quantities of water that exceed the quantities consumed annually.

An important role in the evolution of the hydrothermal regime of soils in the region is attributed to the physical degradation processes of the soils (Table 5) induced by the agricultural activity.

In activities evaluating the relations between the soil and the climate it is to be taken into account that the processes presented in Table 5 are outdated agricultural activities and are caused by the disturbance of the ecological equilibrium and of the trophic chains established at the pedological scale of time (Jigău, 2009).

The product of the interaction of natural processes and induced anthropogenic processes is the agrogenic layer of the arable chernozems that is divided into two substrates: arable and under arrable.

The agrogenic layer is a part of the profile that supports all the changes taking place in the environment, but also all the anthrotehnic involvements. Thus, the most active agrogenic layer responds to the changes in the landscape conditions, thus reflecting the particularities of pedogenesis in agricultural regime.

At the same time, the agrogenic layer mediates the exchange of substances and energy from the environmental components (pedogenic factors) and the underlying horizons of the chernozems profile (AB, B, C). The driving force of this mediation are the biogeopedogenesis products produced in the agrogenic layer layer and materialized in downstream torrents of substances and energy from the agrogenic layer into the underlying ones. Their composition and quality is based on the type of agroecosystems (agrolandscape), which leads to the homogenization of the processes carried out in the agrogenic layer and the diversification of the processes loccuring in the underlying layers.

Table 5. Implications of the physical degradation processes in the aridization of the soil coat in the Carpatho-Danubian-Pontic territory

Processes of physical degradation	**Functional implication**	**Desertification effects**
Stratification of the soil profile	The alternation of layers with different densities and hydrophysic functions. Porous space disturbance. Reduction of permeability for water.	The reduction of hydraulic conductivity and of the depth of profile percolation. Thickness growth of the layer of inner drought. Degradation of the processes of vertical migration of substances.
Compaction	The decrease in the total pore volume and humidity protecting pore volume. Increase of the volume of pores occupied by inactive water. Favoring of the siltization and vertisolaj processes.	The thickness reduction of the layer utilized by the plant root system and thus of the pedogenetically active. Favors the processes of unnecessary loss of soil water and of surface drainage.
Destruction	The decrease in the total pore volume, water permeability, water conductivity, water capacity. Favoring of crusting si siltizare of soil.	The decrease of water reserves in the soil and of its mobility degree and accessibility. Favors unnecessary water consumption processes in soil.
Crusting	The reducing of permeability for water and of the amount of water stored in the soil. Degradation of substance exchange in the soil system: atmosphere.	The reduction of the water reserves in the soil. The favoring of physical evaporation processes.
Siltization	The decrease in the total pore volume and in the active pore volume in the top layer of the soil. Reduction of permeability and water capacity.	The reduction of the water reserves in the soil. The favoring of water stagnation processes in the upper segment of the profile.
Vertisolaj	Formation of preferential water drainage paths through the soil profile. Excessive increase in water infiltration velocity in the groundwater layer.	The favoring of the processes of unnecessary loss of soil water.

As a result, three functional-genetic types of profile are formed:

–eluvial-accumulative – in which the eluvial-carbonatic layer is characterized by intensive processes of biogenic accumulation.

−accumulative-eluvial – in which the layer of humus accumulation and the eluviated carbonatic layer overlap.

−differentiated – composed of the humus-accumulative and eluviated carbonatic layer.

This leads to the diversification of the meaning and intensity of the soil relations in the regions with changing climatic conditions.

Conclusions

The current pedogenic environment (the precipitations, temperatures, humidity regimes, etc.) in the phase of modification on the basis of stability of the parental substrate is able to ensure the unidirectional evolution of the chernozem type of pedogenesis at hierarchically superior levels of taxonomy but with different intensity materialized at the hierarchically inferior taxonomic levels. The main factor limiting the evolution is the biological factor.

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