MANIFESTATIONS OF ANTROPO NATURAL ARIDIZATION IN THE AGROGENIC LAYER OF ARABLE CERNOZEMS: FACTORS, MECHANISMS

Gheorghe JIGAU[1], Anjela STADNIC [1], Boris TURCHIN[1], Natalia BORS[1], Mihai LESANU[1], Eugen SPRANCEAN [2], Nina PLACINTA[1],Tatiana CIOLACU[1]

e-mail: gheorghe.jigau@gmail.com

Abstract

In the present research, anthropo-natural aridization is examined as a complex process manifested in reducing the available water reserves below the potential level within the respective climatic conditions of the region, reducing the biological productivity of ecological soil-plant systems, quantitative and qualitative changes at all hierarchical levels of structural-functional organization of the soil ecosystem materialized in changing the meaning and intensity of chernoziomic typogenetic processes, the involvement of anthropo-natural processes uncharacteristic of chernozemic pedogenesis and increasing the degree of inhomogeneity of the soil cover. In this context, anthropo-natural aridization is a process inherent in the use of chernozems in agriculture caused by the evolution of the pedogenetic environment under the unidirectional intercalated action of natural soil degradation processes (water and wind erosion, decay) and physical, physico-chemical and chemical degradation (disintegration-destructuring, compaction, degradation of the porous space, salinization, solonetization, etc.) in conditions of reducing the role of the biological factor and the process of humus formation and accumulation within the anthropogenic chernozemic process. The current trend of climatic conditions in the Pridanubian space, especially reducing the amount of atmospheric precipitation and changing their regime, increasing the frequency and intensity of droughts, increasing the average multiannual and warm temperatures are factors that intensify the effects of anthropo-natural aridization of arable chernozems.

Key words: natural aridization, natural-anthropogenic aridization, degradative processes, hydrophysical profiles

Soil aridization came to the attention of research in the seventies of the last century through the prism of the contemporary phenomenon of desertification of territories. In this context, Kovda V. considers that the aridization of territories is a natural process of their desiccation due to the evolution of the level of erosion base caused by contemporary epeirogenetic processes, the increasing degree of erosive dismemberment and the degree of natural drainage materialized in the deforestation of ecosystems and reduction of their bioproductivity. (Kovda V.A., 1977).

According to more recent research in the Pridanubian area, the effects and consequences of arid and steppe forest aridization are increasingly felt, being attributed to climate change, especially the increasing frequency of atmospheric droughts and droughts and changes in the frequency, regime and nature of atmospheric precipitation. Based on the analysis of the cyclical conditions of the climate and the regional pedogenetic process, we consider that the aridization of the climate does not inevitably imply the aridization of the soils (Jigau Gh., 2019). It intervened in the evolution of chernozems in the region only at a certain stage of evolution of degradative processes, induced by anthropogenic activity, which intensifies the aridizational impact of natural factors (climatic, geomorphological, geological, hydrological and hydrogeological) (Jigau Gh., 2019; Jigau Gh, Lesanu M., 2021; Jigau Gh. *et al*, 2021).

The purpose of this research is to evaluate the place and role of degradation processes in the aridization of chernozems in the Pridanubian space. Through this prism of ideas, the "manifestation of aridization" presupposes processes and mechanisms that determine the unidirectional realization of the degradative-aridizational processes on the anthropo-natural pedogenesis scale of time.

MATERIAL AND METHOD

In the present research, anthropo-natural aridization is perceived as a complex process manifested in the reduction of the available water

[1] State University of Moldova, Chisinau, Republic of Moldova
[2] SRL „SCHIT-AGROMEX", Criuleni

reserves below the potential level in the respective climatic conditions of the region, reduction of the biological productivity of ecological "soil-plant" systems, quantitative and qualitative changes in all the hierarchical levels of structural-functional organization of the soil ecosystem materialized in the modification of the meaning and intensity of chernozemic typogenetic processes, the involvement of non-characteristic anthropogenous processes chernozemally pedogenized and the increase of the inhomogeneity of the soil cover.

In this sense,the anthropo-natural aridization is examined through the prism of the factorial-regime-procedural analysis of the anthropo-natural pedogenesis within the global process of land aridization on the geological scale of time. In this context, anthropo-natural aridization is perceived as a process inherent in the use of soils in agricultural regime caused by the evolution of the internal pedogenetic environment induced by the physical degradation processes (disaggregation-destructuring, compaction, degradation of the porous space) in conditions of reducing the role of the biological factor and the process of humus formation and accumulation within the anthropogenic chernozem process. Through this prism of ideas, the anthropo-natural aridity in the present researches is evaluated by the parameters of the physical and hydrophysical properties induced by the processes of anthropo-natural evolution of the chernozems.

RESULTS AND DISCUSSIONS

The concept of anthropo-natural aridization of arable chernozems in the Pridanubian space involves several genetic-evolutionary stages that began with the xerophyticization of territories in prehistoric times, manifested in the change of the composition of the vegetal formations caused by the intensification of the superficial leaks, the deepening of the erosion base and the groundwater level within the global processes of aridization of the soil cover and of the steppe ecosystems. The current trend of climatic conditions in the Pridanubian area, in particular the reduction (permanent or periodic) of the amount of atmospheric precipitation and the change of their regime, the increase of the frequency and intensity of droughts, the one-way trend of increasing average annual temperatures, summer temperatures during the warm period (May-October) that favor the evaporation processes, are factors that intensify the global processes of aridization of the steppes (Jigau Gh., 2019).

With the inclusion of chernozems in the agricultural circuit within the chernozem aridization process, a new anthropo-natural stage occurs, starting from the substitution of multiannual natural plant cenoses with polylevel root system functioning during the entire vegetation period with annual crops with superficial root system and short period of vegetation (3-4 months). This leads to the intensification of the degree of continentality of the soil climate characterized by overheating of the soil surface up to 40-60ºC, and in dry years up to 70% (Jigau *et al*, 2018).

Under these conditions, in the profile of arable chernozems, already at the beginning of the summer season the "warm front" that extends from the surface vertically overlaps with the fringe of capillary-suspended water and leads to the intensification of physical evaporation processes and the accelerated reduction of water reserves in soils and the arid stratification even in conditions of relative stability of the amount of atmospheric precipitation and their distribution throughout the year (Jigau Gh., Lesanu M., 2021).

A special place in this stage belongs to the reduction of the ability of arable chernozems to capitalize on and manage water reserves induced by degradation processes *(table 1*).

As a result, the water balance in arable chernozems is established at a lower quantitative level, compared to native chernozems. This is a quantitative expression of the manifestation of the aridization of arable chernozems: a lower degree of water supply than possible corresponding to the climatic conditions of the respective geographical area.

At the same time, agricultural vegetation, as a result of a shallower, less developed root system and a shorter vegetation period, consumes smaller amounts of water from the lower horizons of the profile. Thus, in the agricultural evolution of the hydric regime of arable chernozems, two clearly opposite trends are outlined: a) arid stratification caused by the reduction of total water reserves and productive ones in particular, and its intensive consumption during physical evaporation; b) residual-cumulative neohydromorphization of the lower layers of the profile as a result of the reduction of water consumption from them in a multiannual regime.

Therefore, arable chernozems are characterized by hydrological profiles that are significantly different from those of native analogues.

In the hydrological profile of leached and typical chernozems, the upper layer (0-50 cm) is characterized by an unstable and variable humidity regime depending on the physical state and dynamics of climatic conditions.

The middle segment overlaps with the iluvial-carbonate horizon and is characterized by

Table 1

Soil degradation processes that amplify the phenomenon of arid land drying

Processes	Consequences
Water erosion	- Intensification of surface leaks. - Reduction of water retention capacity due to total or partial destruction of the soil cover. - Reduction or destruction of the capacity of the soil to ensure a normal development of the vegetal layer accompanied by the reduction of the water retention capacity and the increase of the physical evaporation. - Increasing the albedo of the land surface and intensifying the evaporation.
Wind erosion	- Removing the upper horizons richer in organic matter and thus reducing the capacity of the soil to store water and ensure the functioning of the "soil-plant" system. - Reducing the anti-erosion stability of the soil and intensifying superficial leaks. - Increased albedo, increased surface temperature and strong intensification of evapotranspiration.
Compaction	- Reducing the capacity of the soil to allow rooting of crops. - Increasing the risk of erosion by decreasing water permeability and increasing surface leak. - Decreasing the water capacity of the soil by reducing porosity. - Intensification of evaporation.
Destructuration	- Reduction of water permeability, water conductivity, wetting layer thickness. - Reduction of total water capacity, productive water capacity. - Reducing the storage and conservation capacity of water in the soil. - Reducing the degree of mobility and accessibility of groundwater - Unproductive water loss during physical evaporation.
Crust formation	- Reduction of water permeability to the soil surface - Intensification of evaporation - Albedo growth
Grounding	- Increasing the degree of natural land drainage - Deepening the groundwater level. Reducing the share of capillary-supported water fringe in establishing the water balance in the soil. - Increasing the thickness of the "physiologically dead" layer with water contents below the wilting coefficient.
Salinization	- Provocation of soil drought due to the increase of the osmotic pressure of the soil solution over that of cultivated plants. - Direct toxic effect on crop plants - Intensification of evaporation by crust formation and albedo growth
Sodiumisation	- Clay dispersal, formation of dense and compact horizons - Drastic reduction of water permeability and useful water capacity
Vertisolation	- Formation of slip-consolidated horizons with extremely low water permeability. - Reduction of hydraulic conductivity, total capacity for water and for productive water. - Reducing the degree of mobility and accessibility of water.
Cracking	- Formation of preferential routes for internal drainage of water from the active pedogenetic layer in the subsoil and evaporation of water in the dry period.

stable deficient water reserves during the vegetation period.

The lower segment is characterized by higher water reserves during the entire vegetation period, even in years with rainfall amounts below the multiannual average.

Typical low-humiferous arable chernozems and carbonate ones in the southern steppe have a hydrological profile that differs from that of natural analogues by differentiating during the vegetation period in two layers.

The upper layer, as a result of an advanced degree of degradation of the aggregate structure is characterized by a high degree of susceptibility to physical evaporation and accelerated aridization. As a result, even in years with precipitation corresponding to the average multiannual amount, in it, the water deficit is established in the early phases of the vegetation period. For the same reason, the chernozems in the southern steppe are characterized by discontinuous porous space (Jigau Gh. *et al*, 2018). Under these conditions, in the wet period the "descending front" of water seeps deep into the soil profile. Instead, the capillary-ascending fringe of water, during the vegetation, has a discontinuous character. As a result, only a part of the water reserves present in the middle and lower segments of the profile is framed in the process of ascent and displacement in the agrogenic layer. Recent research has shown that in the sub-agro layer, even at the end of the vegetation period, there are free water reserves available for the ascending movement to the "arid zone". (Jigau Gh. *et al*, 2021).

In the current trend of climatic conditions in the region, arid processes are amplified by the interaction of arid and degradative processes. (*table 2*)

Table 2

Interactions between aridizational and degradative processes in the anthropo-natural aridization of arable chernozems.

Degradative processes	Effects that intensify aridization	Amplification mechanisms / processes determined by aridization
Water erosion	Intensification of surface leaking. Reduction of water retention capacity due to degradation of the soil profile. Reducing the capacity of the soil to ensure the normal development of agrophytocenoses.	Excessive drying of the soil surface, reduction of soil stability indices in relation to water. Reducing the cover of the soil surface with vegetation and exposing the soil to the action of water. Deep drying of the profile, the formation of cracks that favor the intensive evaporation of water.
Wind erosion	Reducing the soil's ability to store and conserve water. Bringing the substrate to the surface with low anti-erosion resistance. Increased albedo, intensification of insolation and evaporation.	Exposure of the roots of cultivated plants. Excessive drying of the soil surface spraying the structure and decreasing the cohesion between the solid components of the soil.
Destructuration	Reducing soil capacity for water. Intensification of surface leaking. Increased risk of water and wind erosion. Increased albedo and intensified evaporation.	Alternation of periods of excessive drying and over-wetting. Disaggregation of soil mass. Intensification of inert humus mineralization. Spraying the structure of clay soils. Soil covering with medium and fine granulometric composition.
Compaction	Degradation of porous space. Rocking of the aggregate structure. Reduction of soil capacity for water; reducing the degree of mobility and accessibility of water. Intensifying the risk of water erosion. Increased albedo and intensified evaporation. Reducing soil permeability to water. Intensification of evaporation by increasing capillary porosity (microporosity).	Slitization-consolidation of the arable layer. Cracking the soil with the formation of slip-consolidated blocks.
Sodiumisation	Drastic decrease in water permeability through the formation of compact and consolidated horizons. Drastic decrease in capacity for useful water. Direct toxic effect of sodium and sodium humate.	Contemporary processes of soda formation and alkalization in conditions of secondary overwetting.

CONCLUSIONS

The anthropo-natural aridization of arable chernozems is a complex process that involves not only the reduction of water reserves in the soil but also the radical change of the water regime materialized in the formation of hydrophysical profiles that differ significantly from those characteristic of native chernozems. The current evolution of arable chernozems is influenced by the intercalated action of aridizational and degradative processes and involves changes in the meaning and intensity of typogenetic processes at all hierarchical levels of structural-functional organization of the soil ecosystem.

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