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WATER EROSION OF SOILS IN THE HILLY AREA OF DOLJ COUNTY - ASSESSMENT, CONTROL AND MITIGATION METHODS

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Abstract

Erosion is a process of soil and land degradation, which occurs on a large scale, both in our country and worldwide. Due to its specific characteristics, the study area from the hilly part of Dolj County presents relief, climatic, lithological, hydrological, and vegetation conditions, which have contributed over time and continue to contribute today, to the manifestation of the erosion process, through which the productive capacity of the soils is degraded or diminished. In the reference area, soils subjected to surface water erosion encountered on lands with uniform slope, were identified and evaluated, where slow geological erosion has gradually but permanently removed the solidified surface layer. On slopes with a steep gradient, where deep erosion occurs, strongly eroded soils with gullies and ravines have been identified. By identifying the causes that have produced and continue to produce these short comings and based on the morpho-physico-chemical properties of the investigated soils, the most relevant methods of control and combating water-caused erosion were established (agro-improvement works and hydro-ameliorative works).

Key words*: control measures, prevention, soil degradation, water erosion.*

INTRODUCTION

Erosion, and in particular water erosion, is a degradation process that occurs in large areas of our country, among other processes that degrade soils or reduce their fertility, such as excess phreatic and rainwater moisture, acidity, alkalinity, alluvia, high fine fraction or bedrock content, low organic matter content, compaction, destruction of soil structure, pollution, etc. (Popescu, 2017). Water erosion, landslides, compaction and reduction of humus content, alluvia, are present in the study area. They have been identified as processes that degrade or reduce soil fertility.

In this paper, erosion has been identified and evaluated in both its forms (surface and deep) to establish methods for control, prevention, or mitigation, with the intention of assessing other processes in subsequent research. It should be mentioned from the beginning that water erosion is present in the reference area because of the specific relief, climatic, lithological, hydrological, and vegetation conditions.

On lands with an even slope, surface erosion manifests itself normally on extended surfaces (Figure 1), because it occurs without the anthropic influence intervening and consists in the gradual and slow detachment and transport of material from the solidified surface (Popescu, 2017; Ciocan et al., 2020).

Gully erosion occurs in the area on the lands with higher inclination, where the intensity of detachment and transport of mineral and organic material are much higher compared to surface erosion. Gully erosion is produced by the concentration of water in a certain direction (Figure 2), causing permanent formations (gullies and ephemeral gullies), with a destructive action (Nicola, 2013).

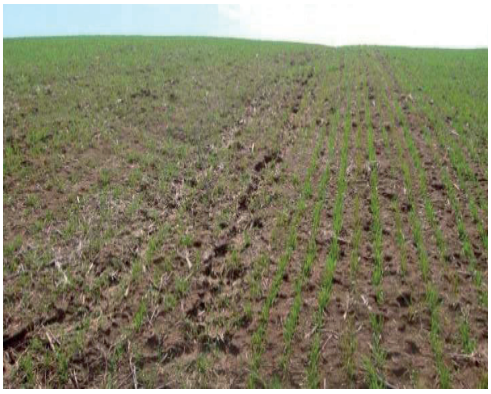

Figure 1. Natural erosion in the hilly area of Dolj County

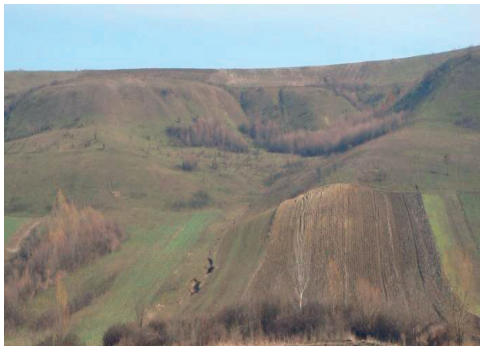

Figure 2. Gully erosion in the hilly area of Dolj County

Figure 3. Landslide in the hilly area of Dolj County

Accelerated erosion occurs together with other forms of degradation listed above: compaction, poor internal drainage, destruction of the structure, acidification (Biali & Cojocaru, 2021).

Losses of soil mineral and organic material, which are imperceptible in the case of slow erosion and produced at a fast pace, through gully erosion, have a negative consequence for agricultural lands and are reflected, in the low level of production (Haidu & Costea, 2012).

Soil erosion also produces other effects on environment, namely the degradation of downstream water (Berghoff et al., 2014), the clogging of rivers, lakes and reservoirs, the degradation of the natural environment, up to desertification (Neamțu, 1996). This explains the fact that worldwide, about 60 million tons of soil are removed annually, from an area of 430 million ha, through water erosion - 31% and wind erosion - 34% (Răuță & Cârstea, 1983).

Having in view these aspects, we can say that we cannot talk about sustainable and efficient development in agriculture, without invoking soil fertility as a decisive factor (Borlan & Hera, 1984). Two major degradation phenomena that occur in the hilly area of Dolj County are soil water erosion and landslides, both diminishing soil fertility (Figure 3).

MATERIALS AND METHODS

In Romania, erosion, in all its degrees of manifestation, on all agricultural lands situated on slopes exceeding 5%, is present on over 6 million hectares, and the intensity of erosion is assessed by the criterion of "degree of soil profile degradation", especially by the horizons that emerge on the soil surface (Răuța & Cârstea, 1983).

In every area of the country, it is important to know the soil and climate conditions as well as soil properties, to evaluate and develop the most effective measures to control the processes that degrade or reduce their fertility.

Laboratory analyses related to the erosion process on soil samples taken from the field soil profiles. Soil profiles of areas subject to natural and accelerated erosion were studied during the field phase. During the field phase, soil profiles were examined, and soil samples were taken in areas of natural morphological variation (Figures 4 and 5).

Laboratory testing consisted of preparing soil samples and conducting physical, hydrophysical and chemical analyses. They were determined according to the IRPA (The Institute of Research for Pedology and Agrochemistry), 1987 methodology:

a) physical-mechanical properties:

- size particle analysis, according to the Kacinski method and the texture was interpreted using the texture triangle;
- bulk density (B_d, g/cm^3) - Nekrasov cylinder method;
- density (D, g/cm^3) - pycnometer method;
- total porosity (Pt, %) - by calculation using the relationship Pt % = (1 – B_d/D) x 100;

b) hydrophysical properties:

- hygroscopicity coefficient (HC, %), by the Mitscherlich method;
- wilting point (Wp, %), by calculation with the relationship WP % = HC % x 1.47;

Figure 4. Soil profile on rupture terrain with natural erosion

Figure 5. Soil profile on rupture terrain with accelerated erosion

- field capacity (FC, %) - by the centrifugation method;
- available water capacity (AWC, %), by calculation using the relationship AWC % = FC % - WP %

c) chemical properties:
- humus by the Scholembergher method;
- total nitrogen, by the Kyeldahl method;
- available phosphorus by extraction with ammonium acetate solution and photocolorimetric dosing;
- available potassium, by extraction with ammonium acetate solution and photocolorimetric dosing;
- soil reaction (pH), by the potentiometric method, in aqueous extract;
- hydrolytic acidity (SH me/100 g soil), the Kappen method, with sodium acetate and titration with sodium hydroxide;
- the exchange capacity for bases (TEB, me/100 g soil), the Kappen method, modified by Chiriță;
- the total cationic exchange capacity (TEC, meq/100 g soil), indirectly with the relationship T (meq/100 g soil) = BS + HS;
- degree of saturation in bases (B%), indirectly through the relationship B % = BS/TEBx100.

RESULTS AND DISCUSSIONS

Surface and gully erosion in the hilly area of Dolj County are differentiated according to the relief or slope units, the thermal regime of the soil and the vegetation. This process was accentuated in the reference area, especially after the application of Law 18/1991, when the land was restituted to the owners on the old sites. They have the appearance of belts or strips (Figure 6), with small widths of 10-12 m, which cross the plateau, the slope with southern exposure, the valley, the slope with northern exposure and end in the plateau from the opposite direction, sometimes stretching on a length of 1-2 km. In this way, all the agricultural tillage on the sloping lands were carried out from the hill to the valley, on the line of the greatest slope, and the erosion process manifested itself more intensively.

On land with a uniform slope, where slow geological erosion has gradually but permanently removed the soil formed surface layer, young soils are found which are known as regosoils. (Florea & Munteanu, 2012). These soils have a short profile, made up of the bioaccumulation horizon (Ao) and the parental material C (Popescu, 2019).

On these soils erosion is imperceptible, but there are situations when it can be easily observed where lower genetic horizons appear on the soil surface (Figure 7).

Morphological description

Ao horizon: 0-23 cm; yellowish-brown color (10YR5/6) in wet state and yellow-brown color (10YR6/6) in dry state; clay-clay texture; unstructured or poorly formed granular structure; porous medium; compact environment; dense fibrous roots; rare whitish spots of calcium carbonate; weak effervescence; gradual transition.

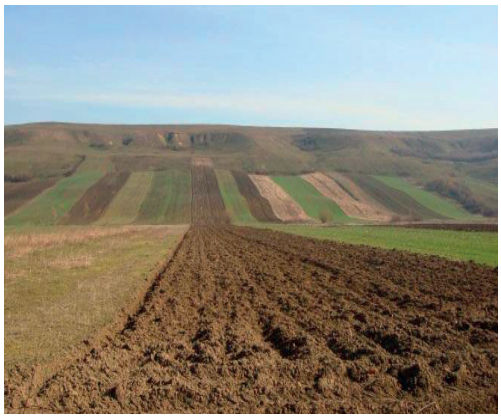

Figure 6. The aspect of the terrain in the form of belts (strips) on the line of highest slope in the hilly area of Dolj County

Figure 7. Lower genetic horizons emerged on even-slope slopes in the hilly area of Dolj County

Horizon C: below 23 cm; yellow-brown color (10YR6/6) in wet state and yellow color (10YR7/6) in dry state; clay-clay texture; unstructured or lumpy by drying; fine porous; compact; rare fibrous roots; frequent spots and rare small calcium carbonate concretions; moderate effervescence.

Size composition

The size analysis (Table 1) shows that the soil found on the slopes with a uniform slope has a high content of clay in both horizons, which determines a clay-loamy texture. The high content in clay means that on these lands, especially if the exposure is southern, a more intense expansion and contraction takes place and in this way the detachment of the layer from the solidified surface is more pronounced.

Physical properties

From the analysis of the densities and total porosity of the soil on the slopes with a uniform slope (Table 2), it is constant that the soil is looser in the bioaccumulation horizon, compared to the parent material, as a result of the agricultural tillage carried out.

Hydrophysical properties

The hydrophysical indices of the soil on the slopes with a uniform slope (Table 3), show low values, because of the low content in organic matter, but depending on the percentage of fine fractions there is a specific correlation.

Chemical properties

The soil subjected to natural erosion has a low content of humus (1.54%), very low total nitrogen (0.086%) and medium in mobile phosphorus (33 ppm) and mobile potassium (149 ppm). This higher content in mobile phosphorus and potassium is due to the application of chemical fertilizers.

Table 1. Size composition of the regosoil in the hilly area of Dolj County

Horizon	Depth (cm)	Clay (%)	Coarse sand (%)	Fine sand (%)	Silt (%)	Texture class
Ao	0-23	48.8	2.5	27.1	21.6	AL
C	under 23	50.6	1.6	26.9	20.9.	AL

Table 2. The physical properties of the regosoil in the area of Dolj County

Horizon	Depth (cm)	Bulk density (g/cm^3)	Density (g/cm^3)	Total porosity (%)
Ao	0-23	1.35	2.55	47
C	under 23	1.50	2.61	42

Table 3. The hydrophysical properties of the regosoil in the hilly area of Dolj County

Horizon	Depth (cm)	HC %	WP %	FC %	AWC %
Ao	0-23	9.53	14.00	29.54	15.54
C	under 23	10.71	15.74	31.04	15.3

Table 4 The chemical properties of the regosoil in the hilly area of Dolj County

Horizon	Depth (cm)	Humus (%)	Total nitrogen (%)	Soluble phosphorus (ppm)	Soluble potasium (ppm)	H_2O pH	SH	SB	T	V (%)
							(me /100 g soil)			
Ao	0-23	1.54	0.086	33	149	7.6	-	26.6	26.6	100
C	under 23	0.66	0.039	31	133	8.3	-	31.2	31.2	100

The reaction is maintained in the weak alkaline range (pH 7.6-8.3), which explains the presence of basic elements in the colloidal complex and the degree of saturation in bases 100% (Table 4).

On the steepness lands (over 30%), where accelerated erosion has removed the horizons from the surface, the erodic anthrosol is found.

These soils have a poorly developed BC horizon at the surface followed by the parent material. It can be stated that on the basis of the remaining uneroded horizons, the old soil cannot be detected, so that these soils can be called "soil stumps".

Morphological description

BC horizon: 0-17 cm; yellowish-brown color (10YR6/4) in the wet state and yellow-brown color (10YR7/4) in the dry state; clay-clay texture; large or small blocky angular polyhedral structure; fine porous; compact; rare fibrous roots, rare yellowish-whitish spots; very weak effervescence; slow passage.

Horizon C: below 17 cm; yellow-brown color (10YR6/6) in wet state and yellow color (10YR7/6) in dry state; clay-clay texture; unstructured, appearing as a compact mass; fine porous; compact; rare fibrous roots; frequent yellowish-whitish spots; moderate effervescence.

Size composition

And in this eroded soil, the size fraction that predominates is clay, with a percentage of over 50 in both identified horizons. At the opposite pole, it is the coarse sand fraction with only 0.2 %, which makes the soil texturally undifferentiated (Table 5).

Physical properties

The values of the physical properties (density, bulk density, total porosity) show that the soil subjected to accelerated erosion is heavily compacted right from the surface (Table 6).

The bulk density increases from 1.50 g/cm^3 in the BC horizon to 1.59 g/cm^3 in the parent material. In the same sense, the density of the soil also increases, from 2.68 g/cm^3 in the first horizon to 2.71 g/cm^3 in the C horizon.

The total porosity has low values in the two horizons of the soil profile, 44% on the surface, in the BC horizon and 41% in depth, in the parent material.

Hydrophysical properties

The hydrophysical indices are characterized by values in the range of clay content that the soil has in both horizons (Table 7).

These measures are needed in order to preseve soil fertility (Bilașco et al., 2018).

Table 5. Size composition of the erodic anthrosol from the hilly area of Dolj County

Horizon	Depth (cm)	Clay (%)	Coarse sand (%)	Fine sand (%)	Silt (%)	Texture class
BC	0-17	52.1	0.2	24.92	22.78	AL
C	under 17	50.15	0.2	27.98	21.67	AL

Table 6 The physical properties of the erodic anthrosoil from the hilly area of Dolj County

Horizon	Depth (cm)	Bulk density (g/cm^3)	Density (g/cm^3)	Total porosity (%)
BC	0-17	1.50	2.68	44
C	under 17	1.59	2.71	41

Table 7 The hydrophysical properties of the erodic anthrosoil in the hilly area of Dolj County

Horizon	Depth (cm)	HC %	WP %	AWC %	FC %
BC	0-17	10.97	16.12	32.73	16.61
C	under 17	9.76	14.34	31.96	17.62

Table 8 The chemical properties of the erodic anthrosoil from the hilly area of Dolj County

Horizon	Depth (cm)	Humus (%)	Total nitrogen (%)	Mobile phosphorus (ppm)	Mobile potasium (ppm)	H_2O pH	SH	SB	T	V (%)
							(meq / 100 g soil)			
BC	0-17	0.76	0.042	3.9	128	8.2	-	28.1	28.1	100
C	under 17	0.37	0.022	2.15	102	8.5	-	31.3	31.3	100

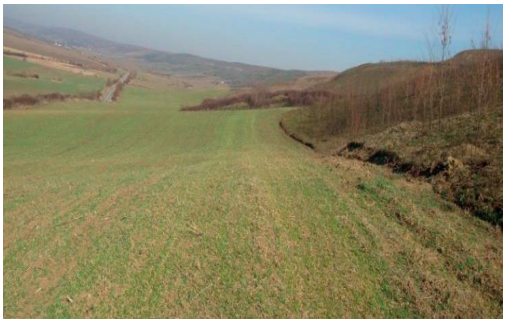

Figure 8. The seeding operation carried out along contour lines on a uniform slope in the hilly area of Dolj County

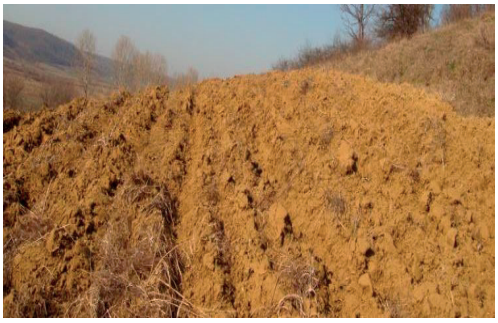

Figure 9. Plowing performed along contour lines on a uniform slope in the hilly area of Dolj County

Figure 10. Wheat crop on land with a uniform slope in the hilly area of Dolj County

Figure 11. Terraces with vines on sloping land in the hilly area of Dolj County

Figure 12. Afforestation with acacia, on land with a large slope and in the form of a strip in the hilly area of Dolj County

In this sense, the prevention, combating and conservation of soils with different degrees of erosion can be achieved through agrotechnical and phytotechnical works, especially for soils affected by natural erosion and through hydro-ameliorative works, complex works to control the development of water leaks on the slope, especially on soils affected by accelerated erosion (Arnaudova et al., 2020).

The execution of all technical works on contour (Figures 8 and 9), the use of crops that are sown in dense rows (Figure 10), the realization of a suitable crop rotation, the administration of organic and chemical fertilizers, are works aimed to preventing erosion by improving the capacity of water infiltration and the reduction of the dispersion of soil particles during precipitation and of course the increase of fertility and the obtaining of higher agricultural productions (Irimuș et al., 2017).

On the lands affected by the accelerated erosion, the efficient works involve the

construction of terraces for the vineyards (Figure 11) and afforestation (Figure 12).
The greatest efficiency in the conservation of lands subject to erosion is the combination of prevention measures and works to combat this process (Biali & Cojocaru, 2020).

CONCLUSIONS

As a result of the geographical location, but also of the natural conditions of relief, climate, vegetation, parent material in the hilly area of Dolj County, surface and gully erosion occur on large areas of land and on smaller areas, landslides.
Generally, the water erosion process involves changes in the properties of the affected soils, being the main degradation process resulting in the mitigating of soil fertility.
By studying in the field and from the laboratory analyzes carried out on the two soils subjected to natural and accelerated erosion processes, there are constant changes regarding the morphological, physical, hydrophysical, chemical and biological properties, as compared to the soils on the unaffected lands.
Both types of eroded soil are compact, compressed, with high density values and low total porosity values, as a result of the high content of fine, clayey fractions, and extremely low humus content. The structure of the soils is also affected, as a result of the decrease in the hydric stability of the structural aggregates, which also explains the compaction of the soils from the surface.
Eroded soils have poor relations with water and air. Being compact soils, permeability to water and air is low. The hydrophysical indices present disadvantages manifested by the increase in the values of the wilting coefficient, the decrease in the values of the field capacity or the moisture equivalent and the useful water capacity.
The chemical properties of the soils subjected to the erosion process are also modified, especially those in the field of organic matter accumulation, reaction and the reserve of nutrients, all as a result of the removal of the mineral and organic soil layer on the surface. Thus, as far as the reaction of the soils is concerned, it was found that it is in the slightly alkaline range, as a result of the presence as close as possible to the surface or even on the surface, of some horizons rich in basic elements. The content in humus is low and very low, also the supply of total nitrogen is very low and in terms of the reserve of chemical elements, phosphorus and potassium we can say that it is medium to low.
The low content of organic matter and the high compactness determines a weak biological activity in eroded soils.
All these manifestations, reflected in the characteristics of eroded soils, determine their low natural fertility, reflected in the low level of agricultural productions, which is directly proportional to the intensity of the process and the amounts of mineral and organic material detached from the slopes.
In addition to these shortcomings, related to the low productivity of eroded soils, it can be concluded that erosion, as a degradation process of soils and lands, also leads to the disruption of landscape.
The measures to prevent and combat erosion process must be established and applied in the complex, in order to achieve the conservation of soils and lands subject to water erosion in the hilly area of Dolj county.

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