

SOIL STRUCTURAL DEGRADATION RISK IN HOROIATA BASIN (TUTOVA HILLS)

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Abstract. The purpose of this study is to investigate a component of the physical soil quality, this being the structural degradation risk. The study area has been the basin of Horoiata River. The profile database used in the study consists of over 140 profile samples, dispersed all over the basin. The indexes used have been soil crusting index, the compaction degree and the susceptibility to cracking.

Introduction

From the moment soil enters production, degradation processes are stimulated, determining the deterioration of soil structure, a decrease in nutrient pools, affecting the carbon cycle and so on. **Degradation** is a consequence of dysfunctional equilibriums, having first of all a dynamic notion, implying the deficient character of the interactive links between the elements of the system. The capacity of re-adjustment offers the system a sustainable functioning, but if this capacity is exceeded it may reach resilience.

Soil degradation implies its decay under the level of its natural or acquired qualities. Sometimes the term has in view only the deterioration of physical characteristics and of the profile integrity, taking into account the effects of erosion, landslides or other mechanical actions. In reality the clear delineation of the aggression forms is not always possible or correct (Ungureanu, 2005). Because of this delineation difficulty, some authors consider that in spite of its severity and global impact, soil degradation remains an emotional rhetoric and not a precise and quantifiable scientific entity (Lal and Stewart, 1990).

Soil structure determines the way in which water and air move through soil, furnishing nutrients. The structure types more stable to water action, formed of micro-aggregates, present the most favorable conditions to infiltration. Soil structure degradation may occur either due to chemical modifications, through the

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decrease in the humus content, the increase in the sodium one, the debazification and acidification of the soil, or due to the direct action of destroying structural elements as a consequence of excessive tillage, compaction, crust formation, etc.

Structure degradation may lead to soil compaction and crust formation, with significant consequences in infiltration reduction and implicitly in surface flow acceleration, with direct effect in increasing erodability. Crust formation is frequent on soils with low humus content, with medium-coarse texture and high silt content.

The favorable effects of soil structure are felt on the extreme textured soils, to whom are partially compensated unfavorable physical conditions such as low water retention capacity (sandy soils), permeability and insufficient aeration (fine-textured soils) (Canarache, 1990).

1. Study area

Horoiața basin is situated in the central-southeastern part of Tutova Hills (fig. 1). The geomorphologic individuality of the region is given by the landscape fragmentation as elongated hills oriented from north to south, separated by a network of consequent valleys. Because structure and lithology represent the secondary elements that stood at the basis of relief formation in this area, the main geomorphic role was detained by the external agents.

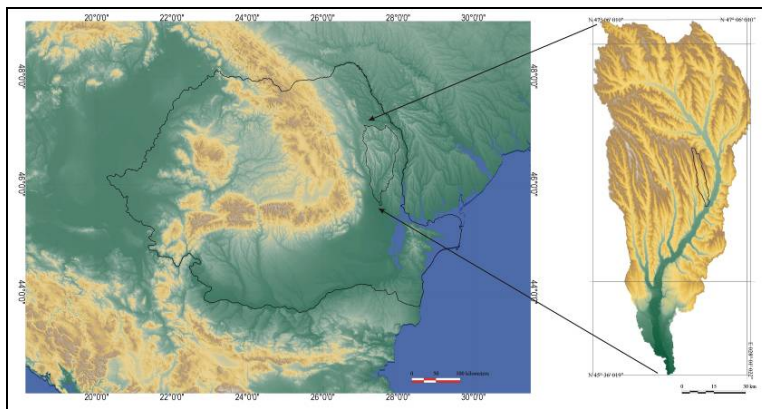


Fig. 1- The position of the study area in Romania and Bârlad basin

Structurally, Horoiața basin corresponds to the southern part of the Moldavian Platform, which sinks towards Bârlad depression. The morphology of the region is conditioned by the sedimentary deposits of the last geologic cycle,

respectively Upper Sarmatian and Meotian ones, disposed in a monocline of 5-7 m/km from NNW towards SSE. The Chersonian deposits in deltaic facies are represented by a monotonous succession of sands, sandy clays and clays. These deposits occur along the slopes as bands that narrow towards the middle and upper part of the rivers courses. The Meotian deposits occur at the upper part of the sedimentary stack, being represented by a lower horizon of Nușasca-Ruseni cinerites and by an upper clayey-sandy one. The cinerite horizon decreases in altitude, while the upper one has an increasing thickness to the south of the region. The valley easily cut through these friable deposits, evolving both through normal and regressive erosion. An extremely important role was held by slope processes, which even today contribute to the intense relief modeling.

2. Materials and methods

The analysis of the soil cover departs from the soil maps scaled 1:10000 surveyed by OSPA Vaslui and from the analytical data included in these studies, verified with field observations or literature data. The profile database used is made up of over 140 sampling points. In what regards their repartition in the basin, we consider it to be quite relevant. The sampling density enters acceptable limits. A small deficiency is registered in the northern part of the basin, where due to the forested surfaces (in which the Romanian agricultural soil survey system does not take samples) we have a lower point density.

The analyzed parameters were three: soil crusting index, the compaction degree, and the susceptibility to cracking.

Soil crusting index was determined with the well-known FAO relation:

$$I_{fc} = \frac{1,5P_{fm} + 0,75P_g}{A + 10MO},$$

where P_{fm} represents silt (0.002-0.02mm) percentage; P_g the coarse silt (0.02-0.2 mm), A the clayey fraction (<0.002mm), and MO the organic matter.

The compaction degree is computed as: $GT = (PMN - PT / PMN) / 100$, and: $PMN = 45 + 0.163 \times A$, where GT = is the compaction degree (% v/v); PT = total porosity (% v/v); A = the clay content (% v/v); PMN = the minimum necessary porosity (% v/v). This final attribute represents the minimum value of total porosity which at certain clay contents insures minimum physical conditions.

Another parameter that offers indications about structure degradation is the **susceptibility to cracking**, which describes the intensity of the mechanisms of swelling-shrinkage, which contribute to the cracking of a horizon or of the

constituent aggregates. The essence of the structural aggregates' fragmentation stands in the variation of the clay volume at different water contents. In natural conditions, the amplitude of the swelling-shrinkage phenomena is determined by the limited absorbed water quantity and the maximum dryness state reached by the soil, that depend on the climatic conditions (summer hydric deficit) and on the cultivation depth.

Also, the swelling amplitude varies directly proportional with the clay content. Different authors have revealed the role of organic matter in reducing the swelling amplitude and limiting fragmentation. The mechanical behavior is very complex, due to heterogeneity and the fact that properties vary with humidity.

Stengel (1983) proposed a classification of the structural activity of materials according to their texture, separating five classes:

- I. Excellent aptitude to cracking through swelling-shrinkage, quite good in the tilled layer ($100 \cdot MO/A > 7$) in comparison to the subsoil (< 7). Soils with a clay content $> 40\%$;
- II. Medium cracking in the presence of organic matter, good in its absence. Soils with a clay content of 25-40%;
- III. Weak and uncertain cracking (> 7), medium in the absence of organic matter. Soils with a clay content of 15-25%;
- IV. Extremely reduced cracking in the presence or absence of organic matter, soils with a clay content $< 15\%$;
- V. Dry granulation in the absence of organic matter, sandy soils, sometimes with rock fragments.

3. Results and discussions

In the study area have been identified 18 soil taxonomic units, to which are added eroded variants and associations of soils. The statistical analyses reveal the clear domination of the Chernisols, that form more than half of the region's surface (58.13%), followed by Luvisols (17.68%). Together these two soil classes sum up more than 70% of the surface and give the defining pedo-geographic mark of the basin, and implicitly of the Tutova Hills.

We must also mention the large occurrence of the Protisols (16.91%), especially of the Regosols, which in associations with the Erodosols also give a specific aspect of the region. Finally, with reduced ratios, we encounter Antrisol and Hidrisols.

Chernisols dominate the soil cover in the south-central and eastern part of the basin, which corresponds to the sylvo-steppe bioclimatic area, while Luvisols are met in the northern part, on the higher hills, as well on the eastern, forested, watershed limit. Erodosols and the eroded variants are characteristic mainly to the

western and northern exposed cuestas, while the most consistent Aluvisols areas are met in the floodplains of Horoiata and its main tributaries.

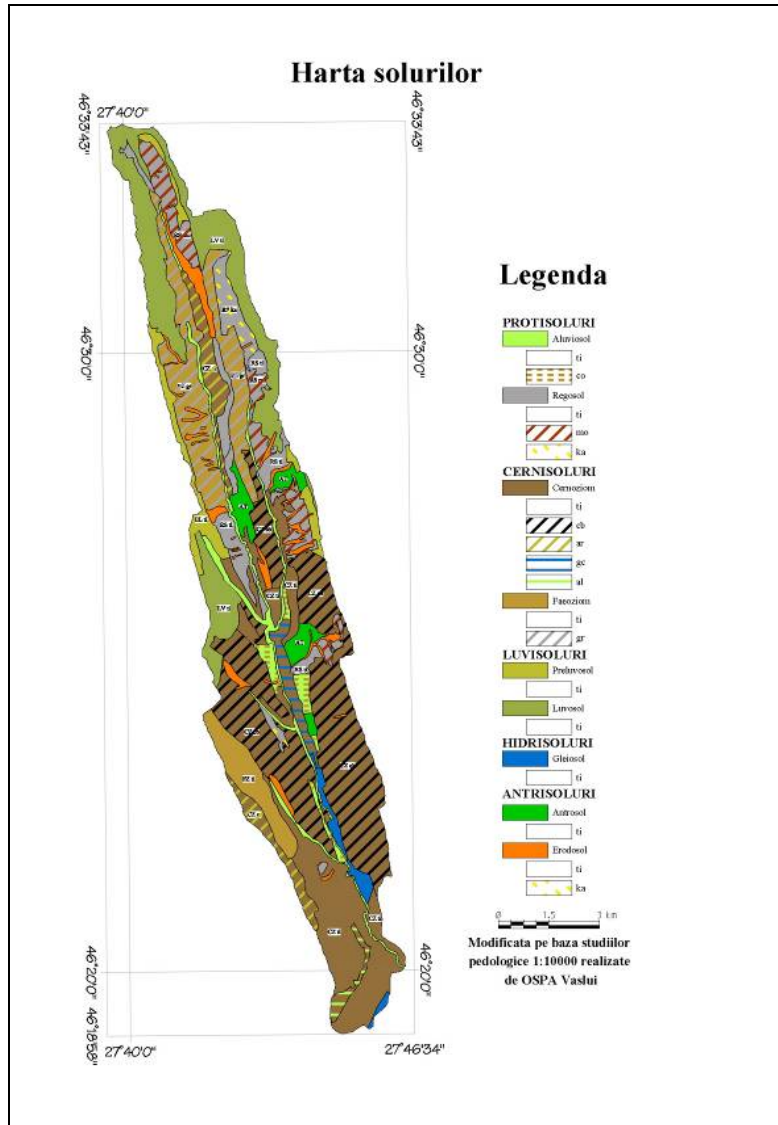


Fig. 2 - Soils of Horoiata basin

Most of the soils from the study area are characterized by a grainy structure in the upper horizon, due to the quite good content of organic matter, but also to the linking elements taken from the parental material. Thus, most of the parental materials being of carbonatic nature, Ca^{2+} is present, stabilizing the soil colloidal complex and contributing to the formation of a well defined grainy structured. When clay eluviation or neo-formation processes are present, the resulting structure is polyhedral angular or sub-angular, rarely prismatic.

Tab. 1 - Statistical variables of some physical parameters sampled from the upper horizons of the soils from Horoiata basin *

Parameter	Max	Min	Median	Average	Standard deviation	Variance
NG	44.5	0	6.48	8.98	8.10	65.66
NF	79.29	17.08	50.7	51.7	9.57	91.74
NT	83.5	17.34	59.1	60.4	12.11	146.8
P	46.28	2.8	11.9	15.32	9.31	86.85
AF	99.75	13.1	36.86	40.86	17.2	295.96
A	65.1	2.99	20.65	24.39	11.57	134.06
DA	1.62	0.73	1.42	1.35	0.17	0.03
IFC	5.60	0.34	1.62	1.64	0.79	0.62
GT	15.76	-30.28	3.82	0.54	9.50	90.29
Apt fis	87.62	1.03	8.23	10.86	9.20	84.64
Erod	5.57	0.31	1.09	1.26	0.62	0.39

* The significance of the abbreviations is: NG – coarse sand; NF – fine sand; NT – total sand; P – silt; AF – physical clay; A – clay; DA – bulk density; IFC – crust forming index; GT – compaction degree; Apt fis – susceptibility to cracking; Erod – erodability.

Not having data regarding aggregate stability, in the analysis of structural degradation or soil susceptibility to such processes, we first used the crust forming index. If the value of 2 makes up the lower limit from which soils are prone to structural degradation, from the below graphic we may see that the majority of the analyzed profiles are situated below this limit. The soils that exceed the value of three of this index are few, being especially those with high bulk densities. In fact, there is a significant direct correlation ($r^2 = 0.6212$) between the crust forming index and soil bulk density.

Analyzing the repartition of the mean values of the index on main soil types (fig. 4) we observe that the soils susceptible to crust formation are especially Regosols and Erodosols, but also Chernozems, Luvisols and Aluviosols, most probable due to the higher silt content in their upper horizons and to the lower humus content.

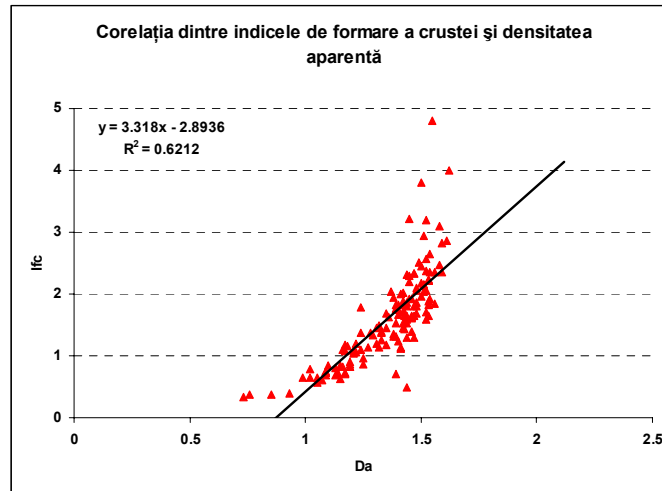


Fig. 3 - Correlation between the crust forming index and bulk density

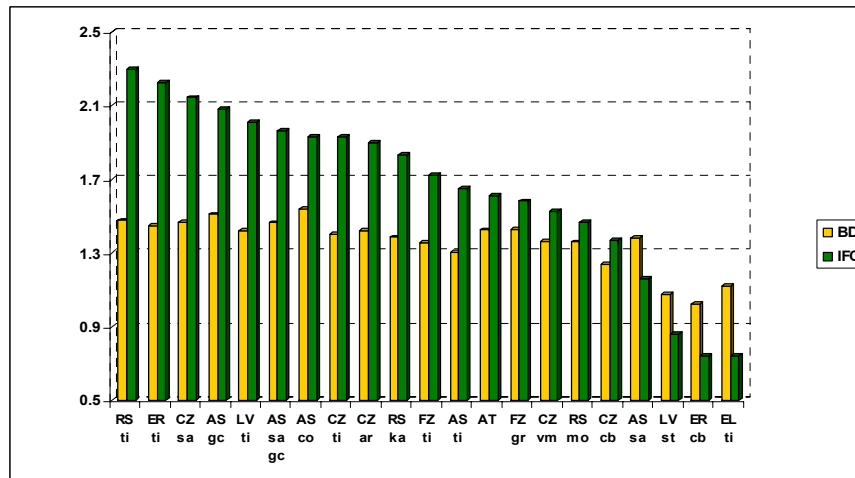


Fig. 4 - Values of bulk density and crust forming index for the main soil types from the study area

The weakest susceptibility to this process characterizes stagnic Luvisols, cambic Chernozems and typical Preluvisols. If we look at the spatial repartition, we notice a growing tendency of the index values from south to north. The smallest values are registered in the lower basin, where we have high clay contents

(Aluvisols, aluvial Chernozems). The central and northern parts of the basin are remarked through mean values (which indicate a weak susceptibility to crust formation), the highest values being met in the northern part of the basin, in the area of greyic Phaeozems and Luvisols, which have a coarser texture in their upper part.

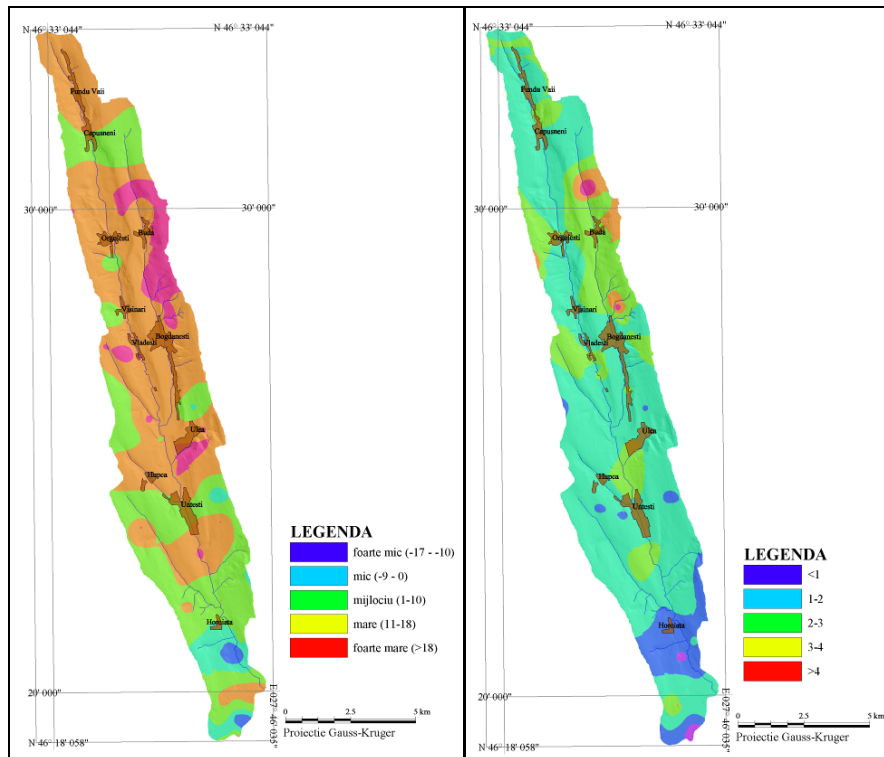


Fig. 5 - The distribution of the compaction degree (left) and crust formation index (right) at the basin level

The classification of the cracking amplitude has been conducted taking into account the content of organic matter, that limits the swelling-shrinkage amplitude, and the nature of the clay grain-size class (<0,002 mm).

If we take into account the values higher than 7 of this index as representing an excellent susceptibility to cracking, we will see that here enter the largest part of the Aluvisols (salic, coluvic, gleyic), due to the high clay content.

In the same class enter some greyic Phaezoems, Regosols (calcaric, typical, mollic), typical Erodosols and stagnic Luvisols, this time most probable due to the low organic matter content.

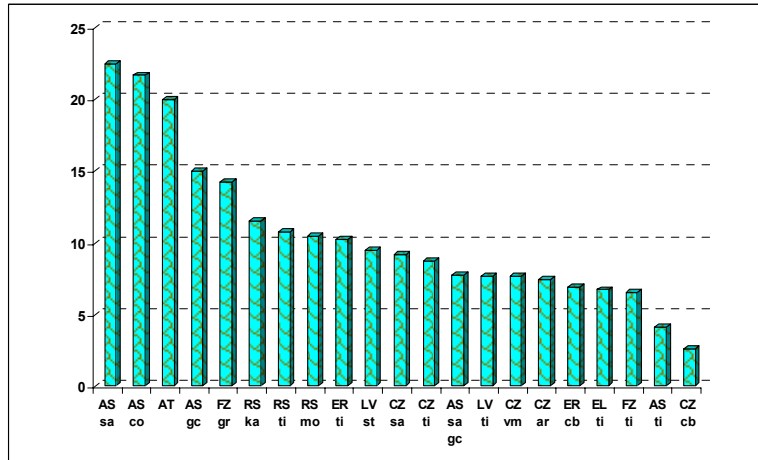


Fig. 6 - Values of the cracking susceptibility index

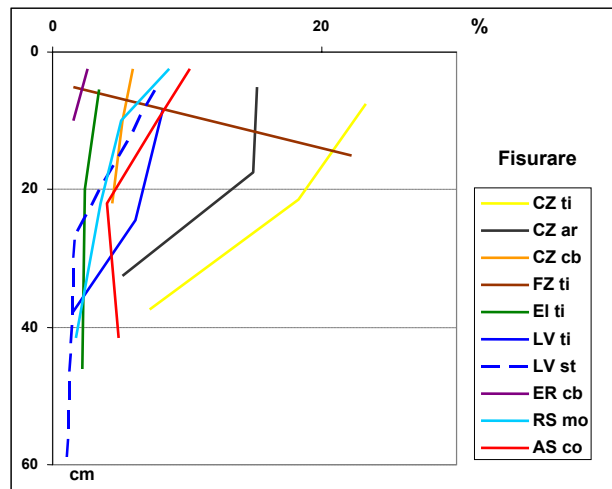


Fig. 7 - Profile distribution of the cracking susceptibility index

In the below graphic, which represents the profile variation of the cracking susceptibility index, we see that among the most susceptible soils to this process are typic and argic Chernozems, Phaeozems and Aluviosols.

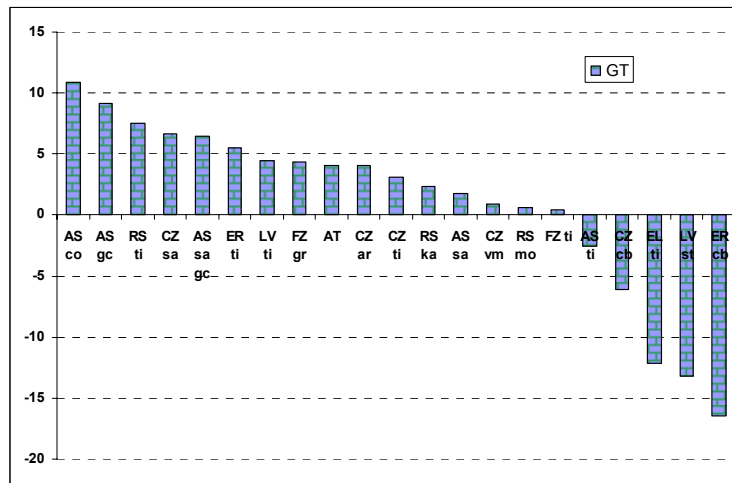


Fig. 8 - The distribution of the compaction degree for the main soil types in the study area

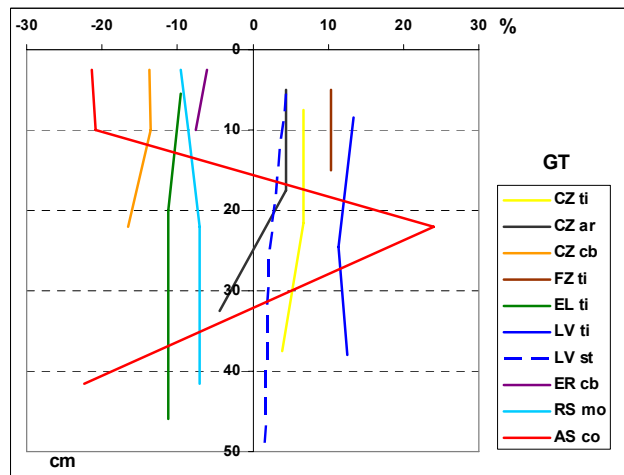


Fig. 9 - Profile variations of the compaction degree values

The compaction degree is an important indicator for appreciating soil characteristics, especially from a practical viewpoint. Being directly dependent on the clay content, it has larger values for the fine textured soils and for the compacted ones. The medium and coarse textures don't pose serious compaction problems except in the case of some loessoid deposits.

The values of the compaction degree for the soils of Horoiata basin are reduced, the highest ones being met in the case of Aluviosols (coluvic and gleyic), Regosols, Erodosols and salic Chernozems, yet classified as medium (1-10). The lowest values characterize the cambic Chernozems, Preluvosols, stagnic Luvosols and cambic Erodosols.

In what regards the profile variations of the values, we may notice an easily compaction at the upper part of the Chernozems, the other soils not presenting significant variations in the first 50 centimeters. The most obvious exception is that of the coluvic Aluviosol, two being the possible causes: natural compaction due to the stratification of the material brought from the slopes, or the existence of the hardpan horizon (at 20-25cm we see a significant increase in the compaction degree, at over 20, which includes the soil as strongly compacted).

The compaction degree, along its usage as general indicator, is used in practice for establishing the necessities for deep tillage of the excessively compacted soils. Thus it is considered that such interventions are need as first urgency on soils having index values larger than 18, the second urgency includes those situated between 11 and 18, and in the end are those with values between 1 and 10%. Soils with index values lower than 0 do not need intervention (Canarache, 1990).

Conclusions

On the overall, the values of the three indexes taken into account in characterizing structure degradation risk enter acceptable limits. Because the indices and the properties taken into account depend mostly on the clay content, and because our study area is mainly sandy, the values enter normal limits. The only exceptions are met in the southern part of the basin, where accumulative processes lead to high clay contents in the case of Aluviosols, and in the northern one, where the main deficiency stands in the low humus content.

References

- Canarache A. (1990), *Fizica solurilor agricole*, Ed. Ceres, București
Lal R., Stewart A.B. (1990), *Soil degradation*, New York, Springer Verlag
Ungureanu Irina (2005), *Geografia mediului*; Ed. Univ. „Al. I. Cuza” Iași, 300p.

