RESEARCH ON SOIL DEGRADATION RESULTING FROM SHEET AND GULLY EROSION PROCESSES. CASE STUDY – THE RAUL ALB HYDROGRAPHIC BASIN, DAMBOVITA COUNTY, UP TO THE POINT IT MEETS BARBULETU STREAM

Florin CIOCAN[1], Laurentiu Catalin MANU[1], Marin Alexandru MATACHE[1], Elena CONSTANTIN[1], Nicolae PETRESCU [2], George MURATOREANU[2]

e-mail: florinciocan74@yahoo.com

Abstract

The research works focused on the upper hydrographic basin of the Raul Alb creek up to the point it meets Barbuletu stream, covering an area of 4 034 ha and aimed at establishing the degree of soil degradation as a result of the complex action of sheet and gully erosion. Following the pedological study, seven soil types have been identified, each with several subtypes, which fall into five large soil classes. Regosols account for 51.00% of the catchment area, followed by eutric cambisols, 18.70%, rendzic leptosols 11.55% and phaeozems 11.00%. The fluvisol, anthrosol and luvisol total 7.75% of the entire basin. The class of Entisols is present in 56.10% of the area, followed by Mollisols 22.55% and Inceptisols 18.70% of the analysed area. The Entisol class (eroded phases) is to be found in 2.26% of the area, whereas the Alfisols account only for 0.39% of the hydrographic basin. In terms of sheet erosion, slightly eroded lands represent 48.26% of the total of 4 034 ha investigated, followed by the moderately eroded ones, 43.97%, whereas 2.27% of soils are strongly and excessively eroded and only 5.50% are not affected by sheet erosion. Deep water erosion is represented by rills, gullies and ravines. Gullies can be found in 35 of the 43 units of identified soils, ravines are present in 2 soil units and only 5 soil units are not affected by gully erosion.

Key words: hydrographic basin, pedological study, soil, sheet erosion, gully erosion

Of all forms of soil degradation investigated over time, erosion is considered by specialists in the field to be the natural hazard with the most intense action on the fertile layer on the planet’s surface (Sevastel M. et al, 2015). Due to its continuous action, it is the phenomenon that changes both the physical appearance of the upper part of the earth’s crust and its chemical properties. When the intensity of erosion is high, fertile lands may be transformed, over time, into poorly productive or even completely unproductive areas (Motoc M., Mihaiu Gh., 2000).

The *JRC* (*Joint Research Centre*) annual report, published by the *European Commission* in *2009*, identifies six processes with a decisive role in soil degradation: erosion, with its two forms, surface and deep, organic matter decline as a direct consequence of erosion phenomena, soil compaction, salinization, soil contamination with various chemical products and drastic and continuous decrease in biodiversity. The same annual report released in *2012* warns that in the EU, an area of 1.3 million km² is affected by water erosion, and in approximately 20% of this degraded area soil losses are larger than 10 t/ha.

Of the approximately 350 billion tonnes that constitute the planet’s fertile soil reserve, around 2.32 billion tonnes are lost by erosion every year, and if this loss rate remains constant, the entire reserve may be depleted in about 150 years (Biali Gabriela *et al*, 2014).

In our country, the value of total specific erosion intensity in agricultural areas ranges between 3.2 and 41.5 t/ha/year, with a weighted average of 16.28 t/ha/year, which entails an annual soil loss by water erosion between 126 and 150 million tonnes (Motoc M., 1982).

In the hydrographic basins in high hilly areas, such as the one investigated in this paper, as well as in mountain regions, water or pluvial erosion occurs at high intensity. Depending on its speed, this type of degradation may take two forms: natural or geological erosion and accelerated or anthropogenic erosion, the latter being directly influenced by uncontrolled human

[1] University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania
[2] Valahia University of Targoviste, Romania

actions (Motoc M, 2002), namely, deforestation, overgrazing, irrational exploitation of lands vulnerable to erosion without implementing anti-erosion measures, expansion of built-up areas to the detriment of agricultural areas etc.

Water erosion on slopes proceeds in several stages, starting from raindrop action or pluvial denudation (impact erosion), then erosion by surface currents (sheet erosion) materialized by surface erosion, and, finally, torrential or deep erosion (rill erosion, gully erosion) produced by currents on moderately and strongly inclined surfaces (Grecu Florina, Palmentola G., 2003).

Surface erosion mainly occurs during heavy rainfall and snowmelt periods, through the removal of fertile material from the topsoil, carried by the water excess running down the slopes in the form of small runoffs. It is the type of erosion that affects the largest areas and also the most harmful because it is hardly observable. The occurrence of this phenomenon is noticed late, when light-coloured areas emerge on the soil surface, pointing to penurious soil or soil devoid of organic matter (Ispas St. et al, 2006).

In time, surface water erosion progresses and becomes deep erosion, which may proceed through the concentrated rainwater flow along certain paths up to the level of the soil parent material (Dirja M. *et al*, 2002).

The direct and irreversible effect of the two forms of soil degradation is the decrease in the productive potential of agricultural lands proportionately to their degree of intensity due to the reduction or removal of fertilizers from the soil (humus, nitrogen, phosphorus, potassium etc.), the reduction of the useful edaphic volume and the modification of the normal soil aero-hydric regime.

Today, GIS techniques play a key role in the identification and quantitative assessment of water erosion effects as they help to carry out research at the level of hydrographic basins, leading to a more accurate estimate of the risk of occurrence of erosion processes and to projections regarding the evolution in time of erosion processes (Ganasri B.P., Ramesh H., 2016).

LOCATION OF THE RESEARCHED AREA

The Raul Alb stream is a tributary of the Dambovita river, which lends its name to the county it runs through, located in the central-southern part of Romania. In Dambovita County, the researched basin lies in the north-west, covering areas in both the high hilly region and the area of transition to the mountains (*figure 1A*).

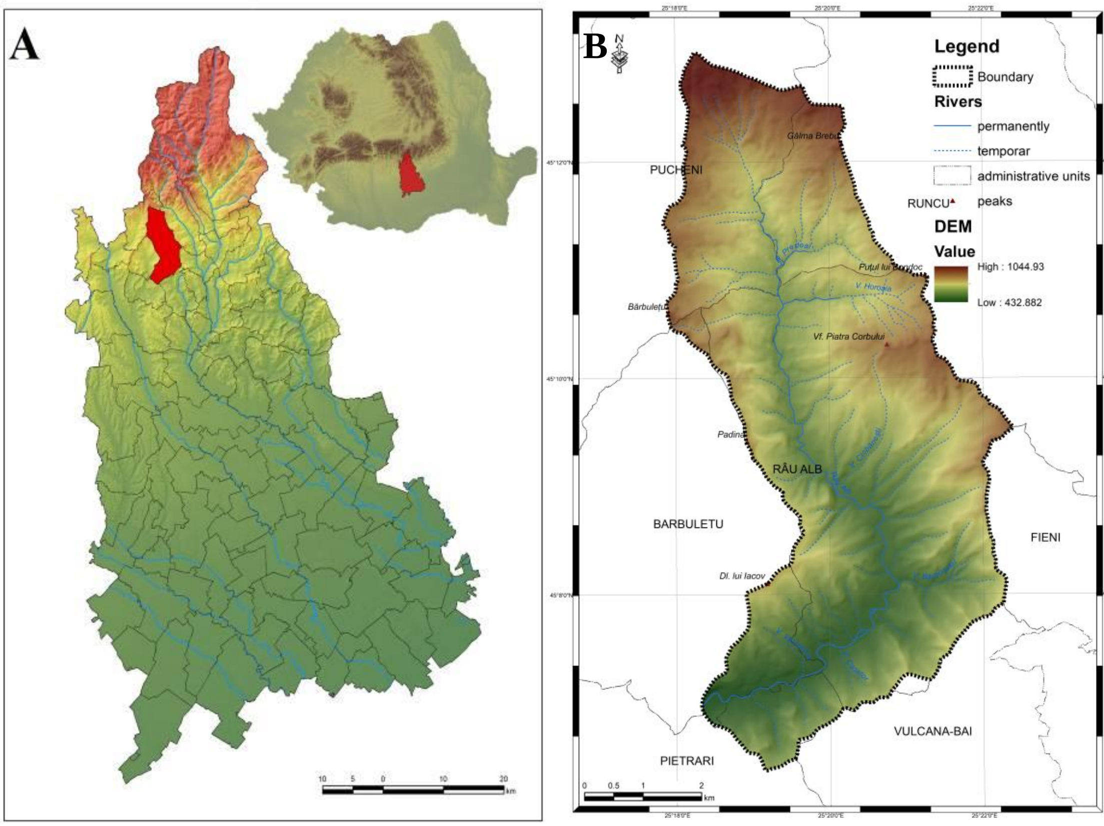

Figure 1 **A. The Raul Alb hydrographic basin location in Dambovita County; B. Digital Elevation Model of the Raul Alb catchment territory as far as its confluence with the Barbuletu creek**

The Raul Alb hydrographic basin covers an area of 9 697 ha, of which 4 034 ha have been researched in this study. More specifically, the upper part of the basin has been analysed, namely the area which starts in the north, in the Plaiul Gavana, the Leaota Mountains, and extends as far as the confluence with the Barbuletu creek in the southern extremity, the dominant landform being the Subcarpathians of Curvature, the Ialomita Subcarpathians subgroup.

The hydrographic basin relief is highly fragmented by many valleys running more prominently on its left side. On the right side of the Raul Alb there are Valcelului, Carpenu, Nucului, Sanduleni and Branduselor Valleys, whereas its left side is crossed by Predeal, Puiusului, Horoaia, Ciobanesti, Stalpului, Barbosului, Caselor, Licestilor, Tulburea, Noroaielor and Iuda Valleys. In addition to the erosive action of these valleys, there are numerous slades and glens, torrential in nature, which also collect the water of downward springs on the slopes.

The maximum altitude of the basin is reached in the mountain sector of the Raul Alb catchment, 1 044 m, whereas the minimum elevation, 433 m, is reached at the point of confluence with the Barbuletu stream (*figure 1B*). Given the length of the analysed upper hydrographic basin, 13.55 km, and the altitude amplitude of 611 m, the average flow slope of this watercourse is 4.5%.

The researched basin includes areas that administratively belong to seven Land Administrative Units (L.A.U.s) (fig. 2A). Of the 4034 ha, 2 477.15 ha are part of the L.A.U. Rau Alb (fig. 2B), followed by 675.70 ha within the L.A.U. Pucheni, 411.75 ha in the L.A.U. Runcu, 265.10 ha in L.A.U. Barbuletu and 199.90 ha located in the L.A.U. Pietrari. Small areas can also be found in the L.A.U.s of Fieni (3.20 ha) and Vulcana Bai (1.20 ha).

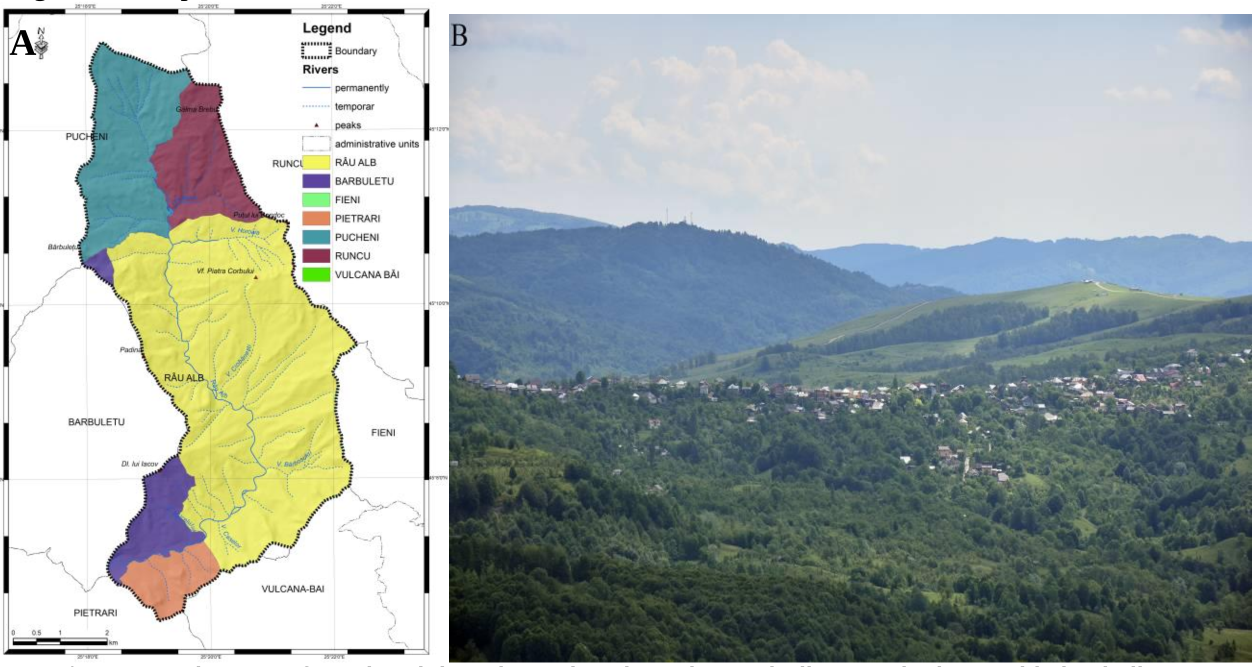

Figure 2 **A. The map of Land Aministrative Units where the Raul Alb upper hydrographic basin lies; B. The village of Rau Alb de Sus (original photo)**

MATERIALS AND METHODS

The pedological study conducted in the upper part of the Raul Alb watershed in 2019-2021 required prior stages of documentation and creation of the topographic base, followed by three technical phases of execution: the field phase, the laboratory phase, in 2019-2020, and the office phase in 2020-2022 (*figure 3*).

The field phase consisted in the execution of 46 soil profiles in representative areas, in which 224 pedological samples were collected from diagnostic horizons; these samples were analysed in the laboratory of the Office of Pedology and Agrochemical Studies (OSPA) Dambovita, according to the *Methodology for the Development of Pedological Studies, Parts I, II, III, 1987*.

Figure 3 **The execution phases of the pedologic study: field phase, laboratory phase and office phase (original photos)**

Along with the interpretation of data in the analysis bulletin, the soil units forming the soil cover in the investigated area and the soil classes to which they belong were established and ordered according to *S.R.T.S. 2012+*, followed by the thematic map drawing.

The final goal of the research of the Raul Alb upper hydrographic basin is the distribution of soil types in its area of development and the identification of lands affected by sheet and gully erosion phenomena. By means of GIS methods, the risk of erosion processes will be assessed and predictions about their evolution in time will be made.

Chemical analyses methods

The following chemical and physicomechanical analyses have been performed in the laboratory of the Office of Pedology and Agrochemical Studies Dambovita:

- pH of the soil, using the potentiometric method in aqueous solution;
- total $CaCO_3$ content, using gas-volumetric method (Scheibler);
- exchangeable aluminium content, using the Sokolov method;
- content of humus, using titrimetric dosing (the Walkley-Black method in the Gogoasa modification);
- mobile phosphorus content, using the Egner–Riehm–Domingo method;
- mobile potassium content, using the ammonium chloride extraction method;
- nitrogen content (nitrogen index: I.N.), resulting from a calculation;
- H exchange capacity (S.H.), using the extraction by percolation to exhaustion with potassium acetate pH 8.3;
- total exchangeable bases (S.B.), using the extraction with HCl 0.05n;
- granulometric analysis or soil texture (5 fractions), using the Kacinski method.

Creating the GIS database

The first step in creating the GIS database consisted of scanning the declassified military topographic maps with a 1:25 000 scale and 5 m equidistance, followed by georeferencing in the *Stereo 70* projection system. In addition, using the *Open Street Map* application, the map showing the delimitation of built-up areas of localities covered by the Raul Alb upper hydrographic basin and that of administrative boundaries of component land administrative units have been drawn up.

The *ArcToolbox - Spatial Analyst Tools - Interpolation - Topo to Raster* functions, components of the *ArcGis 10.6.1* software, have made it possible to create the Digital Elevation Model (DEM) by digitizing the level curves and the hydrographic network at 10-m resolution and the morphometric and morphographic maps used in presenting the natural environment of the investigated area (*figure 4*).

Through the weighted overlay of various thematic maps (*WOA* method), it will be possible to assess the erosion risk in this hydrographic basin by means of GIS methods, to compare the obtained data to the current state of soil degradation due to water erosion and to make predictions regarding this unwanted phenomenon.

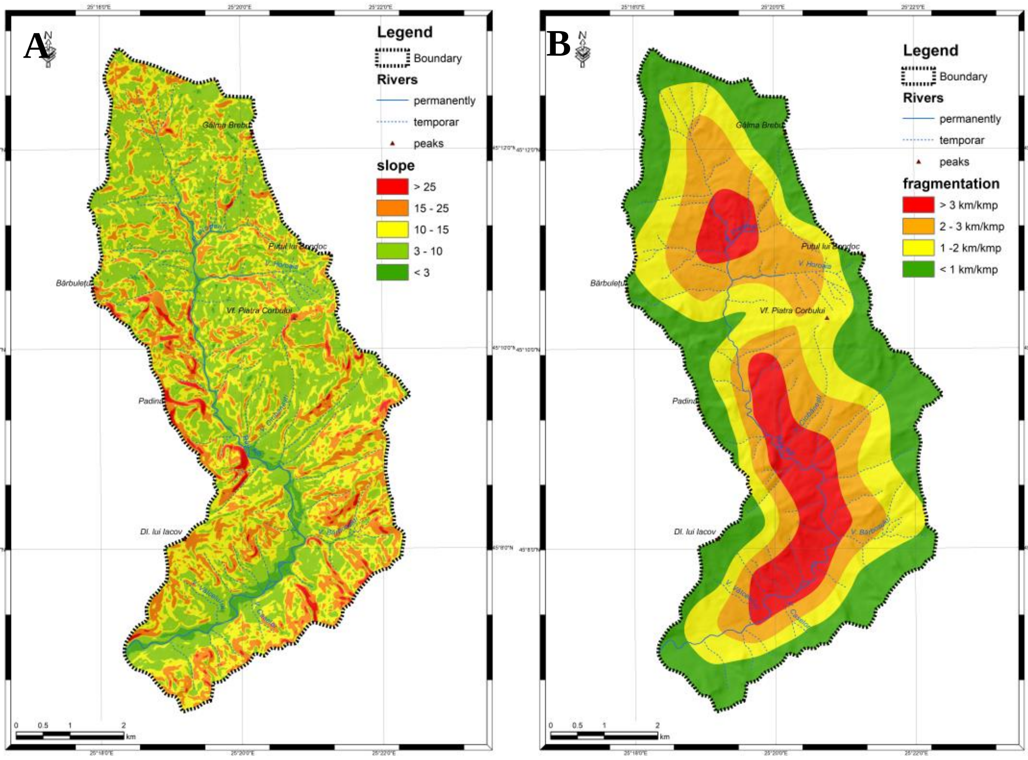

Figure 4 **A. Slope map; B. Map of relief fragmentation density (isolines)**

RESULTS AND DISCUSSIONS

Soil types and classes

The soil type covering the largest part of the Raul Alb upper hydrographic basin is Regosol (*figure 5A*), distributed in the soil units from 18 to 36 (S.U. 18 – S.U. 36), followed by Eutric Cambisol (S.U. 10 – S.U. 17), Rendzic Leptosol (S.U. 1 – S.U. 3) and Phaeozem (S.U. 4 – S.U. 8). Fluvisol (S.U. 37 – S.U. 39), Anthrosol (S.U. 40 – S.U. 43) and Luvisol (S.U. 9) are to be found in smaller areas.

The regosol, eutric cambisol, rendzic leptosol and phaeozem generally cover moderately and strongly inclined slopes, the fluvisol overlaps the narrow meadow areas along the watercourse, the luvisol occupies small areas in poorly represented plateaus, on the hydrographic basin boundary in the L.A.U. Runcu, whereas the anthrosol is found in the upper part of versants, with pastures whose vegetation is damaged due to the locals' irrational exploitation and to the fact that these areas have not been introduced in pastoral arrangements.

In terms of the amount of land they cover in the researched area, the situation of soil types is as follows:

- regosol – 2 056.62 ha;
- eutric cambisol – 754.19 ha;
- rendzic leptosol – 465.79 ha;
- phaeozem – 443.81 ha;
- fluvisol – 206.10 ha;
- anthrosol – 91.49 ha;
- luvisol – 16.00 ha.

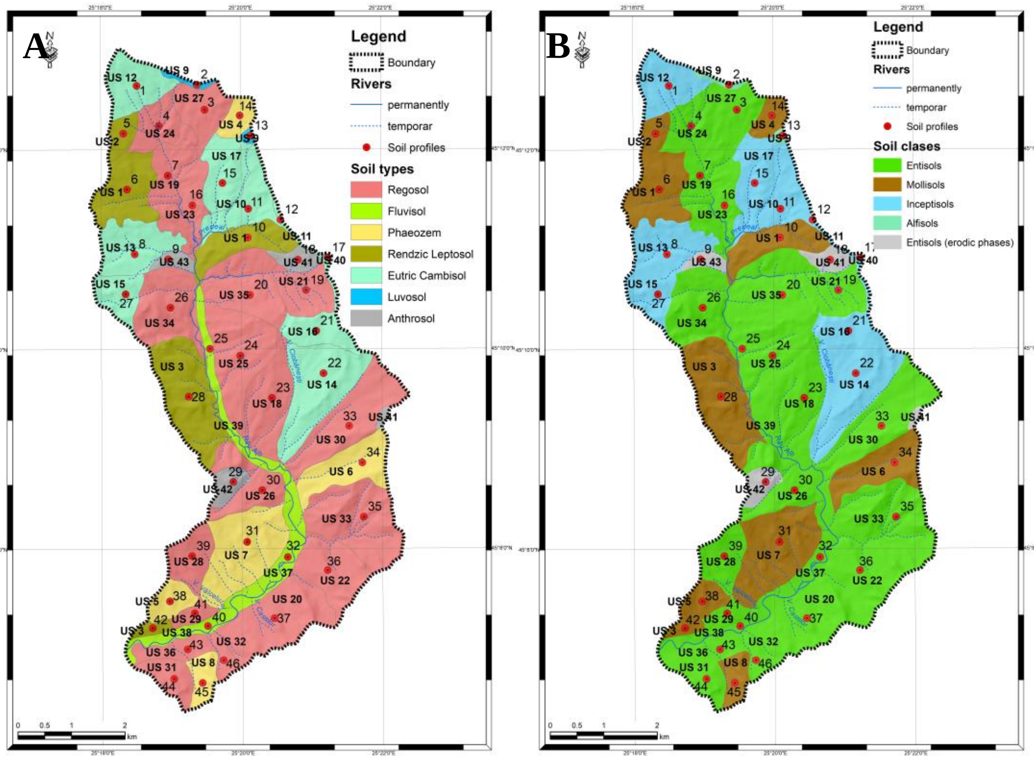

Figure 5 **A. Map of soil types, according to WRB-SR 2006; B. Map of soil classes, according to USDA-ST 1999**

The seven soil types identified in the Raul Alb hydrographic basin fall into 5 major soil classes (*figure 5B*), as follows:

- Class of Entisols, extending over 2 262.72 ha, which includes regosol and fluvisol;

- Class of Mollisols, covering 909.60 ha, which includes rendzic leptosol and phaeozem;

- Class of Inceptisols, which cover 754.19 ha, with only one soil type, the eutric cambisol;

- Class of Alfisols, occupying 16.00 ha of land, represented by the luvisol;

- Class of Entisols (eroding phases), covering 91.49 ha, represented by the anthrosol.

Soil subtypes and their classification into soil units (U.S.)

Each soil type has several subtypes depending on various soil properties, among which we can mention texture in upper horizon and profile, total $CaCO_3$ content and the depth at which it appears, humus content, parent material etc., which are to determine the order of soil units (S.U.s) specific to each identified subtype.

Table 1 lists the soil types and subtypes present in the investigated area and the S.U.s in which they are included.

4.3. Soil degradation due to sheet erosion

The degree to which soils in the analysed hydrographic basin are affected by surface water erosion has been determined based on the diagnostic horizon from the surface of sloping areas and its thickness.

Depending on these elements, the identified soils fall under degrees of sheet erosion as follows:

- not eroded by water, when Am and Au horizons are more than 30 cm thick and the Ao horizon is more than 20 cm thick;

- slightly eroded by water, when the thickness of Am and Au horizons ranges between 20 and 30 cm and that of the Ao horizon, between 10 and 20 cm;

- moderately eroded by water, when Am and Au horizons have a thickness ranging between 10 and 20 cm, whereas that of the Ao horizon is less than 10 cm or when A+E horizon do not exceed 20 cm on the soil surface;

- strongly eroded by water, when the A/C transition horizon with a thickness of less than 20 cm or the B horizon appear on the soil surface;

Table 1

Distribution of soil types and subtypes in the Raul Alb upper hydrographic basin by soil units (S.U.s)

No. S.U.s	Soil type	Soil subtype	Area (ha)
1	Rendzic leptosol	clayey	219.88
2,3		calcaro-rendzic clayey	245.91
4, 6, 7, 8	Phaeozem	calcaric clayey	396.51
5		calcaric loamy	47.30
9	Luvisol	stagni-albic loamy	16.00
10, 11	Eutric Cambisol	typically loamy	109.61
12, 13		typically clayey	219.09
14, 15, 16, 17		mollic clayey	425.49
18	Regosol	eutric loamy	134.36
19		eutric clayey	112.31
20, 21, 22, 23, 24, 25, 26, 27, 28, 29		calcaric clayey	1 044.32
30, 31, 33, 34, 35, 36		mollic calcaric clayey	740.08
32		mollic calcaric loamy	25.55
37	Fluvisol	calcaric loamy	94.18
38		calcaric clayey	49.03
39		mollic calcaric loamy	62.89
40	Anthrosol	erodic clayey	2.11
41, 42, 43		erodic calcaric clayey	89.38

- excessively eroded by water, when C or R horizons (parent material or parent rock) appear on the soil surface (*figure 6A*).

The 4 034 ha of the upper sector of the Raul Alb hydrographic basin are affected by this degradation phenomenon as follows:

- not eroded by water – 222.10 ha;
- slightly eroded by water – 1 946.77 ha;
- moderately eroded by water – 1 773.64 ha;
- strongly eroded by water – 58.39 ha;
- excessively eroded by water – 33.10 ha.

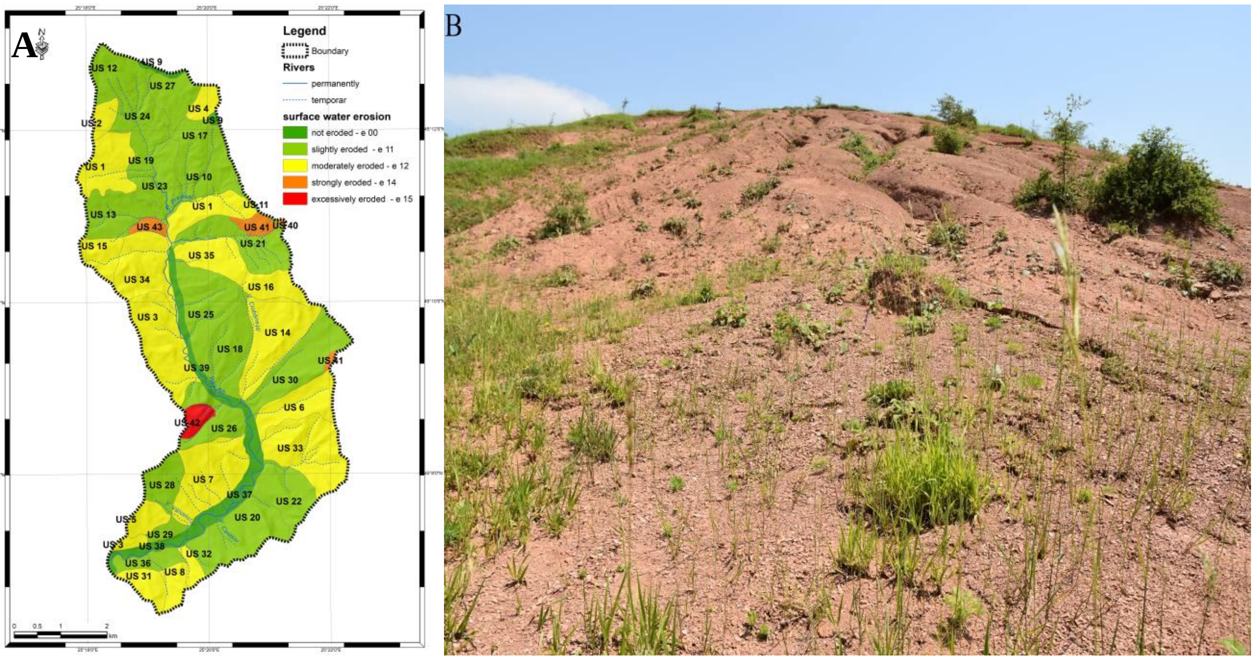

Figure 6 **A. Surface water erosion map, according to Indicator 20 in SRTS 2012; B. Surface water erosion in the Rau Alb area (original photo)**

Surface water erosion forms are present in almost all soil units (table 2), with the exception of S.U.s 37, 38, 39, which define the fluvisol, and S.U. 9, which defines the luvisol. These soil types cover flat areas and are not influenced by the slope factor.

Table 2

Soil units in the investigated hydrographic basin affected by sheet erosion

No.	Sheet erosion degree	Area of affected S.U.s (ha)	Affected soil units (S.U.s)
1	Slightly eroded	1946.77	10, 11, 12, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 36
2	Moderately eroded	1773.64	1, 2, 3, 4, 5, 6, 7, 8, 14, 15, 16, 31, 32, 33, 34, 35
3	Strongly eroded	58.39	40, 41, 43
4	Excessively eroded	33.10	42

Soil degradation due to deep water erosion

Deep water erosion forms, such as rills, small gullies, deep gullies and small ravines, have been identified in the analysed area (*figure 7A*).

Rills are between 0.2 and 0.5 m deep, whereas gullies and ravines become negative mainly active landforms characterized by:

- depths of 0.5-2.0 m in the case of small gullies, unbranched appearance and the thalweg relatively parallel to the topsoil;
- depths of 2.0-3.0 m in the case of deep gullies, unbranched appearance and the thalweg roughly parallel to the topsoil;
- 3.0-5.0 m deep in the case of small ravines, often branched appearance and a thalweg with longitudinal profile similar to that of a valley.

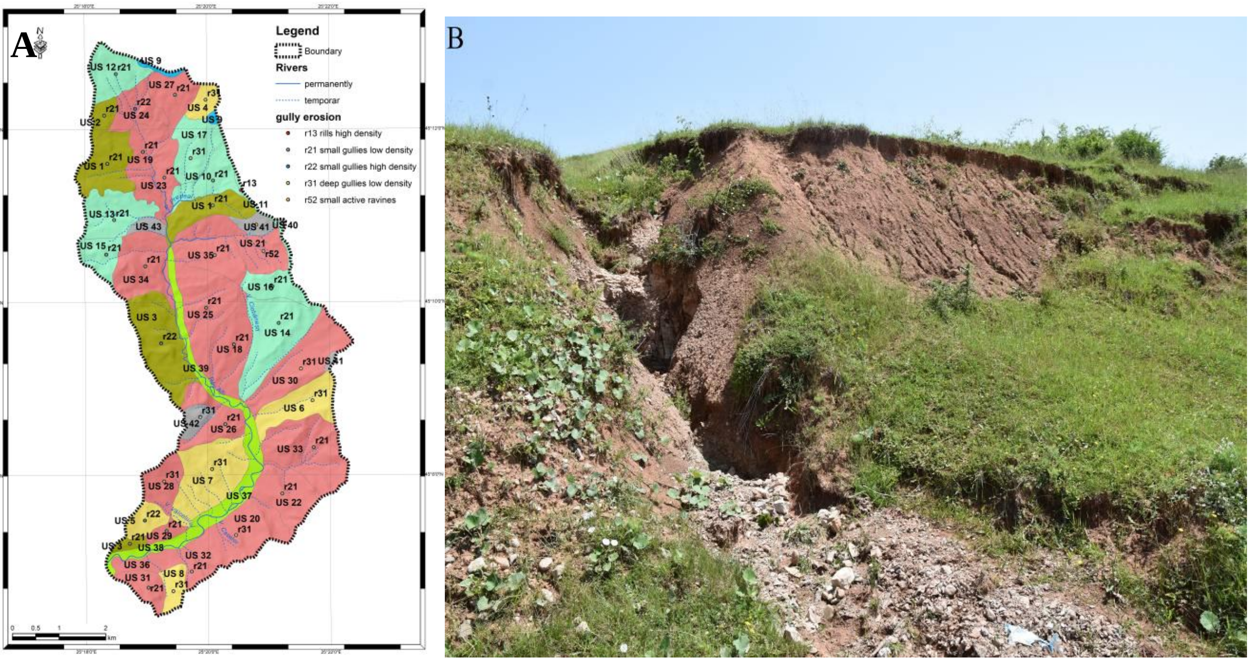

Figure 7 **A. Gully erosion map, according to Indicator 37 in "Methodology for the Development of Pedological Studies, Part III"; B. Gully erosion in the Barbuletu area (original photo)**

Deep water erosion forms in the upper part of the Raul Alb hydrographic basin are present in soil units (S.U.s) as follows:

- rills, in one soil unit;
- small gullies, in 24 S.U.s;
- deep gullies, in 11 S.U.s;

- small ravines, in 2 S.U.s.

Deep water erosion forms are present, just like the surface ones, in most soil units (*table 3*), with the exception of the same S.U.s located in relatively flat areas that are well covered by vegetation.

Table 3

Soil units in the investigated catchment affected by forms of deep water erosion

No.	Deep erosion form	Soil units (S.U.s) with deep erosion forms
1	Rills	11
2	Small gullies	1, 2, 3, 5,10,12, 13, 14, 15, 16, 18, 19, 22, 23, 24, 25, 26, 27, 29, 31, 32, 33, 34, 35
3	Deep gullies	4, 6, 7, 8, 17, 20, 28, 30, 40, 42, 43
4	Small ravines	21, 41

CONCLUSIONS

The Raul Alb upper hydrographic basin, up to the point it meets Barbuletu stream, has a diversified soil cover, conditioned by geographic and climate factors in which the pedogenesis process began and evolved.

The soils identified in the analysed area are both undeveloped or developing soils and developed soils, classified into five major classes arranged in terms of the amount of land they cover as follows: Entisols, Mollisols, Inceptisols, Entisols (eroded phases) and Alfisols.

The class of Entisols covers 56.10% of the catchment area, followed by the class of Mollisols, 22.55% of the area, the class of Inceptisols, 18.70%, whereas the class of Entisols (eroded phases) and Alfisols extend over the smallest areas, 2.26% and 0.39%, respectively. The soil types included in the class of Entisols are regosol and fluvisol, the class of Mollisols includes rendzic leptosol and phaeozem, the class of Inceptisols is represented by the eutric cambisol, the class of Entisols (eroded phases), by the anthrosol, and the class of Alfisols, by the luvisol, each of these with several soil subtypes.

The upper basin of the Raul Alb stream is 51.00% covered by regosols, followed by eutric cambisols, 18.70%, rendzic leptosol, 11.55%, and phaeozem, 11%. Fluvisol, anthrosol and luvisol occupy the smallest amount of land in the researched area, totalling 7.75%.

The most common soil subtypes are the calcaric clayey, mollic clayey and mollic calcaric clayey ones, of which the last two influence the degree of surface soil erosion through the thickness of the Am horizon.

In terms of sheet erosion, 5.50% of the analysed area is not affected by this phenomenon, the slightly water eroded lands occupying 48.26%. Moderately water eroded soils cover 43.97% of the 4 034 ha investigated, whereas the remaining 2.27% of the hydrographic basin lands are strongly and excessively degraded by this phenomenon.

Deep water erosion mainly evolved in the same areas also affected by surface erosion, with rills, gullies and ravines on slopes. Of the 43 S.U.s defined in the upper basin of the Raul Alb stream, only 5 are not affected by deep erosion forms, more specifically S.U. 9, S.U. 36, S.U. 37, S.U. 38 and S.U. 39. Gullies, either small or deep, are the most frequently encountered, i.e. in 25 S.U.s of the analysed area, while ravines are found in 2 soil units.

Due to the erosive action of water flowing down slopes, the degree of soil fertility is reduced through a decrease in the content of basic nutrients (humus, nitrogen, phosphorus and potassium), with direct implications in reducing the productive potential of agricultural lands. In many cases, areas affected by erosion become unsuitable for various agricultural uses, thus being necessary either to change the category of land use, to introduce them into improvement perimeters through afforestation, or to carry out works aiming to reduce the negative effects of this soil degradation process, such as spring catchments, drainages, drainage channels, dams and thresholds etc.

Many of the valleys crossing the investigated hydrographic basin were improved in 1960-1980 by carrying out anti-erosion hydrotechnical works, which, unfortunately have not been well-maintained, degraded and are no longer functional. Undertaking new works has not even been considered in the last decades.

Starting from the state of soil degradation by water erosion, established by the pedological study, we intend, in the next period, to make a quantitative estimate of soil losses in the Raul Alb hydrographic basin by applying the RUSLE and

ROMSEM models in order to provide a basis for comparison of the results obtained.

ACKNOWLEDGMENTS

We would like to thank our colleagues from ICPA Bucuresti and OSPA Dambovita for the professionalism they showed during our collaboration, which resulted in carrying out the pedological study, with the three phases of execution, for the 4 034 ha area in the upper part of the Raul Alb hydrographic basin. Furthermore, we are grateful for the support they provided in creating and completing the database necessary for the proper conduct of investigations and for the completion of a work of such complexity.

REFERENCES

Biali G., Patriche C. V., Pavel V.L., 2014 - *Application of GIS techniques for the quantification of land degradation caused by water erosion***,** Environmental Engineering and Management Journal, 13:2665-2673**.**

Dirja M., Budiu V., Pacurar I., Tripon D., 2002 - *Research on the risk of gully erosion in the Valea Ungarasului sub-basin, (In Romanian)*, FIFIM Bucharest - Proceedings of the honorary scientific session 17 – 18 May 2002, pp. 159-164, ISBN 973-648-020-8.

European Commission, 2009 - *Joint Research Centre – Annual report,* ISBN 978-92-79- 14655-8, Catalog number LB-NA 24228 EN-C, doi 10.2788/54084.

European Commission, 2012 - *Joint Research Centre – Annual report,* ISBN 978-92-79-28677-3, doi: 10.2788/8436.

Florea N., Balaceanu V., Rauta C., Canarache A., 1987 - *Methodology for the Development of Pedological Studies, Part I, II, III, (In Romanian)***,** Oltenia Publishing House, Craiova.

Ganasri B.P., Ramesh H., 2016 - *Assesment of soil erosion by RUSLE model using remote sensing and GIS - A case study of Nethravathi Basin,* Geosci, Front. 7:953–961, https://doi.org/10.1016/j.gsf.2015.10.007.

Grecu Florina, Palmentola G., 2003 – *Dynamic Geomorphology, (In Romanian),* Technical Publishing House, Bucharest.

Ispas St., Muratoreanu G., Leotescu R., Ciulei S., 2006 – *Pedology – Soil research in the field, (In Romanian),* Valahia University Press, Targoviste*.*

Motoc M., Mihaiu Gh., 2000 – *The strategy regarding the carrying out of studies and the design of works for the development of gullies, new works and the restoration of existing ones, (In Romanian),* Hidrotehnica Magazine, No. 9.

Motoc M., 2002 - *Achievements and perspectives regarding the study of soil erosion and its combat in Romania, XX Century - Performances in agriculture, (In Romanian),* Ceres Publishing House, Bucharest.

Motoc M., **1982** - *The average rate of soil erosion degradation in R.S. Romania, (In Romanian),* ASAS Newsletter, 12, Bucharest.

Sevastel M., Petrescu N., Augustina Tronac, 2015 – *Some aspect concerning gully erosion process in small torrential watersheds and its impact on environment***,** Carpathian Journal of Earth and Environmental Sciences, 10(2):115-122.

Vlad V., Florea N., Toti M., Mocanu V., 2014 - *Correlation of soil classification system SRCS and SRTS. SRTS+ System, (In Romanian)*, Sitech Publishing House, Craiova. .