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THE ANCIENT CITY OF CALLATIS AND THE NEOTECTONIC MOVEMENTS

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Abstract

Southeastwards of Mangalia, 6 - 7 meters under the sea level, on a surface of about two hectares, there were discovered vestiges of the ancient fortress of Callatis. The settlement known since the 4th century B.C. had almost a millenary existence, but it is not known when it ceased to exist and what causes triggered it. Different suppositions were made and, among them, the telluric causes are plausible. The Southern Dobroudja Platform is penetrated by mobile faults and the compartment of Mangalia is affected by a negative neotectonic movement that gets accentuated towards southeast, where the epicentres of earthquakes with repeated manifestation have been observed. The negative movement rate is 3 - 4 mm/year and, cumulated during the 15 centuries that passed since the disappearance of the city of Callatis, it could explain the depth at which the vestiges of the settlement are presently located.

Keywords: *Podisul Dobrogei, vestigii submerse, miscari neotectonice, seisme, cicluri de sedimentare, retea de falii*

Rezumat

Vechiul oraş Callatis şi mişcările neotectonice. La sud-est de Mangalia, sub nivelul mării, la o adâncime de 6 - 7 m, pe o suprafaţă de aproximativ 2 ha, au fost descoperite vestigii ale cetăţii antice Callatis. Cunoscută din secolul al IV-lea î.e.n., a avut o existenţă de aproape un mileniu, dar nu se ştie când anume şi-a încetat existenţa şi mai ales din ce cauze. S-au făcut diferite presupuneri şi, dintre acestea, cauzele telurice sunt cele plauzibile. Platforma Dobrogei de Sud este străpunsă de falii mobile, iar compartimentul Mangaliei este afectat de o mişcare neotectonică negativă care se accentuează spre sud-est, acolo unde s-au constatat epicentrele unor seisme cu manifestări repetate. Rata mişcărilor negative de 3 - 4 mm/an, cumulată timp de 15 secole de la dispariţia oraşului Callatis, ar putea explica adâncimea la care se află în prezent vestigiile oraşului.

Cuvinte-cheie: *Dobrudja Tableland, submerged vestiges, neotectonic movements, earthquakes, sedimentation cycles, fault network*

SUBMERGED VESTIGES

By the middle of the year 2009, in the daily press there appeared 2 - 3 articles of the type of those destined for curiosities and somewhat sensational, concerning the presence of the vestiges of the antique Callatis fortress at 6 or 7 meters under the sea water level. After brief investigations, a team of autonomous divers, eager of submerged archaeological research, assessed that numerous remains of the renowned disappeared settlement are to be found on a surface of about two hectares, in the sand and ooze on the bottom of the sea. The fact is extremely inciting for those who wish to investigate the unknown, but also for any person who knows about the temporarily prosperous settlement that existed more that 20 centuries ago, the present location of its vestiges being under the sea water.

There is no doubt that when such a discovery is made many questions arise and numerous hypotheses may appear, some of them even being the product of a rich fantasy, but still, the phenomenon must have a correct, verifiable explanation. The archaeological remains of Callatis fortress certify its existence from the 4th century B.C., but there are certain references that appear in written documents dated two centuries before. We are more interested in the moment of the disappearance of the fortress than in that of its foundation by the Greeks, on the place of a Getae settlement.

During its about one millennium long existence, the fortress had prosperity and decline periods, being known the fact that the decay registered at the beginning of our era was followed by a flourishing period, which probably lasted for a few centuries. The exact duration, as well as the moment and precise causes of the disappearance of the fortress are not known. Different suppositions have been made in connection with this phenomenon, the most plausible causes being the telluric ones, especially since the vestiges of the fortress are under the sea water.

One of the hypotheses argues that the disappearance was provoked by a strong earthquake that led to the submersion of an important part of the settlement. Another one pleads for the progression of the sea (an ingression), which would have destroyed the settlement through inundation and the action of the waves (abrasion). Without taking into account other probable social-economic and historic causes that would have led to the desertion of the settlement, the main cause is still the one related to natural phenomena of tectonic nature, the one that changed the relations between sea and land in a relatively short period.

The tectonic signals have always been noticeable, even in 2009, when a shallow depth earthquake, having the epicentre at approximately 15 kilometres distance of Mangalia town, shook the region. Although the earthquake registered only 5.1 degrees on the Richter scale, it was felt on a large area and it did not cause prejudices. Nevertheless, there occurred other more severe earthquakes, with important effects on the seaside and on Dobroudja region, firstly affecting the settlements. Among these events, it is important to mention the earthquake that took place on March 31st, 1901, when there were registered 7.2 degrees on the Richter scale; the earthquake occurred at a depth of 15 kilometres in the Black Sea, had the epicentre eastwards of the Caliacra Cape and it led to the formation of a tsunami wave that flooded the settlement of Mangalia and important seashore surfaces.

STRUCTURE OF THE REGION

From the structural viewpoint, the region belongs to the South-Dobroudja Platform (Eoproterozoic unit), being bordered northwards by the main (crustal) fault Palazu (Capidava - Ovidiu). Towards south and south-west, it is limited by Fierbinţi fault, which crosses the entire Moesic domain. From the morphological point of view, it represents the entire Southern Dobroudja Tableland, in the southeastern part of which there is located the Mangalia Tableland.This unit is made of old formations and its base, constituted of granitic gneiss and mesometamorphic crystalline schists (Palazu crystalline), deepens southwards. The above sedimentary formations accumulated during several sedimentary cycles, very probably starting with the Lower Paleozoic (Vendian - Cambrian), the presence of which was registered in the drills realized at Palazu Mare, Cumpăna, and around Mangalia (V. Mutihac et al, 2004, p. 30). The next cycle, taking place from the Middle Jurassic to the Cretaceous, mainly marked the deposition of the carbonaceous rocks.

The Jurassic deposits do not crop out, while the Cretaceous ones are open in the valleys from the western part of the Tableland, which are directed towards the Danube, and especially along the Carasu Valley. When the Danube - the Black Sea Canal was dug along the Carasu Valley, the formations of the Cretaceous cycle got to be known in detail and they prove that in the second half of the Cretaceous the region underwent certain tipping movements that led to the appearance of sedimentation discontinuities.

The following sedimentation cycle - the Paleogene one - led to the accumulation of predominantly calcareous (Eocene) and disodilic bituminous (Oligocene) formations, which are preserved on limited surfaces. After a stratigraphic gap up to the Badenian, there followed the last sedimentation cycle, the Mio-Pliocene one, which started with sandy Badenian depositions that only appear discontinuously. They are discordantly covered by Sarmatian organogenic limestones, giving the general characteristic of the Southern Dobroudja Tableland. They appear in all valleys directed towards the Danube, but also on the seaside, in the sector located southwards of Eforie. This last sedimentation cycle ends with the deposition of certain clayey Pliocene sands that are present at the surface of the tableland only towards the Danube.

The entire ensemble of rocks appeared during the last sedimentation cycles is covered by a relatively thick layer made up of loess and loessial deposits, hiding the character induced by the Sarmatian calcareous formations.

A geological cross-section with general south - north direction along the seaside, going from the border to north of Palazu, points out a structure that is pierced by numerous faults, the compartments located north of Mangalia showing a lowering tendency towards south and southeast. Besides the old Paleozoic and Mesozoic formations, the faults also influence the Paleogene and Miocene sedimentary layer. Although this layer is less affected in vertical plan than the older formations, its compartments are involved in the same general lowering movement towards southeast, which corresponds to the general direction of the faults (Fig. 1).

TECTONIC MOBILITY

During its very long evolution and on its structural completion in the time of the last sedimentation cycle and after it, the Southern Dobroudja Tableland underwent certain tipping movements and, at the same time, a breaking process determined by a network of faults that cross this structural edifice on its entire depth, touching all formations, from the Proterozoic fundament to the Mio-Pliocene layers.

The faults - especially the main ones and those that structurally delimitate the Southern Dobroudja Tableland - will always be reactivated, defining this tableland as a horst, in relation with the neighbouring units from the north towards the south. Another important element is that the faults within this unit delimitate compartments that are characterized by different vertical movement tendencies and some of them are very active.

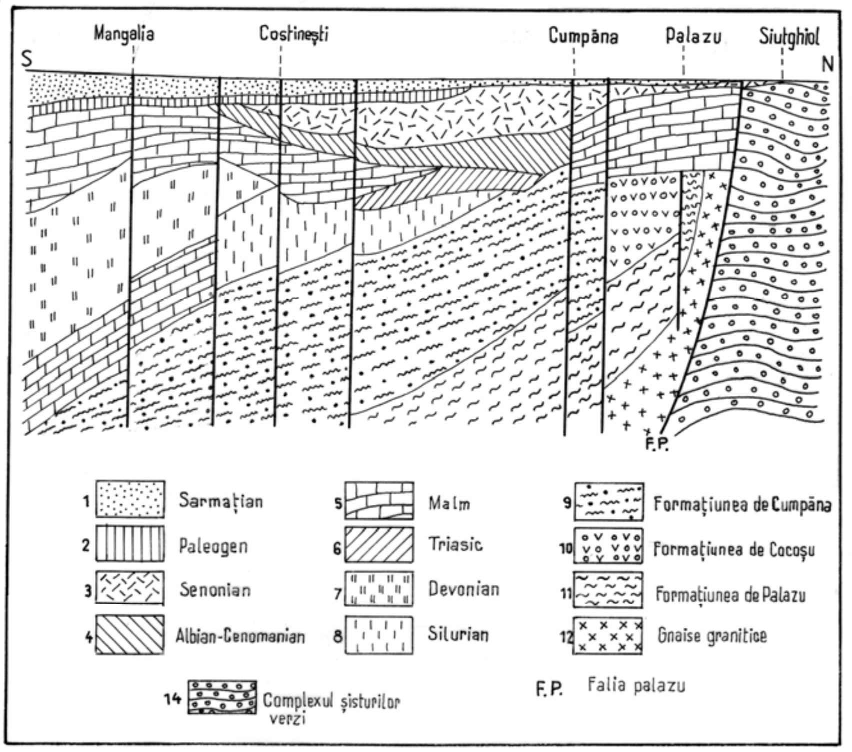

Fig. 1 Geological cross-section along the seaside, between Vama Veche and Siutghiol (after V. Mutihac et al. 2009)

In other words, the Southern Dobroudja Platform is not a rigid structural unit. Besides the main faults that delimitate it, the base plate was affected by secondary faults, the mobility of which is pointed out by the neotectonic movements and by the earthquakes.

North of Mangalia (approximately on the Cobadir - Topraisar - Costineşti alignment) there is located an important fault that delimitate the compartment of Mangalia, bordered southwards by another important, active fault: Sabla - north Caliacra. The earthquakes with the epicentres located southeastwards of Mangalia - such as the one that took place on March 31st 1901 (7.2 degrees – it led to the formation of a big wave that flooded the seashore) and the one that occurred on August 5th 2009 - depend on this fault.

The above-mentioned compartment descends towards southeast and it is permanently affected by present movements that are not uniform from viewpoints of sense or intensity.

On the Map of the Recent Vertical Crustal Movements (work of M. Visarion, M. Săndulescu, I. Drăgoescu, M. Drăghici, I. Cornea, M. Popescu, printed at the Institute of Geology and Geophysics, 1977), the western and southwestern parts of the Southern Dobroudja Tableland are shown as an area caught in a positive movement of more than 1.5 mm/year. As we approach the seaside, the positive movement decreases, then is inverted and the negative character of the movement becomes more and more accentuated up to the shore line.

On the map that is annexed to the article published in 1998 by D. Zugrăvescu et al., in the southeastern sector there is delineated an area in which the negative movements reach 3 - 4 mm/year. This area slightly broadens towards the sea, the town of Mangalia - the place of the ancient fortress Callatis - being located in its central part.

The eastern side of the Dobroudja Tableland is generally affected by a light negative present neotectonic movement, but the research conducted during the last 50 - 60 years underlined the most important subsidence in the area located around Mangalia (Fig. 2). The recurring earthquakes, which register or even surpass 7 degrees, represent the most obvious proof of the instability of the structure crossed by an active fault. To the subsidence movements characterized by intensities of 3 - 4 mm/year during the earthquakes, there were associated plungings (falls) of the soil, which explains clearly enough the alteration and relatively rapid disappearance of the city of Callatis.

Usually, on long term, the intensity of the movements is variable and their value can decrease down to the cessation or even reversal of the movement. On the other hand, on short periods, the assessment made at a given moment can be considered as such.

The rate of 3 - 4 mm/year, which was recorded by the researches conducted during the last hundred years, can be taken into consideration for the almost 15 centuries past since the disappearance of the city of Callatis under the seawater.

The remains of the fortress are to be found at a depth of 6 - 7 meters, which generally corresponds to the subsidence process characterized by values of 0.3 – 0.4 m/century and confirms the hypothesis of the disappearance of the settlement as a consequence of the neotectonic process that affects the seaside in the Mangalia – Vama Veche sector.

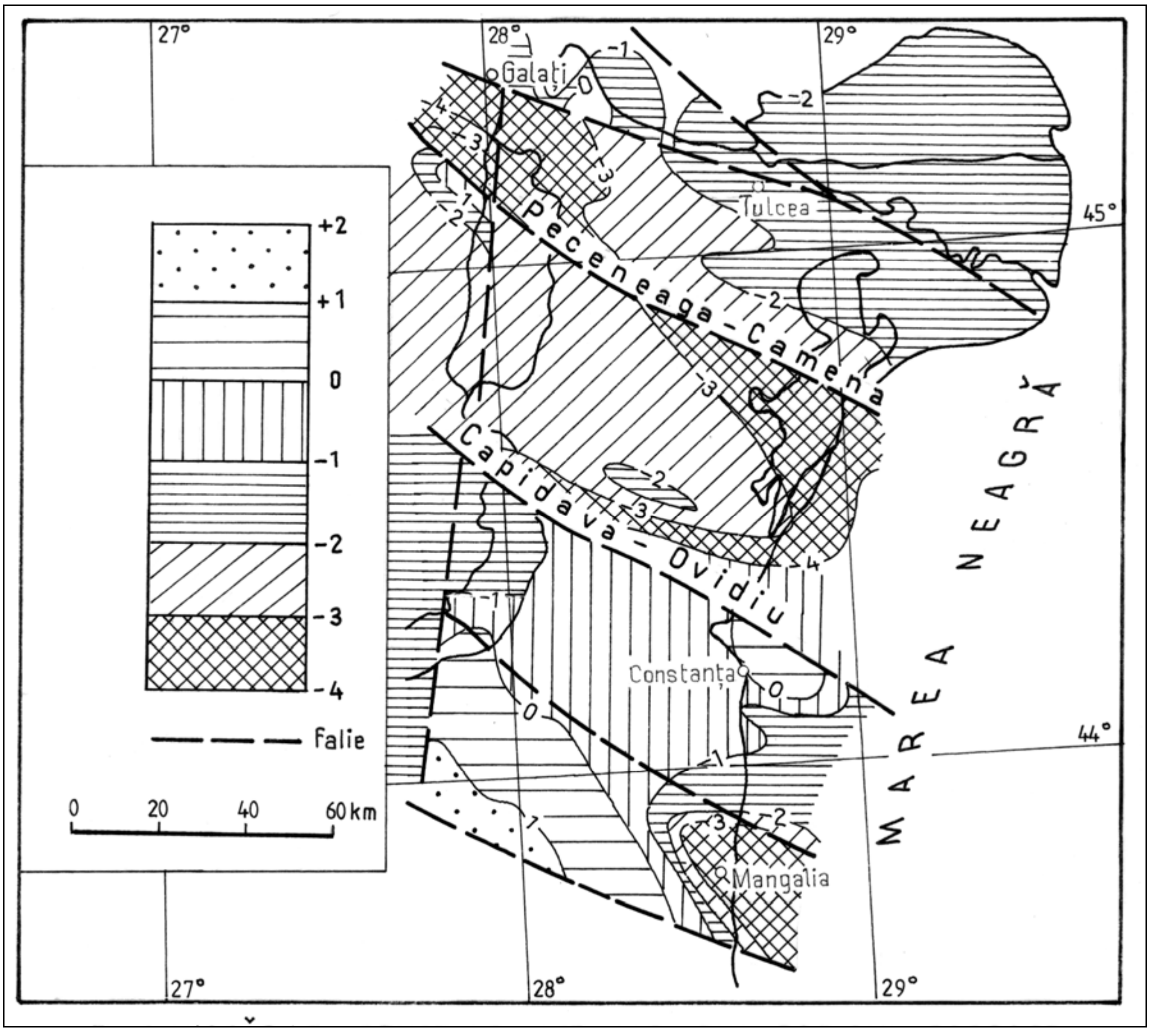

Fig. 2 The present crustal movements within the Dobroudja Tableland (after D. Zugrăvescu et al. 1998)

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THE ANALYSIS OF THE RELIEF FRAGMENTATION FEATURES WITHIN THE BĂLĂCIŢA PIEDMONT

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Abstract
Within the Bălăciţa Piedmont there are to be distinguished two areas with specific features, which correspond to the Danube catchment and to the Jiu drainage area. Both in the case of the drainage density, as well as in that of the relief energy, the distribution of the value classes correlated with the two catchments underlines major differences, but also certain resemblances, situation which is explained by the evolution time, the base level, the flow direction in relation with the structure and the lithological and climatic homogeneity.
The analysis of the data enabled the quantification of the relief energy and of the drainage density within the Bălăciţa Piedmont, as well as the correlation of the two parameters in report to the main catchments. The computation and representation methods for the two indicators of the relief fragmentation (i.e. the depth and the density) allowed for a quantitative interpretation (the identification of five value classes), as well as for a spatial interpretation (the grouping of the values depending on the two collecting rivers: the Danube and the Jiu). The aggregation of the influence factors on the two main drainage areas is mostly due to the fact that the Danube catchment extended its area in the detriment of the Jiu catchment, the three more important tributaries (the Blahniţa, the Drincea and the Desnăţui) catching sectors within the upper course of the tributaries of the Jiu.
The analysis of the relief fragmentation within the Bălăciţa Piedmont shows that this unit is on different evolution stages. The complexity of the fragmentation is closely connected to the maturity degree of the valleys and to the morphogenetic complexes imposed by the paleogeographical evolution.

Keywords: *catchment, relief energy, drainage density, correlation coefficient, the Bălăciţa Piedmont*

Rezumat
Analiza particularităţilor fragmentării reliefului în PiemontulBălăciţei. În Piemontul Bălăciţei se disting două areale cu particularităţi diferite, aferente bazinului hidrografic al Dunării şi bazinului Jiului. Distribuţia claselor de valori corespunzătoare celor două arii de drenaj, atât în cazul densității, cât şi în cel al adâncimii fragmentării, reliefează diferenţe majore, dar şi unele similitudini, fapt datorat timpului de evoluţie, nivelului de bază, direcţiei de scurgere faţă de structură şi omogenităţii litologice şi climatice.
Analiza datelor a permis cuantificarea energiei reliefului şi a densității fragmentării reliefului din Piemontului Bălăciţei şi corelarea celor doi parametrii în funcţie de bazinele hidrografice principale. Metodele de calcul şi reprezentare a celor doi indicatori ai fragmentării reliefului au permis atât o interpretare cantitativă (identificarea a cinci clase de valori), cât şi una spaţială (gruparea valorilor în funcţie de cele două râuri colectoare: Jiu şi Dunăre). Gruparea factorilor de influenţă, pe cele două bazine hidrografice principale se datorează în principal faptului că bazinul Dunării s-a extins în detrimentul bazinului Jiului, cei trei afluenti mai importanti - Blahniţa, Drincea şi Desnăţuiul captând sectoare din cursul superior al afluenţilor Jiului.
Din analiza fragmentării reliefului Piemontului Bălăciţei rezultă că acesta se află în diferite stadii de evoluţie, complexitatea fragmentării fiind strâns legată de gradul de maturitate a văilor şi de complexele morfogenetice impuse de evoluţia paleogeografică.

Cuvinte-cheie: *bazin hidrografic, adâncimea fragmentării, densitatea fragmentării, coeficient de corelaţie, Piemontul Bălăciţei*

INTRODUCTION

The Bălăciţa Piedmont represented the study object for both geographers and geologists and, thus, a series of information was recorded in papers that were particularly dedicated to this sub-unit of the Getic Piedmont, or in works that referred to more extended regions. Among these authors, we mention Roşu Al. (1959), Ghenea C. et al. (1963), Badea L. (1970) Badea L. et al. (1974, 1976), Posea Gr. et al. (1974), Cucu V. et al. (1980), Stroe R. et al. (1980, 1983).

The study of this region is minutely resumed in 1992, in the work entitled *Geografia României*, volume IV, where the natural background, the human geography elements concerning the population and the settlements, as well as the economic potential of the Bălăciţa Piedmont are analysed. Within this study, the denomination used for the researched area is "Bălăciţa Piedmont" (Rom. "Piemontul Bălăciţei"), as a component of the Getic Piedmont. The most recent studies that deal with this geographical unit belong to Stroe R. (2003), Enciu P. (2007), Enache C. (2008) and Boengiu S. (2008).

The river network in the Bălăciţa Piedmont is distributed on two drainage basins: of the Danube and of the Jiu. The interfluve between the two catchments divides the piedmont into two parts that are approximately equal and symmetrical in form. The geological conditions, although apparently simple, the generally divergent character, the dominance of the autochthonous rivers, except for the Motru and the Jiu, give the original note in the organization and the evolution of the hydrographical network within the Bălăciţa Piedmont (Boengiu S. 2002).

The hydrographical network that is tributary to the Jiu has west – east orientation, the main tributaries being on the right; towards the springs, the slope of the thalweg ascends rapidly – in the area of origin being 3 – 6 gullies that come together to form the main watercourse. The valleys are asymmetrical, the slopes on the left (the north) being much steeper and more linear, while those in the right (the south) are generally convex and show gentler slopes. At the same time, the rivers are quite long, 20 – 70 kilometres, showing narrow valleys in the upper sector, but also wide floodplains at least on half of the distance covered.

All these characteristics show the fact that the watercourses situated north of the watershed between the catchments of the Jiu and of the Danube appeared on the initial surface that was cut by the rivers that regressively advanced from the Jiu towards the west, as the Jiu deepened its riverbed, but they were also influenced by the structure of the fundament in which the strata incline towards north-east, making easier the appearance of the right side tributaries. The main factor that led to the configuration described above and to the slopes of the valleys, which are steeper towards north, is represented by the general inclination of the piedmont that, as shown by the maximum heights on the interfluves, descends from the north-west (330 – 350 meters) towards the south-east (150 – 200 meters).

The watercourses that head from the Piedmont towards the Danube show a west – east or north-west – south-east orientation in the upper sector, they gradually gravitate towards south and, before leaving the piedmont or at its limit, they bend towards west. There can be noticed a resemblance between the course of the Danube, which firstly bends towards west at Ostrovul Corbului, and its tributaries, fact which underlines the dependency of these watercourses on the route followed by the Danube (Boengiu S. 2002).

The analysis of the cross-sections and the hypsometrical map shows the permanent movement of the Blahniţa and of the Drincea towards east, the western slope being less inclined than the eastern one, which is steep, forming the scarp of a cuesta. All the tributaries are consequent to the geological structure and come from the west, on the eastern slope in the upper and middle sector being only much younger gullies.

MATERIALS AND METHODS

The map of the relief drainage density and that of the relief energy were achieved on the basis of the topographical maps, scale 1:25,000, through the method of the cartograms; a geographical database was realised by using the ArcGIS 9.2 software and the entire hydrographical network was vectorised, starting with the 1st order in the Horton-Strahler system. Taking into account the significant leaps within the series of values and the morphometrical aspects of the study area, there were chosen five classes. The repartition of the surfaces and the share of the value classes were graphically represented and, in order to realise a unitary, comparative analysis, the classes of the drainage density and relief energy were also computed and represented in intervals with entire values.

Methods specific to the statistical analysis allowed for the observance of the parameters of the drainage density, relief energy, as well as the correlation between the two parameters.

The field observations were conducted in order to clarify or to add certain elements that did not appear on the maps.

DISCUSSIONS AND RESULTS

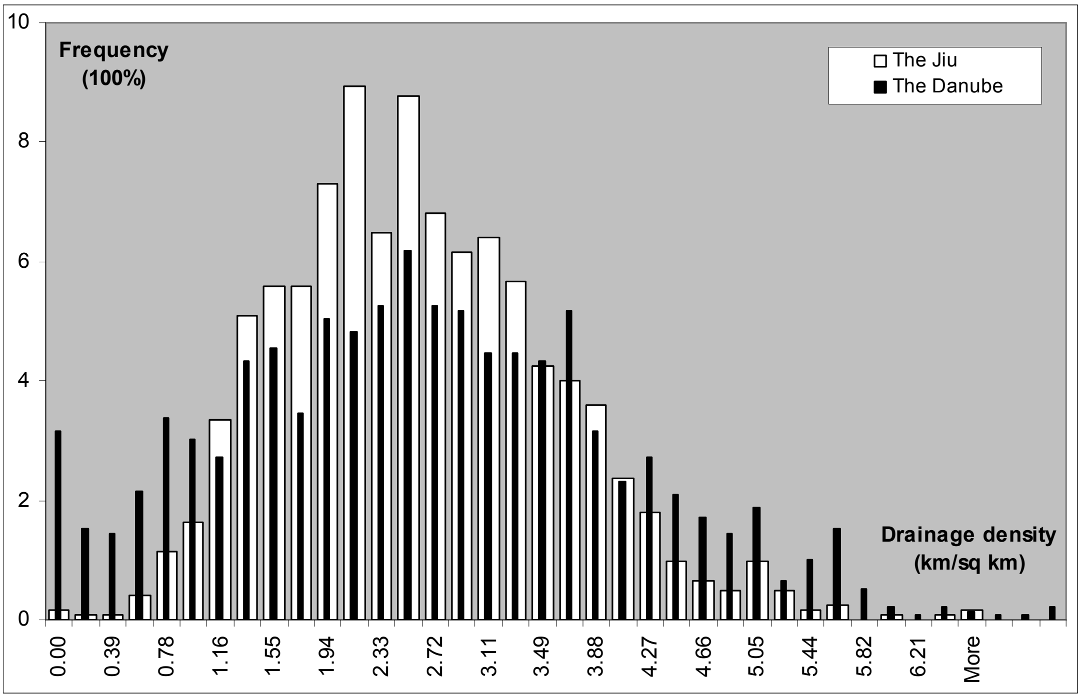
The relief of the Bălăciţa Piedmont is characterised by the existence of three areas that display specific features (Boengiu S., 2008), i.e. the catchments of the Blahniţa and of the Drincea, that of the Desnăţui and the Jiu catchment area.

The drainage areas of the Blahniţa and of the Drincea (Boengiu S. et. al, 2003) are characterised by rivers with subsequent valleys, which deeply cut a monocline structure with north-west – south-east orientation, made up of deposits of soft, predominantly sandy rocks; thus, they reduced much of the initial piedmont surface, which was maintained only on the narrow interfluves. The catchment of the Desnăţui is completely different, the interfluves are broad, tabular, the deepening of the hydrographical network being much diminished. The drainage area of the Jiu river is characterised by the parallelism of the main valleys and the consequent watercourse of the Jiu tributaries, while the interfluves are narrow, sometimes made up of intersection hills and the valleys keep a relatively important width.

The previous analyses (Stroe R., 2003; Boengiu S., 2005, 2008; Boengiu S. & Avram S., 2009) were conducted for the entire piedmont or for each catchment area within the piedmont, while the present study follows a comparative analysis between the area corresponding to the Danube catchment and that connected to the Jiu river catchment.

The drainage density

The map of the drainage density (Fig. 1) displays values comprised between 0 km/sq km and 6.6 km/sq km. The density that accounts for the highest share (Table 1), representing more than half of the territory (54.11 percent) is given by the values of up to 3 km/sq km; this class of values is mostly distributed in the catchment of the Desnăţui, where the interfluves present the aspect of genuine high plains.There follows the class with density values comprised between 3 and 4 km/sq km, with a share of 19.35 percent, which underlines the fact that higher densities (4 – 6.6 km/sq km) represent exceptions from the general rule (6.47 percent). The distribution of the value classes corresponding to the two basins (Graph 1) points out to major differences, but also to certain similarities. Thus, the repartition of the surfaces and the share of the drainage density classes display lower values within the area related to the Danube (2 - 3 km/sq km – 15.37 percent, 3 - 4 km/sq km – 8.16 percent and 4 – 6.6 km/sq km – 2.49 percent) than within the one corresponding to the Jiu river (2 - 3 km/sq km – 17.36 percent, 3 - 4 km/sq km – 11.19 percent and 4 – 6.6 km/sq km – 2.98 percent) for the classes comprising values above 2 km/sq km.



Graph 1. The frequency of the value classes of drainage density on the sectors corresponding to the Danube and to the Jiu

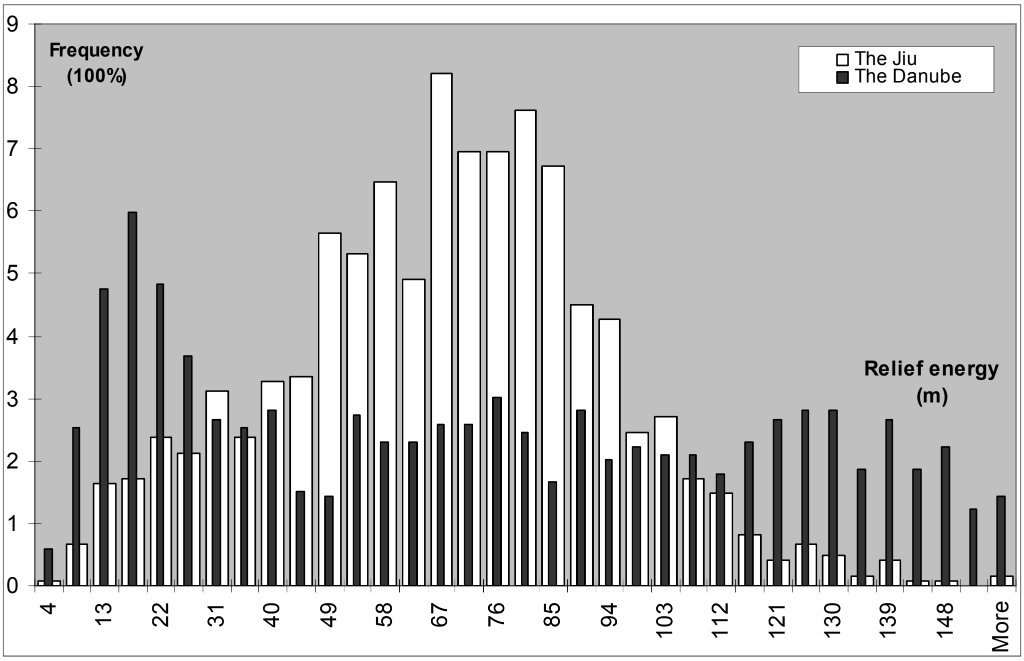
When the values between 0 and 2 km/sq km are taken into account, the share is favourable to the area that corresponds to the Danube (0 - 1 km/sq km – 9.27 percent, 1 - 2 km/sq km – 17.90 percent), as compared to the area that corresponds to the Jiu (0 - 1 km/sq km – 1.64 percent, 1 - 2 km/sq km – 12.57 percent). The most important difference of the drainage density between the two areas is to be noticed in connection with the 0 - 1 km/sq km class – with 7.63 percent, followed by the 1 - 2 km/sq km class – with 5.33 percent, while at the upper classes the difference is attenuated, being under 3 percent.

The relief energy

The map of the relief energy (Fig. 2) displays values comprised between 0 and 157 meters. The highest share in the relief energy (Table 2), representing almost half of the territory (45.52 percent) is given by the values of up to 30 meters, which are mainly distributed in the north and the west of the piedmont.

They are followed by the 30 - 60 meters and 60 - 90 meters value classes, which account for 31.93 percent, respectively 32.01 percent of the surface; the less extended surfaces are occupied by the values comprised between 90 and 120 meters (8.50 percent) and above 120 meters (only 1.45 percent).

The distribution of the values corresponding to the two catchment areas (Graph 2) underlines a total lack of synchronization related to the repartition of the surfaces and of the share of the relief energy classes. Thus, the most numerous population of values within the catchment corresponding to the Danube is registered at the level of the 0 – 30 meters class (21.5 percent), while in the drainage area corresponding to the Jiu, it registers only 4.02 percent and the highest share for the surface corresponding to the Jiu is given by the 60 – 90 meters class (21.47 percent), while within the area corresponding to the Danube, it owns only 10.54 percent of the values.



Graph 2. The frequency of the value classes of relief energy on the sectors corresponding to the Danube and to the Jiu

Table 1
Quantitative data on the drainage density

Values (km/sq km)		Number of values		Relative frequency (percent)	
The Jiu	The Danube	The Jiu	The Danube	The Jiu	The Danube
0.00	0.00	2	44	0.16	3.17
0.19	0.15	1	21	0.08	1.51
0.39	0.30	1	20	0.08	1.44
0.58	0.45	5	30	0.41	2.16
0.78	0.61	14	47	1.15	3.39
0.97	0.76	20	42	1.64	3.03
1.16	0.91	41	38	3.36	2.74
1.36	1.06	62	60	5.08	4.32
1.55	1.21	68	63	5.57	4.54
1.75	1.36	68	48	5.57	3.46
1.94	1.52	89	70	7.30	5.04
2.14	1.67	109	67	8.93	4.83
2.33	1.82	79	73	6.48	5.26
2.52	1.97	107	86	8.77	6.20
2.72	2.12	83	73	6.80	5.26
2.91	2.27	75	72	6.15	5.19
3.11	2.43	78	62	6.39	4.47
3.30	2.58	69	62	5.66	4.47
3.49	2.73	52	60	4.26	4.32
3.69	2.88	49	72	4.02	5.19
3.88	3.03	44	44	3.61	3.17
4.08	3.18	29	32	2.38	2.31
4.27	3.34	22	38	1.80	2.74
4.46	3.49	12	29	0.98	2.09
4.66	3.64	8	24	0.66	1.73
4.85	3.79	6	20	0.49	1.44
5.05	3.94	12	26	0.98	1.87
5.24	4.09	6	9	0.49	0.65
5.44	4.25	2	14	0.16	1.01
5.63	4.40	3	21	0.25	1.51
5.82	4.55	0	7	0.00	0.50
6.02	4.70	1	3	0.08	0.22
6.21	4.85	0	1	0.00	0.07
6.41	5.00	1	3	0.08	0.22
More	5.16	2	2	0.16	0.14
-	5.31	-	1	-	0.07
-	5.46	-	1	-	0.07
-	More	-	3	-	0.22

Table 2
Quantitative data on the relief energy

Values (meters)		Number of values		Relative frequency (percent)	
The Jiu	The Danube	The Jiu	The Danube	The Jiu	The Danube
4	4.00	1	8	0.08	0.58
8.5	7.70	8	67	0.66	4.83
13	11.41	20	155	1.64	11.17
17.5	15.11	21	98	1.72	7.06
22	18.81	29	54	2.38	3.89
26.5	22.51	26	60	2.13	4.32
31	26.22	38	58	3.11	4.18
35.5	29.92	29	49	2.38	3.53
40	33.62	40	67	3.28	4.83
44.5	37.32	41	82	3.36	5.91
49	41.03	69	53	5.66	3.82
53.5	44.73	65	51	5.33	3.67
58	48.43	79	60	6.48	4.32
62.5	52.14	60	54	4.92	3.89
67	55.84	100	52	8.20	3.75
71.5	59.54	85	79	6.97	5.69
76	63.24	85	65	6.97	4.68
80.5	66.95	93	40	7.62	2.88
85	70.65	82	48	6.72	3.46
89.5	74.35	55	36	4.51	2.59
94	78.05	52	31	4.26	2.23
98.5	81.76	30	21	2.46	1.51
103	85.46	33	18	2.70	1.30
107.5	89.16	21	16	1.72	1.15
112	92.86	18	17	1.48	1.22
116.5	96.57	10	15	0.82	1.08
121	100.27	5	9	0.41	0.65
125.5	103.97	8	5	0.66	0.36
130	107.68	6	4	0.49	0.29
134.5	111.38	2	5	0.16	0.36
139	115.08	5	1	0.41	0.07
143.5	118.78	1	2	0.08	0.14
148	122.49	1	0	0.08	0.00
152.5	126.19	0	1	0.00	0.07
More	129.89	2	2	0.16	0.14
-	133.59	-	1	-	0.07
-	137.30	-	3	-	0.22
-	More	-	1	-	0.07

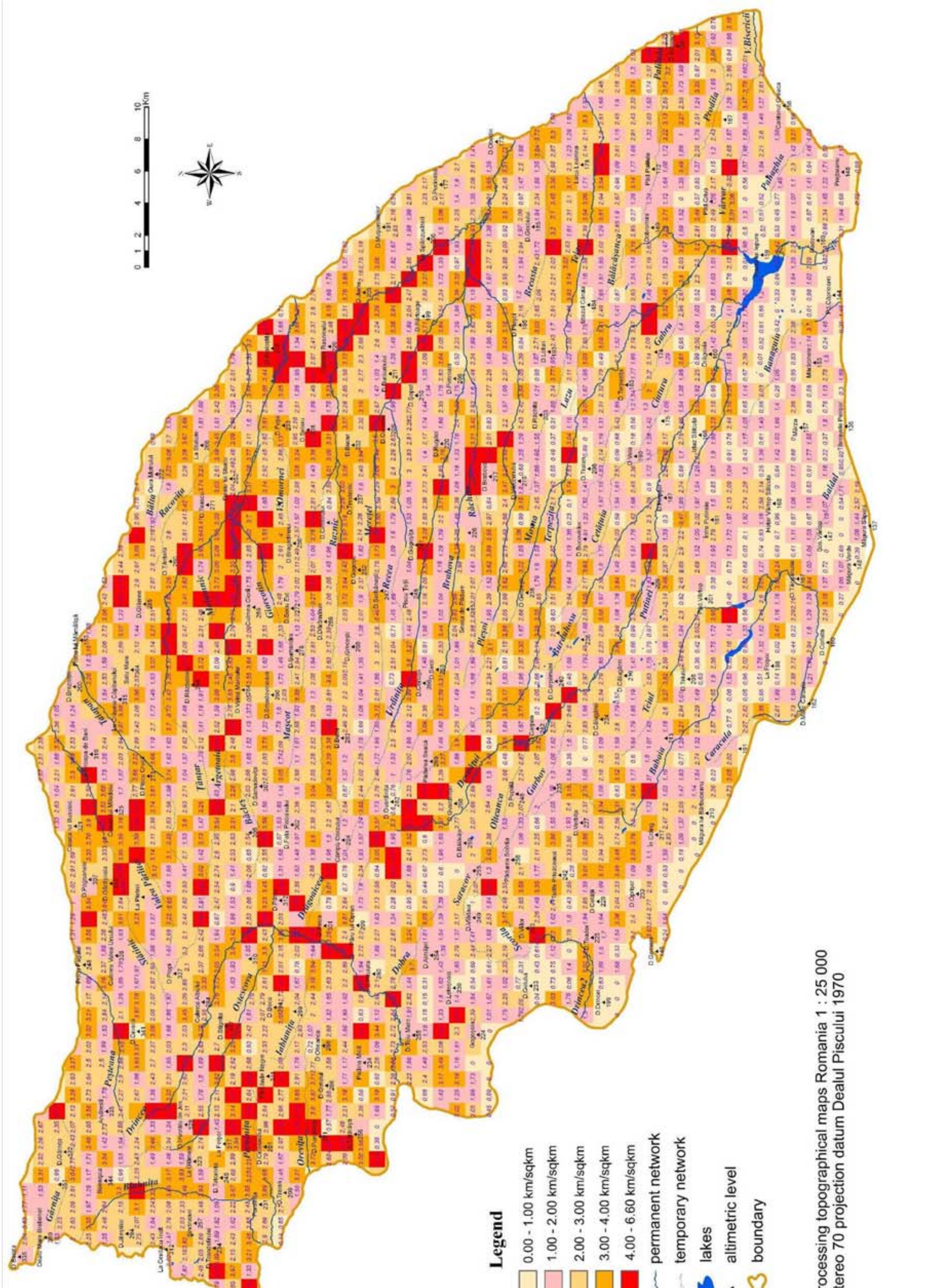


Fig. 1. The map of the drainage density in the Bălăciţa Piedmont

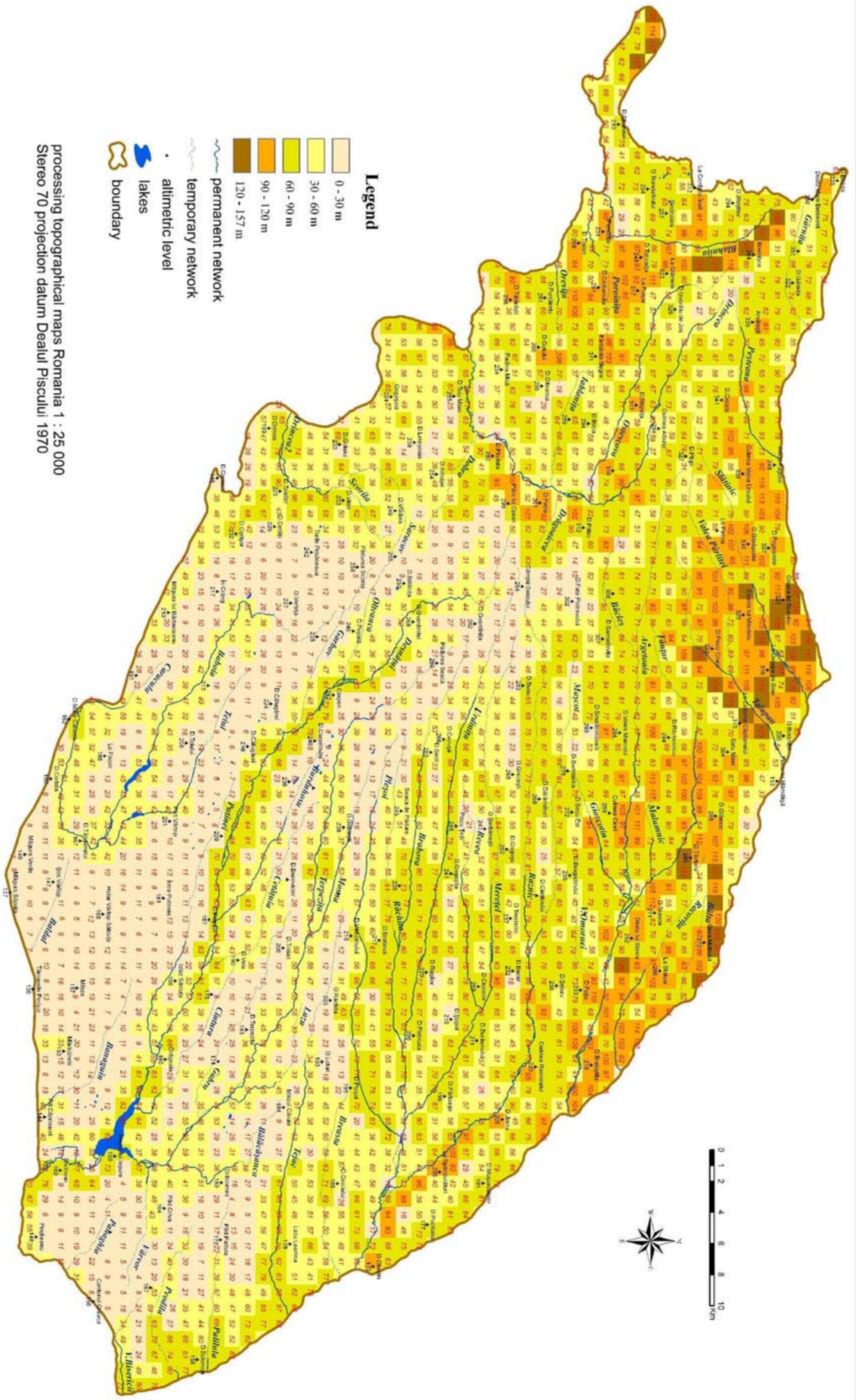


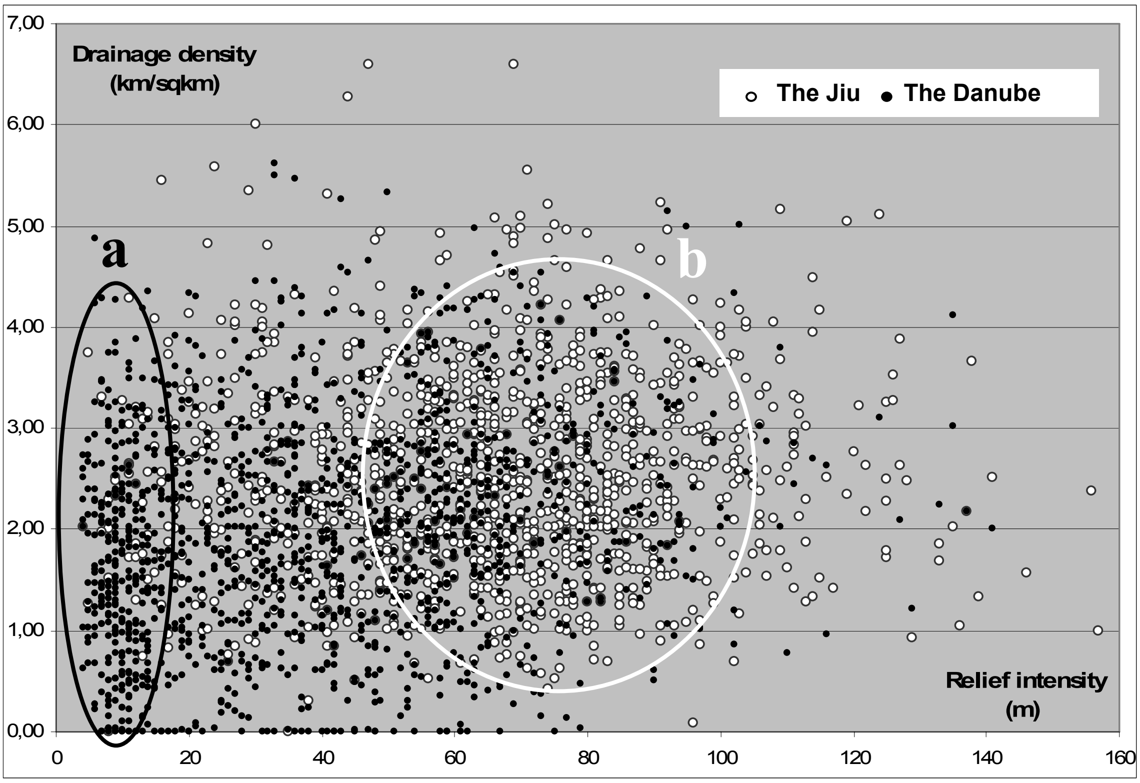
Fig. 2. The map of the relief energy in the Bălăciţa Piedmont

The correlation between the drainage density and relief energy

The representation in rectangular system (Graph 3) of the 2,608 values (1,388 for the area corresponding to the Jiu catchment and 1,220 for that within the Danube catchment) led to a correlation coefficient (r) of 0.202. The signification of this value was achieved through the application of the Student t=10.528 and Fischer z=0.327 control tests, as well as through the computation of the standard deviation or of the square average error of the size Sz, Sz=0.019.

For the drainage density – relief energy correlation there was computed the determination coefficient CD=4.07, which means that 4.07 percent of the values of the relief energy are determined by the drainage density (the unexplained variation showing the value of 95.93 percent).

The analysis conducted on the basis of the applied tests and of the graphical representation led to the conclusion that the repartition of the fragmentation density and depth determinations that were obtained do not enter a Gauss curve, being dependent on certain other factors. The significant spreading of the data into the intervals of values of relief energy of 0 - 20 meters and 60 - 70 meters demonstrates the grouping of the influence factors on the two main catchments (of the Danube and of the Jiu).



Graph 3. The correlation between drainage density and relief energy
a – the interval of points concentration within the area corresponding to the Danube catchment;
b – the interval of points concentration within the area corresponding to the Jiu catchment

CONCLUSION

The highest values of the fragmentation are registered in the western and the northern parts, while the south and the east display the lowest values.

The analysis of the relief fragmentation within the Bălăciţa Piedmont shows that this unit is on different evolution stages, the complexity of the fragmentation being closely connected to the maturity degree of the valleys and to the morphogenetic complexes imposed by the paleogeographical evolution (Boengiu, 2005). The sector corresponding to the Danube, which comprises the catchments of the Blahniţa and of the Drincea, as well as the Danube slope between Şimian and Batoţi settlements, is characterized by erosion in the most advanced stage, the initial piedmont surface being almost totally destroyed. The sector that comprises the Desnăţui drainage area is characterised by much more reduced fragmentation densities and depths than the rest of the unit, the piedmont surface forming interfluves.

The sector corresponding to the catchments of the Jiu and of the Motru rivers is characterized by a less advanced evolution stage, the piedmont surface forming relatively rounded and very narrow surfaces on the interfluves.

The resemblances concerning the fragmentation parameters between the two areas are due to the lithological and climatic homogeneity, while the differences are a consequence of the evolution time depending on a certain base level and of the flow direction in report to the structure.

The grouping of the influence factors on the two main catchments (of the Danube and of the Jiu) is mainly due to the fact that the Danube catchment extended its surface in the detriment of the Jiu drainage area, the three more important tributaries, i.e. the Blahniţa, the Drincea and the Desnăţui capturing sectors from the upper course of the tributaries of the Jiu river.

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THE DYNAMICS OF THE PRESENT PROCESSES WITHIN THE SĂRĂŢEL CATCHMENT AREA

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Abstract

The Sărăţel catchment displays a territory mostly located in the molasse area of the Buzău Subcarpathians. The physical-geographical characteristics, as well as the social-human impact, created a complete geomorphologic system, in which the present geomorphologic processes register accentuated dynamics. Starting with the year 2002 until 2008 there were monitored areas with significant impact on the landscape, among the most important processes under study being the landslides, the torrents, the ravines and the creep.

Keywords: *present geomorphologic processes, landslides, torrents, ravines, creep*

Rezumat

Dinamica proceselor actuale din bazinul hidrografic Sărăţel. Bazinul Sărăţel prezintă un teritoriu localizat în cea mai mare parte în arealul molasic al Subcarpaţilor Buzăului. Caracteristicile fizico-geografice, la care se adaugă impactul socio-uman, au creat un sistem geomorfologic integral, în cadrul căruia se manifestă o dinamică accentuată a proceselor geomorfologice actuale. Începând din anul 2002 şi până în 2008 au fost monitorizate areale cu impact însemnat asupra peisajului, dintre care se remarcă alunecările de teren, torenţii, ravenele şi creepul.

Cuvinte-cheie: *procese geomorfologice actuale, alunecări de teren, torenţi, ravene, creep*

INTRODUCTION

The dynamics of the present processes represents a segment of global interest because of the always more extended altered surfaces and of the intensities that sometimes affect the human society, even if occasionally the location, the amplitude and the intensity are (irreversibly or not) generated by man. The geomorphologic research passed from the descriptive studies conducted at the beginning of the last century to a monitoring and highly accurate analysis based on the technologies and the methodologies in use. The present studies can facilitate the explanation, the stage and the dynamics of certain geomorphologic processes and this is why the field familiarity with the area under analysis constitutes a requirement.

In the Romanian Subcarpathian area, the modelling processes represented the subject or constituted chapters of the numerous PhD theses or scientific papers bearing the title „study of geomorphology”. Among the published theses we mention those edited after 1967, in which the dynamic morphology is highly important - Roşu Al. (1967), Badea L. (1967), Grumăzescu H. (1973), Brânduş C. (1981), Bălteanu D. (1983), Armaş Iuliana (1999), Dinu Mihaela (1999), Ene M. (2004) and so on; there are to be added other PhD theses defended but not yet published (Micu M., Cruceru N. and so on). Furthermore, the palpable results of the present processes monitoring were presented in scientific papers that are well supported by field data. We shall limit the area to that in the Buzău Subcarpathians, where we quote the studies related to the dynamics of the processes, which were conducted by Mihăilescu V. (1951), Posea Gr., Badea L. (1953), Alexandru Medelaine, Dragomirescu Ş., Şeitan Octavia (1964), Posea Gr., Ielenicz M. (1970), Popescu Dida (1971), Posea Gr. (1969, 1972), Badea L. (1972, 1973), Iancu Silvia (1974), Ielenicz M. (1978, 1986), Bălteanu D. (1979), Niculescu Gh. (1986), Cruceru N. (2004, 2005), Vespremeanu-Stroe A., Micu M., Cruceru N. (2007) and so on.

The present study aimed at achieving detailed mathematical data related to the present morphology and to the dynamics of certain processes (*landslides, torrentiality, ravination and creep*). Through the time monitoring of the main geomorphologic processes, we aim at quantifying and extending the monitored area.

Study area

The morpho-hydrographical catchment of the Sărăţel river is located at the exterior of the

Carpathian Bend, in the Buzău Mountains group and in the Buzău Subcarpathians sub-group.

From the mathematical viewpoint, it is located within the following coordinates:

- North – 45°28'40" N and 26°30'52" E;
- South – 45°17'10" N and 26°40'38" E;
- East – 45°24'21" N and 26°43'46" E;
- West – 45°25'12" N and 26°31'56" E.

From the hydrographical viewpoint, it is a left tributary of the Buzău river, the confluence being located near the settlement of Berca, Buzău County. The limit of the Sărăţel is represented by the watershed between the river with its tributaries and the conterminous catchments: the Slănicul de Buzău valley in the northeast and the east; the Murătoarea valley in the east (southwards of the mud volcanoes plateau); the Bălăneasa valley in the west.

From the altitudinal point of view, in the northern part, the Sărăţel catchment reaches 935.4 meters in the Ivăneţu Ridge and the altitudes descend near the confluence with the Buzău to only 141.6 meters.

The catchment area covers a total surface of 189.54 square kilometres, representing one of the smallest catchments that are tributary to the Buzău. At national level, it enters the category of small catchments.

The river is 34.21 kilometres long and it is characterised by an average multi-annual flow around 1 cubic meter/second.

From the geological viewpoint, the catchment area is located in the south of the Paleogene flysch and within the Mio-Pliocene molasse, with friable rocks, affected by present modelling processes. There appear rocks such as the sandstones, the limestone, the conglomerates, the gypsum, the salt, the marls, the clays, the sands, included in the folded and faulted structures. The impact of the external agents generated a special landscape, dominated by landslides and torrential organisms.

The altitudes descend from the north to the south, from 900 meters in the Leordeţu Hill, 885 meters in the Pietrişului Peak, 821 meters in the Bocu Peak, 802 meters in the Piţigoiului Peak and so on, to altitudes under 150 meters in the lower sector of the Sărăţel floodplain.

Within the catchment area there are dominant the narrow interfluvial ridges, the main ones respecting the morpho-tectonic influence, while the secondary ones are perpendicular on the former. The structural relief, with numerous cuesta escarpments, creates a special note within the landscape. In the saliferous areas, there was formed a spectacular specific karst relief with accentuated dynamics.

The hydrography is represented by a poor phreatic nappe, with scanty flows. The surface water shows important seasonal and annual variations. Nevertheless, there are to be noticed the sulphurous, chlorinated, salty etc. springs located in the areas of Căneşti, Păcuri, Negoşina, Gonţeşti settlements.

From the climatic viewpoint, the Sărăţel catchment area is comprised between the 6 and 10° C isotherm, with an average pluvial value of about 700 millimetres/year.

METHODOLOGY

Besides the classical methods that imply the use of maps and the field mapping with traditional means (compass, theodolite, steel measuring tape etc.), we used new instruments and methodologies in the detriment of the geographical science.

The maps or other finalities of the system impose two types of structures/models: raster and vector. The raster model uses a network of cells with regular distribution and an element belonging to this network is called pixel, being distributed row after row (from top to bottom) and column after column (from left to right). The raster data are presented under the form of points, lines and areas. The raster model answers the requirement of representing an object in a more precise image (closer to the truth), results through numerous geometrical data, such as the position, the shape and their dimensions in space. The data analysis and the combination of strata (data or maps) are based on complex algorithms and imply an ideal topology, which imposes the elimination of the errors from the beginning.

The topographical elevation surveys were conducted during many field campaigns:

- for the landslides: August 2002, August 2005 and September 2008;
- for the torrents: June 2007;
- for the ravines: August 2002, August 2005 and August 2008;
- for the creep, depending on the depth: July 2003 – July 2007.

During the topographical measurements/ elevation surveys, the theodolite was used in 2002, afterwards the total topographical station (Sokkia 610), the Garmin GPS (GPSmap 60Csx) for the landslides (the contour and the markers implanted in the slid mass), torrents (the contour), ravines (the length and the contour), the creep (the location). For the creep, we drew upon the "pillar test" method mentioned by A. Young (1960, 1972), quoted by N. Rădoane, 2002 and which consists in the introduction of plastic rodlets (5 millimetres in diameter and up to 5 centimetres long) in the profile of the materials; this method offers the possibility to know the general movement of the superficial part of the phenomenon but not the differentiation of the movement speed of the material in depth. For this purpose, we used another method inspired by the examples emitted by N. Rădoane in 2002, with small changes. Thus, on two of the sample-plots (Plopeasa and Scoroşeşti) we used, instead of the plastic rodlets and wooden stakes (numerically marked with paint), red brick powder perpendicularly introduced (in 2003) on the topographical surface down to the depth of 50 centimetres, with the help of certain metallic tubes (3 centimetres in diameter), disposed at about 10 meters distance. Within these plots, the depth observations were conducted during 4 years, only at the beginning and at the end of the monitoring.

As database, there were used:

- ***The Topographical Maps*** scale 1:25,000, editions of 1979, 1981, 1982 (scanned and georeferenced);
- ***The Geological Maps*** scale 1:200,000, Covasna sheet (29 – L-35-XXI; year 1968) and Ploieşti sheet (36 – L-35-XXVII; year 1967) (scanned and georeferenced);
- ***The Satellite Images*** LANDSAT TM in seven bands, with 30 meters resolution;
- ***The Aerial Images or Aerial Photographs*** overlapped on the Digital Terrain Model (DTM), based on the above-mentioned topographical material.

RESULTS

The Sărăţel catchment lies on a complex fundament from the geological-structural and lithological points of view, represented by tight folds and faults and a diverse lithology dominated by Mio-Pliocene formations, poorly resistant at erosion and favourable to the present modelling processes. There are to be added the frequency and intensity of the downpours, the temperature variations, the energy and the fragmentation density of the relief and the land use, which lead to a great complexity and variety of the present geomorphologic processes. The present study deals with the complex of slope processes, such as the landslides, the torrentiality, the ravination and the creep.

The landslides

Numerous landslides with a great complexity of types are present within the Sărăţel catchment area. A total number of 338 plots with landslides were inventoried (2006-2007), covering an affected surface of more than 100 square meters (both the active and the stabilised ones). As case studies, we present two landslides monitored between 2002 and 2008.

Căneşti 1 Landslide

The landslide is located on the southern slopes of the Bocu hill, the slope ”towards Păcuri”, on an old, relatively stabilised glacis. The deposits belong to the Bedanian and they are dominated by marls and clays, tuffs and gypsums. The landslide is located within Căneşti settlement, in the concave bank of the former meander of the Sărăţel river. After the construction of the communal road, the water of the Sărăţel was deviated 80 meters towards the south. From the mathematical viewpoint, the landslide has the following coordinates: in the south 45°23’46’’ N and 26°36’41’’ E, in the north 45°23’51’’ N and 26°23’36’’ E, in the east 45°23’48’’ N and 26°36’39’’ E and in the west 45°23’49’’ N and 26°36’43’’ E.

This is a landslide tongue with average depth and it is located on a slope with relatively small inclination, of up to 27°. The movement of the clayey mass does not take into account the geological structure (asequent landslide). The study area is crossed by a drainage that is only maintained during the rains that supply the clayey matrix with water. The area affected by the landslide extends on about 5,000 square meters, 4,020 of which are comprised between the detachment scarps and only 3,224 square meters represent the body of the landslide (September 2008) (Table 1).

Table 1 Morphometrical characteristics of the Căneşti 1 Landslide

Morphometrical features	in meters
L (average length)	158
l (average width)	22.6
h (average thickness of the mass)	2.4
S (surface of the slid mass)	3224 square meters
V (volume of the slid mass)	8569.92 cubic meters
Average movement speed (per year)	2.2

The sector of the slope that is strictly affected by the landslide extends on a maximum length of 166 meters and a maximum width of 37.5 meters, having a maximum thickness of 5.3 meters in the narrowing sector from the terminal part. The detachment scarp has an almost circular shape, being fragmented by ravines that favour the withdrawal of the cornice. It is 0.5 – 3 meters deep and it is affected by gullies and ravines. The slid mass shows a wavy micro-morphology, with steps comprised between 0.30 and 0.70 meters. There are also present small steps that are perpendicular on the flowing direction and are characterised by dimensions under 0.8 meters (Fig. 1).

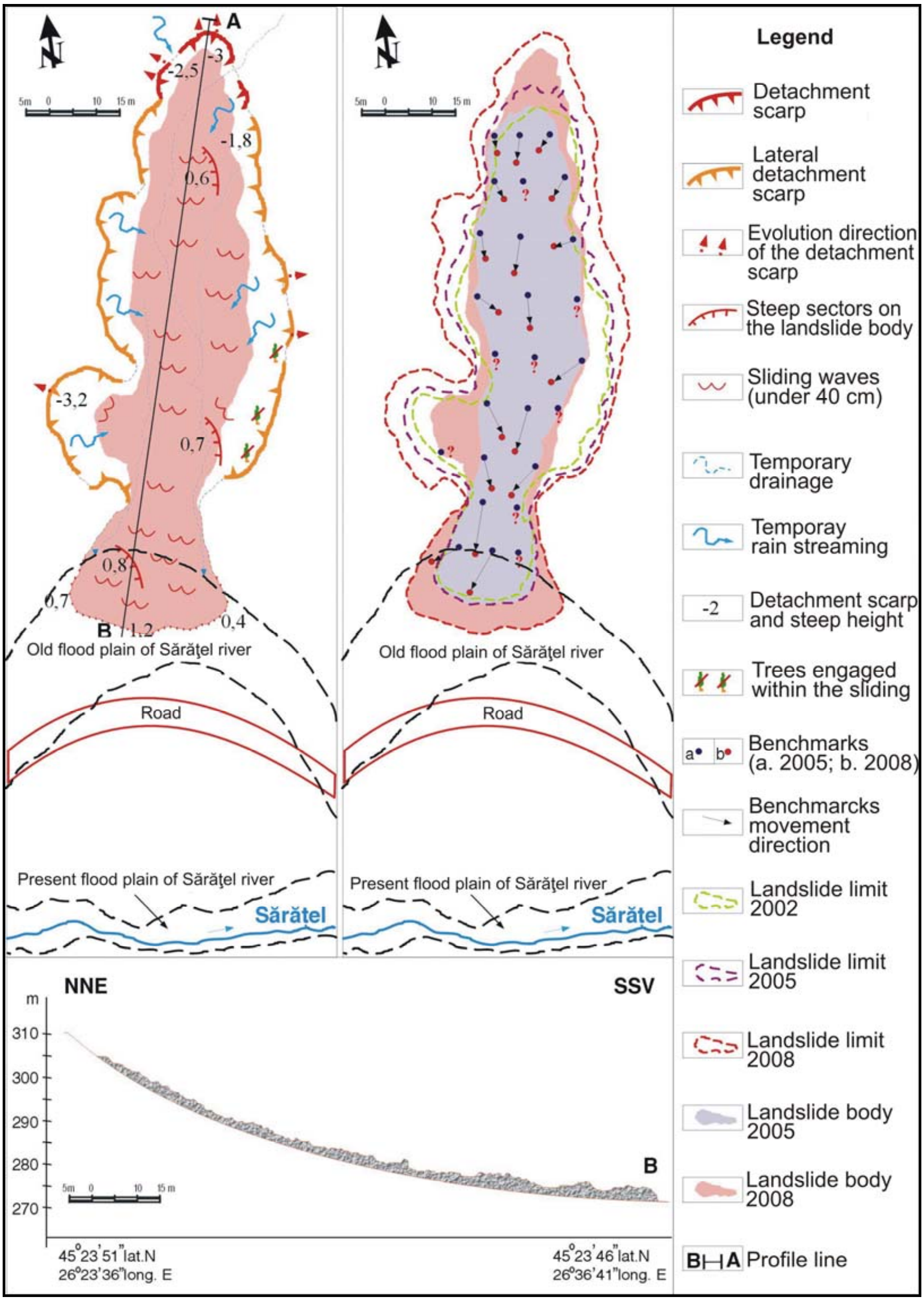

Fig. 1 Căneşti 1 Landslide

The slid mass has a volume of 8,569.92 cubic meters. The landslide toe is located on a quasi-horizontal surface, having the shape of a spreading cone and, at the terminal part, it takes the form of a wave that slightly surpasses one meter. The movement speed of the slid mass is realised differently. The monitoring period of the markers was relatively short (only three years) and, thus, no pertinent conclusion can be drawn. During this interval, the movement speed of the markers varied from 2.1 meters to 11.3 meters (during 3 years, from August 2005 until September 2008) (Table 2). The data acquired in the field support the fact that the most intense movements took place in 2005, both in spring, after the sudden snow melting, and at the end of the summer, after a downpour. After this period, the movement was extremely slow, almost imperceptible.

There developed a drainage network that crosses the body of the landslide on its central part, sometimes leading to a strong moistening of the nearby material and imposing it a more rapid movement speed than to the other stripes.

It is a semi-stabilised landslide, being invaded by a vegetation of small bushes. Nevertheless, it remains a geomorphologic process with important impact on the landscape and it represents a risk factor because of the nearby social-economic activities. The terrain on which the landslide is located belongs to the common pasture. In the eastern part, the residences are situated at only 30 meters of the lateral detachment scarp, while the courtyard and the orchard are located on the upper part of the respective cornice. In the western part, the residences are to be found starting with 63 meters. From the landslide toe to the communal road there is only a distance of 16.35 meters, this portion presenting a prolonged spring moistening.

Table 2 Distance covered by the markers within the Căneşti 1 Landslide

Markers No.	Distance covered between August 2005 and September 2008 (meters)
1.	2.1
2.	4.8
3.	4
4.	3.8
5.	-
6.	5.1
7.	5.3
8.	7.7
9.	5.1
10.	6.2
11.	6.8
12.	-
13.	-
14.	-
15.	10.1
16.	6.2
17.	10.2
18.	-
19.	-
20.	6.3
21.	8.2
22.	11.3
23.	-
24.	6.2
25.	8.9
26.	-
Average speed = 6.6 meters	

Şuchea Landslide

The landslide is located on the northern slopes of the Pietricica Suchii hill, on the slope called ”Strâmbu Şuchii cu Pini”, which has been stabilised through pine tree plantations starting with the ’60s. The deposits belong to the Badenian and to the Helvetian, being dominated by marls, clays and gypsums. The landslide is located within Şuchea settlement, near the Strâmbu Şuchii riverbed, which is a tributary of the Sărăţel on the right. From the mathematical point of view, the landslide has the following coordinates: in the south 45°24’06’’ N and 26°35’01’’ E, in the north 45°24’30’’ N and 26°34’58’’ E, in the east 45°24’26’’ N and 26°35’02’’ E and in the west 45°24’25’’ N and 26°34’60’’ E.

It is a landslide tongue with average depth and it is located on a slope with relatively small inclination, of up to 28°. The movement of the mass is realised on a dominantly clayey slope and it does not consider the geological structure (asequent landslide). The landslide under study developed as a typical mudflow, but without having a clear supply area. Initially, the landslide appeared at the end of the 60’s under the form of a ravine that evolved regressively both upstream and laterally. In the 90’s, it became a real mudflow that reached the riverbed, the materials being subsequently taken by the Strâmbu Şuchii stream. The lateral slopes mainly supplied the materials. Once the slope gets milder, the flow becomes a landslide, having a slower and periodical movement.

The area affected by the landslide extends on almost 3,300 square meters, 2,120 of which are comprised between the detachment scarps and only 1,943 square meters represent the body of the landslide (September 2008) (Table 3). The slope that is strictly affected by the landslide extends on a maximum length of 202 meters, a maximum width of 46.7 meters near the toe (the spreading cone) and a minimum one of 5.3 meters, having a maximum thickness of 6.9 meters in the narrowing sector from the terminal part. The detachment scarp has an ovoid shape and it is fragmented by ravines that favour the withdrawal of the cornice. Its depth varies between 0.5 and 0.8 meters and it is affected by gullies and ravines. The slid mass shows a wavy micro-morphology, with steps comprised between a minimum of 0.30 meters and up to 0.80 meters. There are also present small steps perpendicularly disposed on the flow direction, their dimensions being less than 1.8 meters (Table 4 and Fig. 2). The volume of the slid mass is of about 7,469.28 cubic meters. The landslide toe is located on a quasi-horizontal surface, a floodplain terrace, and it takes the form of a spreading cone, while on the terminal part it has the shape of a wave that reaches the riverbed of the stream. The terminal part of the landslide is washed after each flash flood.

Table 3 Morphometrical characteristics

Morphometrical features	in meters
L (average length)	182
l (average width)	10.8
h (average thickness of the mass)	3.8
S (surface of the slid mass)	1,943.6 square meters
V (volume of the slid mass)	7,469.28 cubic meters
Average movement speed (per year)	3.23

Table 4 Distance covered by the markers within the Şuchea Landslide

Markers No.	Distance covered between August 2005 and September 2008 (meters)
1.	9.8
2.	7.9
3.	7
4.	12.7
5.	11.3
6.	12.2
7.	11.9
8.	7.6
9.	10.3
10.	7.9
11.	7.8
Average speed = 9.67 meters	

There are differences related to the movement speed of the slid mass. The monitoring duration of the markers was relatively short (only three years), which does not allow for a concrete evaluation of the dynamics on a statistical term. During this period, the movement speed of the markers varied from 7 to 12.7 meters (during three years; from August 2005 until September 2008) (Table 4 and Fig. 2). It can be said that the average movement speed of the landslide is of about 3.23 meters. The data acquired in the field support the fact that the dynamics of this landslide is felt during the entire year, with peaks within the snow melt period and during the downpours. It is important to mention the fact that the landslide evolves both regressively and laterally, a fact which affects the pine tree plantation.

This is an active landslide, with negative impact on the slope. The landslide is located on a forest that belongs to the Local Council, which did not take any pertinent measure to stop the evolution of the respective process until 2008.

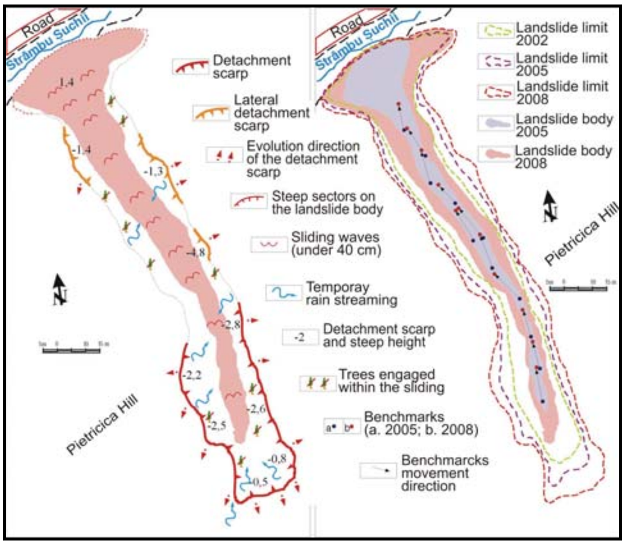

Fig. 2 Şuchea Landslide

4.2. *The torrents* or *the torrential bodies* appear on the slopes with friable rocks (especially marls, sands, gravels and clays, to which there are to be added the sandstones) and even on the old, relatively stable deluvial accumulations. The forms and dimensions differ from one place to another under the impulse of the local conditions and the processes generally occur during the spring (March - April) and towards the autumn (June - September).

In order to determine the intensity of the torrential phenomenon within the Sărăţel catchment (Table 5) and in certain sub-basins, the torrentiality index (I_T), was calculated with the formula:

$I_T = \Sigma_{LT} / \Sigma_{LH} \bullet 100$, *where:*

I_T – *torrentiality degree (in percent);*

Σ_{LT} – *the summed length of the ravines and of the torrents (in kilometres);*

Σ_{LH} – *the total length of the hydrographical network (in kilometres).*

The computation of the index for the Sărăţel catchment area was based on the topographical map, scale 1:25,000 and on ortophotographs, scale 1:5,000. There were mapped torrential organisms up to 500 meters long, which justifies an extremely high torrentiality index. There is to be noticed the fact that on two of the tributaries, the torrentiality index is in the general note of the Sărăţel morpho-hydrographic catchment. As case studies, we present three torrents that are well defined in the landscape.

The Şuchea torrent is located near the Sărăţel - the Slănicel confluence, on the right side of the collector, on the eastern slope of the Pietricica Hill. It is developed on friable Sarmatian rocks (marls, clays, sands). It is a poorly developed torrential organism, with prolonged shape. Most of the flow channel crosses a pine and oak forest, while the catchment basin is located on an intensely used pastureland. The alluvial fan overlaps the floodplain terrace of the Sărăţel. The catchment area displays an ovoid shape, being 186 meters long and 85.3 meters wide (maximum width) (Fig. 3). The catchment basin covers a surface of about 7,439 square meters, with extremely intense occurrence of ravines and of gullies. The flow channel is 204 meters long, being characterized by a maximum width of 33 meters, a minimum one of 10.3 meters and a maximum depth of 11 meters. The alluvial fan covers a surface of 4,650 square meters. The catchment basin developed as a consequence of the irrational land use, on an average slope of more than 20º. Within the catchment area, the evolution is mainly realized through ravination and sheet washing, which acquire maximum intensities within the pluvial summer period and during the sudden snow melting; there are to be added small superficial landslides. The flow channel has a "V" shape, with the thalweg freed of sediments. On the left side, there are located three ravines that are 62 m, 27.5 m and 31.6 m long; the share of the alluvia is significant, even though the ravines are located within the forested area. On the left side, there is located only a 61 meters long ravine, less active that the ones situated on the opposite bank. The alluvial fan consists of two different sectors, one of which is relatively stable, covered with grass, with a 35º slope in which the torrent dug a valley heading towards the Sărăţel riverbed. At the terminal part, there is situated a new sector with a slope under 12º, which pushes the thalweg of the Sărăţel towards the opposite bank.

Table 5 Torrentiality index within the Sărăţel catchment

Name of the catchment	Total length of the hydrographical network (kilometres)	Total length of the hydrographical network (kilometres)	Torrentiality index (percent)
The Slănicel	204.21	132.05	64.66
The Băligoasa	294.55	192.13	65.29
THE SĂRĂŢEL	1,565.67	1,029.25	65.74

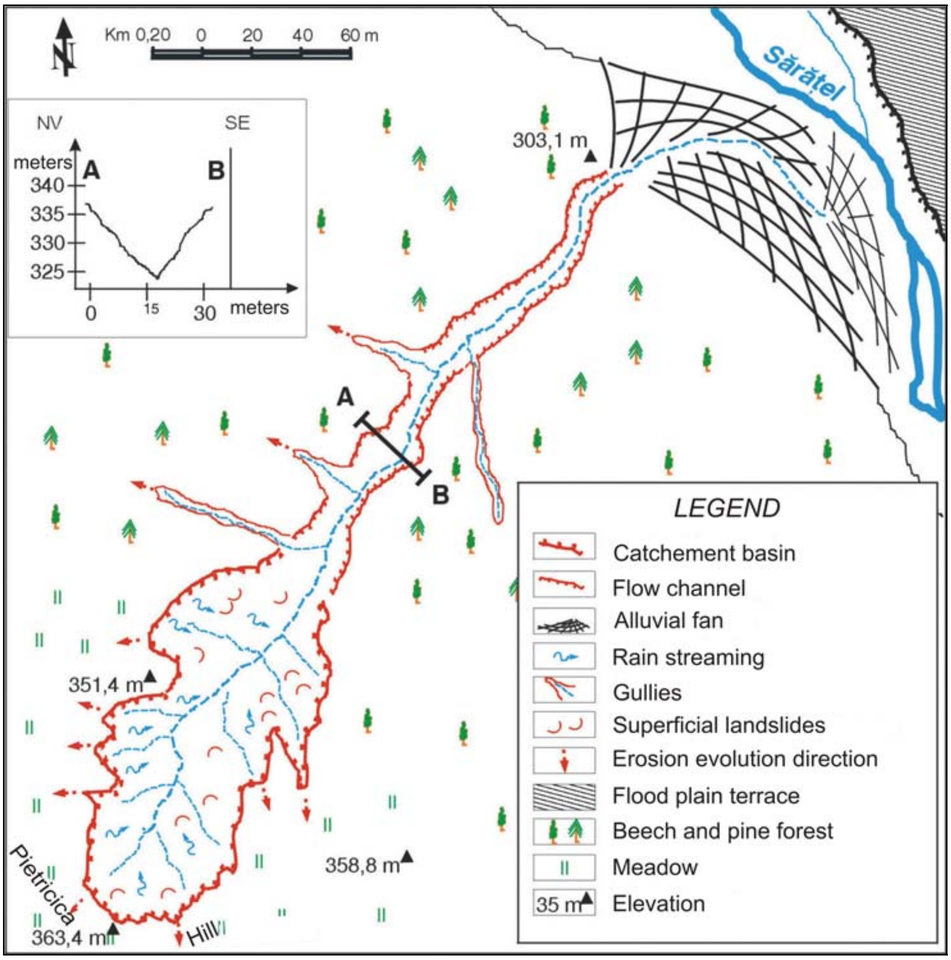

Fig. 3 The Şuchea torrent

The Goluri torrent is located on the left of the Sărăţel, between Gura Văii and Scorţoasa settlements, on the western slope of the Muchia Golului Hill, which is sporadically covered with oak and pine forest. The lithology is dominated by (Dacians and Quaternary) sands, gravels, marls and clays. The catchment basin displays an almost circular shape and covers a surface of about 6,230 square meters, being relatively covered with forest and touching the top of one of the Sărăţel's terrace. The flow channel is 150 meters long, the maximum width of which is 32.4 meters and minimum one 9.6 meters. The channel is 5.7 meters deep and shows massive accumulations that are relatively stabilised. The alluvial fan is of important dimensions, being located within the Sărăţel floodplain, with a general slope below 18º in the upper part and around 10º in the terminal one. It displays a triangular lobed shape, which pushes the course of the collecting valley. It covers a surface of 4,655 square meters and it is mostly covered with grass. Because of the degree of forest coverage, the torrent shows a slower dynamics than the other similar organisms. The liquid flow transported along the discharge channel is mostly due to the snow melting or to the downpours, without an underground contribution. Within the alluvial fan there is to be found a shallow prolongation of the flow channel, which conducts the water of the torrent (Fig. 4).

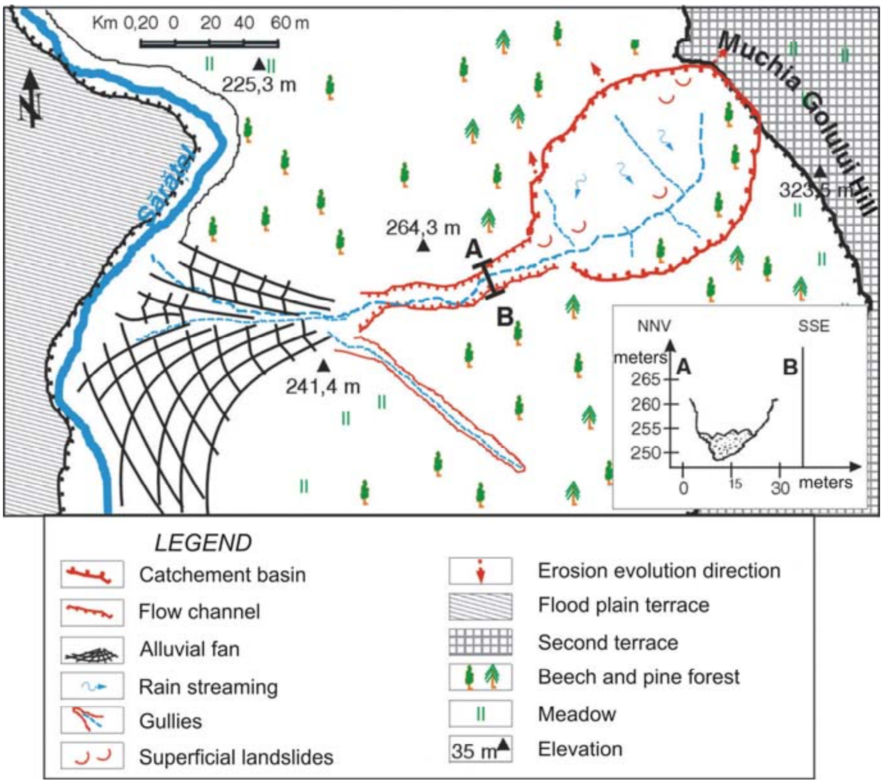

Fig. 4 The Gloduri torrent

The Negoşina torrent is located on a right tributary of the Sărăţel, called the Valea Negoşina, within a saliferous sector that actively influences the dynamics of the present geomorphologic processes.

The lithology is diverse and it presents a succession of sandstones, marls and Sarmatian sands, while in the base there are marls, clayey schist, breccia and salt. The slope displays a complex shape (with the general inclination of about 40º), both concave (in the upper half) and convex (in the lower half). At the morphographic inflexion, there appeared numerous saliferous depressions (Cruceru N., 2004), at the base of which there are salt kernels (Badenian); the depressions are located in the left of the torrent under study. Despite the fact that the slope is significantly covered with pine tree forest, the gullies and the ravines display an intense manifestation (Fig. 5).

The catchment basin displays a prolonged, ovoid shape, covering a surface of about 21,250 square meters and evolving regressively towards Negoşina and towards the road that heads to this settlement, which is located on an interfluvial top surface that is relatively flat and characterised by about 450 meters of altitude (the 350-450 erosion level), which display the shape of replats, being apparently carved at the end of the Upper Pleistocene (Ielenicz M., 1978).

The scarps of the catchment basin are affected by ravination and sheet washing, which are extremely active. The flow channel is 432.8 meters long, its width varying from 57.4 meters to 1.7 meters in the discharging sector. The banks are affected by gully erosion and ravination (giving the aspect of *bad lands*). The ravines are dominantly short, about 3 meters long, but in rare cases, they can reach 162 meters (such an example is located on the right side, at 114.1 meters downstream of the catchment basin). Approximately in the same point there is the confluence with another ravine, which is located on the left side, is less active and is 98.7 meters long. The cross section of the channel is carved under the "V" letter shape, being strongly deepened from 8 to 15 meters. The alluvial fan is extremely small, covering only 104 square meters. This torrent shows high dynamics because of the lithology, diapirism and slope. Starting with the year 2006, within the catchment basin there have been conducted improvement works under the form of small terraces, on which box thorn and southernwood were planted. The implants accelerated the propagation speed of the processes because of the irrational system, i.e. the roots of the plants were not taken out from the transporting plastic bags, which were brought to the surface by the gully erosion and were moved during each downpour.

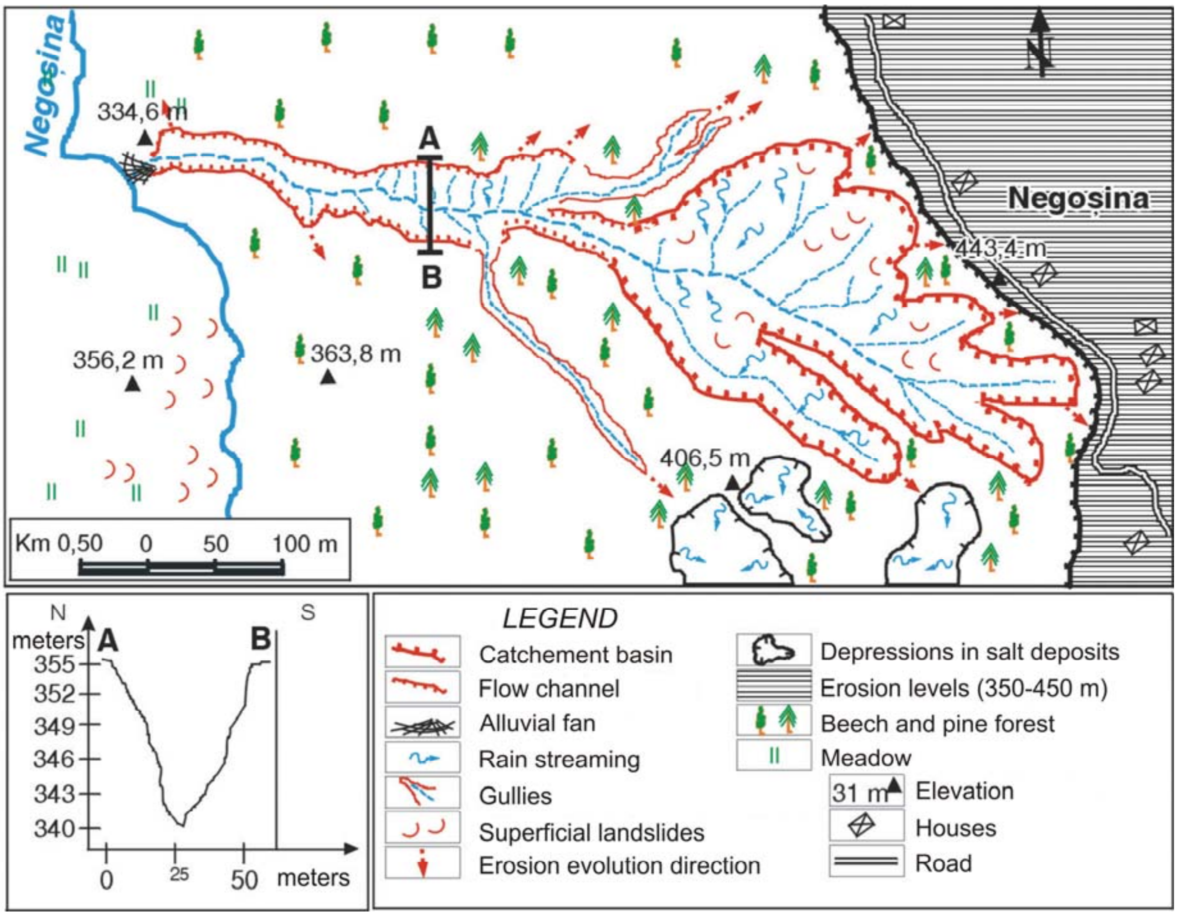

Fig. 5 The Negoşina Torrent

The ravines. As in the case of the processes presented above, the ravines display a great variety, their most important classifications following: the location within the catchment area, the shape of the transversal section, the criterion of the evolution cycle (used by Poesen and Govers, 1990), the depth, the width and the drainage surface (Kozmenko, 1954; Armand, 1955; Bălăiu, 1965; Moţoc, 1963; 1975; quoted by Rădoane Maria et al., 1999 and so on). Among the ten monitored ravines, we shall concisely present only three.

The Căneşti 1 ravine is located 300 meters downstream of the confluence between the Slănicel and the Sărăţel, on the right slope of the Sărăţel, in the Bocu hill ("Dinspre Păcuri"). The slope (mostly used as a pasture, with the exception of the upper third part) on which the ravine appeared is affected by sheet washing processes, ravination and torrentiality on a surface of 1700 square meters.

Following certain intense deforestations that occurred at the beginning of the 90's, these processes affect the lower third part of the slope. The soil was mostly washed because of the ablation processes and, on the remaining surfaces, it is only 30 – 45 centimetres thick. The general inclination of the slope is comprised between 23 and 45º, its length being around 750 meters. In August 2002, the ravine was 249 meters long, 23 meters wide (maximum width) and 6.3 meters deep. In June 2005, the ravine was characterised by a length of 254.5 meters, a maximum width of 24.3 meters and a depth of 6.8 meters (Table 6 and Fig. 6).

In August 2008, the length of the ravine reached 259.3 meters and its width was considerable, within the confluence sector with the Sărăţel measuring 25.3 meters, with a widely open "V" profile. In the source sector there is to be found a small basin with numerous rills, which is characterised by a maximum width of 27.5 meters. The maximum depth displays values up to 7.5 meters. The altitude of the source area is 355.4 meters, while the mouth of the ravine (the Sărăţel riverbed) is situated at an altitude of 255.2 meters. The ravine follows approximately the general west – east direction.

Table 6 The average multi-annual regression of the continuous ravines between 2002 and 2008

No.	Name of the ravine	Total regression of the length of the ravine (meters)	Average multi-annual regression
1.	The Şuchea	8.6	1.43
2.	The Căneşti 1	10.3	1.72
3.	The Căneşti 2	19.5	3.25
4.	The Berca	3.4	0.57
5.	The Negoşina	14.4	2.4
6.	The Scoroşeşti	8.4	1.4
7.	The Măneştilor	7.8	1.3
8.	The Mociaru	6	1
9.	The Budeşti	10.9	1.82
10.	The La Şicari	8.3	1.38

The Scoroşeşti Ravine is located on the right bank of the Strâmbu valley, under the Pietricica Hill. From the lithological viewpoint, it is dominated by marls and clays, to which there is to be added the soil intensely affected by pluvial denudation. The ravine displays two important branches located in the upper half part, while the terminal part is intensely affected by slope processes, such as the shallow landslides. The general inclination of the slope is comprised between 18 and 25º. In 2002, the length of the valley sector down to the confluence reached 252 meters, while the right branch was 145 meters long and the left one was 151 meters long. The maximum depth reached 2.3 meters and the width of the main sector was comprised between 7 and 18 meters, depending on the slope processes. In 2005, the main sector was 252.6 meters long and the branches were 146.2, respectively 153.2 meters long. On a long part of the main sector (after the confluence), the thalweg of the ravine displays important heterogeneous accumulations that are mainly obturated by the slope contributions. In 2008, the length of the ravine down to the confluence reached 253 meters, while that of the branches arrived at 148.2 and 158.4 meters respectively (Table 6 and Fig. 6).

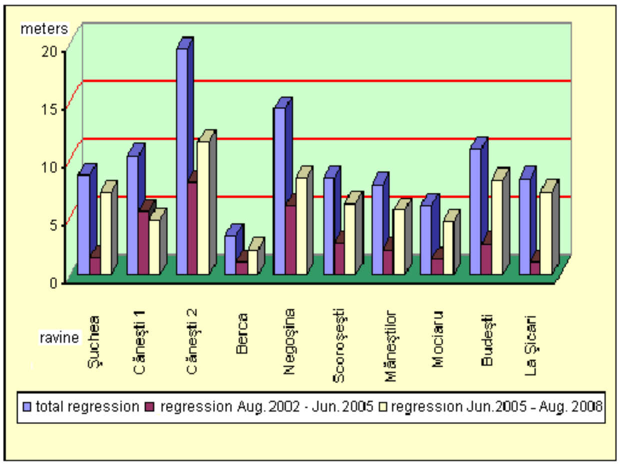

Fig. 6 The graphic representation of the ravines regression between 2002 and 2008

The main sector was 3.1 meters deep and its width varied between 7 and 25 meters. The ravine follows the general north-east – south-west direction and descends from 373.4 meters to 334.2 meters. It is worth mentioning that the thalweg is alluviated, even strongly clogged on certain sectors. The terminal sector displays narrowing parts that can reach 3 meters and are correlated with the presence of numerous knickpoints.

The Budeşti ravine is located on a cuesta escarpment (with northern orientation) that is situated on the left side of the Sărăţel (which cuts it perpendicularly) and consists of an alternation of sandstones and marls. The soil does not exist and at the upper part of the cuesta (on the structural surface), there is to be found a vegetation dominated by beech forests and pine tree plantations. The general slope of the cuesta is comprised between 25 and 35º. In 2002, the ravine was 145.2 meters long, 23.8 meters deep (maximum depth) and 82.3 meters wide (maximum width). In 2005, the length of the ravine reached 147.9 meters, while its maximum depth and maximum width were 25.5 meters, respectively 84.2 meters. In 2008, the ravine arrived at a length of 156.1 meters, a depth of 26.8 meters and a maximum width of 85.5 meters (Table 6 and Fig. 6). The ravine follows the general south-east – north-west direction and descends from 649 to 566.3 meters of altitude. It is a linear, strongly deepened ravine because of the accentuated slope, undergoing intense dynamics in spring, after the snowmelt and the periglacial action that is manifested on the cuesta escarpment since the beginning of the winter until in the early spring. The thalweg of the ravine displays numerous structural knickpoints under the form of veritable thresholds, behind which certain sandstone blocks sometimes stagnate. It becomes free of materials after the spring downpours. The banks are steep and affected by weathering through frost-thaw, which contributes significantly with materials. The ravine undergoes accentuated dynamics on its entire surface and the most important fact that must be noticed refers to the incapacity to stop its evolution.

The creep

Within the Sărăţel catchment area, there can be distinguished more areas affected by creep, among which the more evident in the morphology are located on the slopes with small and average inclination, which are developed on strata with poor forest coverage and with a varied lithology (fragments of weathered rock – marls, sandstones, limestones etc., with superficial mobile sandy-clayey deposits). During 4 years there were monitored 7 sample plots: **I** – on the eastern slope of the Botanul Hill (near Plopeasa settlement); **II** – on the eastern slope of the Botanul Hill – under the peak called La Stână (towards Gonţeşti settlement); **III** – on the northern slope of the Botanul Hill (towards Scoroşeşti settlement); **IV** – on the north-western slope of the Bocu Hill (towards Chiliile settlement); **V** – on the southern slope of the Trestioara Hill (near Trestioara settlement); **VI** and **VII** – within the Ivăneţu Ridge (near Potecu settlement, on the right bank of the Sărăţel, where two sample plots were prepared) (Table 7).

Table 7 Characteristic data of the monitored perimeters, on the creep within the Sărăţel catchment area

Perimeter /sample plot		Geodeclivity	Land use	Period and distance covered (millimetres)				Total distance covered (in mm)	Annual average speed (mm/year)
				VII 2003 – VII 2004	VII 2004 – VII 2005	VII 2005 – VII 2006	VII 2006 – VII 2007		
I	at surface	25-28°	pasture land	7	5	5	11	28	7
	at - 25 cm			-	-	-	-	15	3.75
	at about - 40 - 50 cm			-	-	-	-	10	2.5
II	at surface	15-20°	shrubs	4	6	7	5	22	5.5
III	at surface	30-35°	pasture land	9	7	6	12	34	8.5
	at - 25 cm			-	-	-	-	21	5.25
	at about - 40 - 50 cm			-	-	-	-	15	3.75
IV	at surface	35-45°	shrubs	12	10	12	13	47	11.75
V	at surface	15-20°	pasture land	4	3	4	5	16	4
VI	at surface	30-35°	rare forest	5	3	6	6	20	5
VII	at surface	35-45°	rare forest	8	5	9	11	33	8.5

Within the monitored plots, there appear numerous trees with modified trunks, phenomenon generated by the soil creep, and the monitoring would require a much longer observation period. The changes mainly occur in the rooting area of the trees, leading to the downhill inclination (in the direction of the creep propagation). These changes get accentuated with the tendency of the (growing) trees to regain their initial position, to return to the vertical one.

The inherent anomalies appeared when big mobile fragments that had been gravitationally detached during the winter - spring periods descended from the upper part of the slope.

CONCLUSIONS

Within the Sărăţel catchment, as well as in almost the entire Subcarpathian Bend space (and not only), the present geomorphologic processes undergo intense dynamics, are very diverse and are correlated with an indirect, sometimes direct, implication of the social-human activities.

During the monitoring period, within the landslides there is to be noticed a seasonal cyclicity influenced by the downpours and by the sudden snow melting.

The ravination and the torrentiality display a significant distribution, which justifies the high terrain fragmentation.

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ENDOKARSTIC RELIEF WITHIN THE NATURAL RESERVE AREA OF "REPEDEA HILL FOSSIL SITE"

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Abstract

This study aims to analyze the endokarstic relief of the reserve from Repedea Hill. Although there have been made many geological and geomorphological researches on this sector of the Moldavian Plateau, the endokarstic relief remained largely unexplored until now. The main geomorphological factor in the evolution of this type of relief is the geological substrate from which the lithological component stands out as importance. In the Repedea reserve area the thickness of the lithological association is about 10m and favourable to karstification, composed of oolitic and lumashelic limestone and sandstone. The Repedea oolitic limestone appears as a succession of layers with thicknesses of 2-40 cm separated by intercalations of fine, conchiferous sands of 0.5 - 10 cm. These resistant rock packages have conducted to the forming of a structural karst plateau called the Repedea plateau. The high position of this karst plateau from the whole relief of the studied area can be considered a determining factor for the formation of a suspended authigenic karst with vadose hydrological regime. 9 caves were mapped in the Repedea reserve area and they are located on a relatively small surface of approx. 7 ha. The total length of the mapped underground galleries is of 401 m, thus determining an average density of 5.7 km/sqkm. Unlike the Carpathian caves, in Repedea Hill, the rock type and the local hydrological characteristics do not favour the emergence of massive carbonate concretions because the caves are in a continuous process of caving. In conclusion, the endokarstic relief from "Repedea Hill fossil site" reserve is well developed, strongly differentiating from other endokarstic areas of Romania.

Keywords: *oolitic limestone, endokarstic relief, caves, Repedea Hill*

Rezumat

Relieful endocarstic din perimetrul rezervaţiei naturale "Locul fosilifer Dealul Repedea". Studiul de faţă vizează analiza reliefului endocarstic aferent rezervaţiei din dealul Repedea. Deşi asupra acestui sector din Podişul Moldovei au fost făcute numeroase cercetări de natură geologică sau geomorfologică, relieful endocarstic a rămas în bună măsură necercetat până în prezent. Factorul geomorfologic determinant în dezvoltarea acestui tip de relief este substratul geologic din care se detaşează ca importanţă componenta litologică. În perimetrul rezervaţiei Repedea grosimea asociaţiei litologice favorabile carstificării constituite din calcar oolitic, calcar lumaşelic şi gresii este de cca. 10m. Calcarul oolitic de Repedea se prezintă ca o succesiune de strate cu grosimi de 2 - 40 cm separate de intercalaţii de nisipuri fine, cochilifere de 0,5 - 10 cm. Aceste pachete de roci rezistente au favorizat formarea unui platou carstic structural numit platoul Repedea. Poziţia ridicată a acestui platou carstic faţă de ansamblul reliefului din zona studiată poate fi considerată una determinantă pentru formarea unui carst suspendat autigen cu regim hidrologic vados. În perimetrul rezervaţiei Repedea au fost cartate un număr de 9 peşteri dispuse pe o suprafaţă relativ restrânsă de cca. 7ha. Lungimea totală a galeriilor subterane cartate este de 401 m rezultând astfel o densitate medie de 5,7 km/km^2 . Spre deosebire de peşterile din Carpaţi în dealul Repedea tipul de rocă cât şi caracteristicile hidrologice locale nu favorizează apariţia concreţiunilor carbonatice masive deoarece peşterile sunt într-un continu proces de prăbuşire. În concluzie se poate afirma că relieful endocarstic din rezervaţia „Locul fosilifer Dealul Repedea" este bine dezvoltat diferenţiindu-se pregnant de alte arii endocarstice ale României.

Cuvinte-cheie: *calcar oolitic, relief endocarstic, peşteri, Dealul Repedea*

INTRODUCTION

"Repedea Hill fossil site" reserve is located at 9 km Southwards of Iaşi in Repedea Hill belonging to Iaşi Coast, at the contact between the Central Moldavian Plateau and the hilly plain of Jijia. The mathematical location of the reserve is at the intersection of the parallel of 47˚05'12" North latitude with the meridian of 27˚38'20" East longitude (Fig. 1).

The study area

The perimeter of Repedea Hill was declared a reserve since 1953, being the first geological reserve of Romania. The initial scientific reserve area was 1.9 hectares, but, in 1973, it was increased to 5.8 hectares, with a buffer zone of 38.5 hectares, with a total of 44.30 hectares. The reserve scientific area of 5.8 hectares is represented by the western and north-western slope of Repedea Hill, including the limestone walls, the former quarries (oolitic limestone), the caves and an area of the structural plateau. The buffer zone of the reserve is largely located on the Repedea structural plateau, which represents a reversed cuesta. Many Basarabian lithological outcrops which lay along the Western and North-Western steep of the hill are protected within the scientific reserve and contain a rich and representative Sarmatian fossil deposit, representative for the Moldavian Platform. The value of this reserve is amplified by the fact that **Grigore Cobălcescu** (1862) accomplished the first geologic study of these limestones in the paper „***Calcariul de la Răpidea”***, thus writing the first page in the history of Romanian geology.

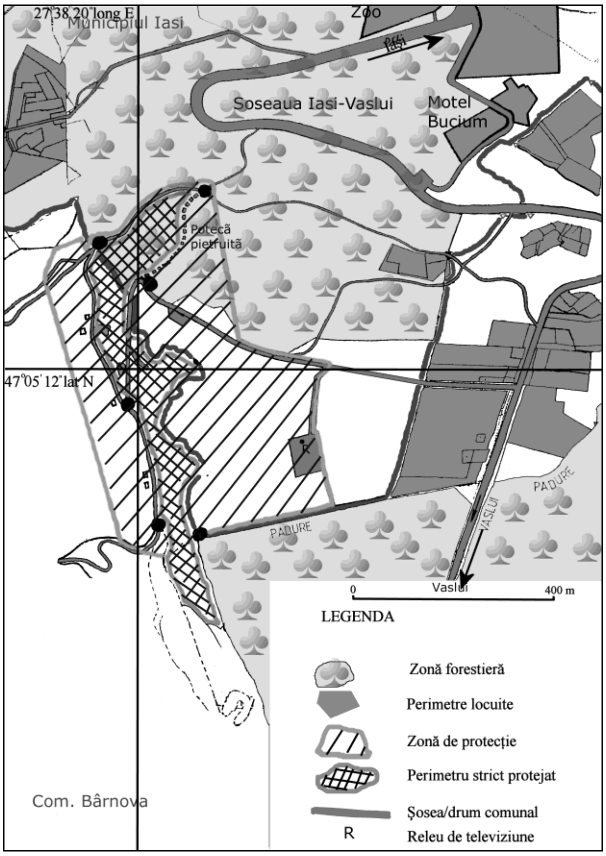

Fig. 1 The geographical location of „Repedea Hill fossil site” reserve

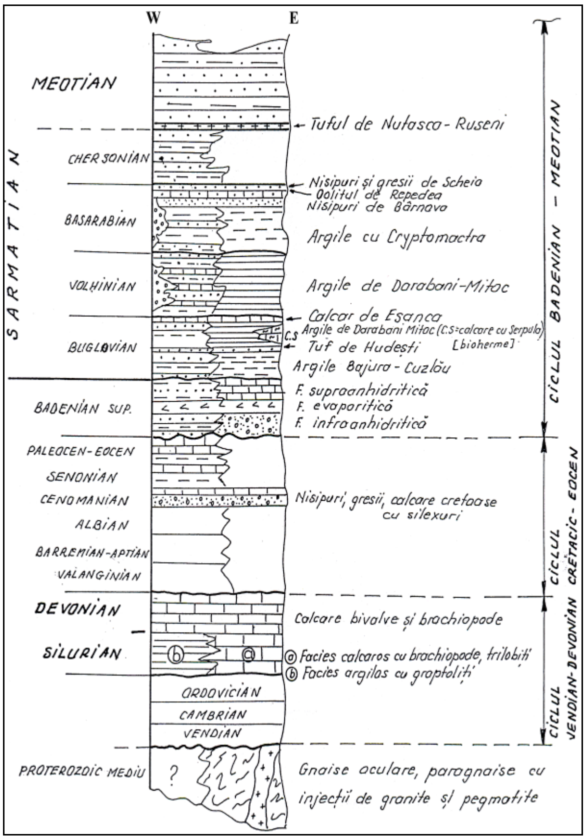

Fig. 2 The lithologic succession of the Moldavian Platform (after M. Brânzilă, 1999)

DATA AND METHODS

The methodology used in this study is based on the following steps:

- the analysis of the existing bibliographic and cartographic materials;
- geomorphologic field mapping;
- topographical mappings of the caves;
- using the "Toporobot” speological software for creating the cartographic materials of the caves.

RESULTS AND DISCUSSIONS

The main objective of this study concerns the analysis of the endokarstic relief of Repedea Hill reserve. The geological substrate, from which stands out as importance the lithological component is the determinant geomorphological factor in the development of this type of relief. The lithology of the reserve belongs to the last cycle of sedimentation within the Moldavian Platform, formed of Basarabian sediments. The entire cuesta escarpment from Repedea Hill has altitudes up to 310 m in its lower part, on a complex of clays and marl rocks with intercalations of fine sands known as "the layers with Cryptomactra pesanseris” (Fig. 2). A complex of sands overlaps above these, at altitudes ranging between 310 and 377m, on which there are oolitic limestones and sandstones with Mactra Podolica. In the reserve area, the thickness of the lithological association consisting of oolitic limestone, lumashelic limestone and sandstone is about 10m (Fig. 3).

The Repedea oolitic limestone appears as a succession of layers with thicknesses of 2-40 cm separated by intercalations of fine, conchiferous sands of 0.5 - 10 cm. The layers have irregular

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surfaces, noticing a gradual transition from limestone or compact oolitic sandstone to the same rocks, increasingly porous and brittle up to interstratificated sands.

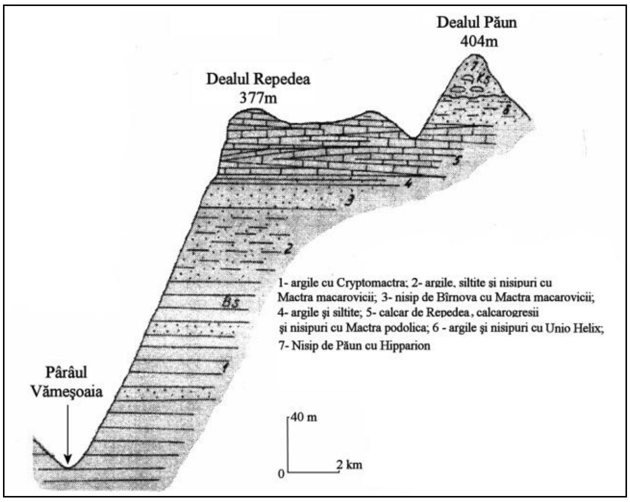

Fig. 3 Geological profile through Repedea Hill (processed after L. Ionesi, 1994)

An alternation of levels is noticed in the upper part of the succession, made up of lumashelic limestone with mactra, mixed oolitic–conchiferous limestones and oolitic limestones, grouped cyclically. The rocks layers are crossed by a system of differential compaction cracks with rough surfaces, filled with fine sand (I. Kalmar, 1991).

The bioclasts are particularly important for this protected area, which are represented, according to their frequency, by fragments of bivalves, benthic foraminifers sometimes complete with lodges filled with calcite. Small gastropods and tubes of worms are seldom seen. The bioclasts have different sizes, ranging from a few centimetres (mactrea, cents, Solen) to 0.05- 1.00 mm.

In the lithologic substrate of the Repedea reserve, the oolites are represented in varying proportions, from 5 to 85%, they have spherical shapes, rarely ovoid or irregular and do not exceed 0.4 mm in diameter. In most cases, the oolites are simple and centered on the sand.

Oolites also appear seldom, with two or three centers successively unified and covered by common layers increasingly closed, having spherical shape. Inside the oolites, a core can be distinguished, but also at least two to ten concentric layers of fine granular, filamentous calcite (oomicrite).

From a petrographical point of view, a generic term was issued for these rocks - the Oolite of Repedea; in fact, several varieties may be recognized when using this term.

Thus, based on chemical analysis it was found that 38% of the predominantly oolitic rocks are mostly grouped into the category of dolomitic calcareous sandstones and less into sandy limestones (Kalmar, 1991).

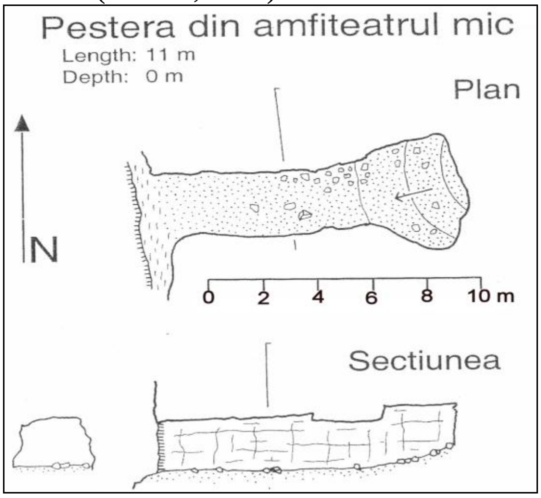

Fig. 4 The cave plan and section from the Small Amphitheatre

In what concerns the genetic process of oolites, Kalmar (1991) notes that the pure chemical precipitation of Calcium carbonates can not take place in environments with low alkaline reserve. The same author promotes the supposition that a primary pellicle of green - blue algae is installed around future cores, respectively around the granules of different compositions which assimilate, through photosynthesis, the carbon dioxide from water and the soluble bicarbonates, precipitating monogranular calcium carbonate alongside with the accretion of carbonate or non-carbonate material. In this way, a filamentous layer of sedimentation will be formed, with a thickness of 5 to l0 microns, which will stifle the algal colony installed around the core-grain. This layer will be the support of a new colony of algae, which continues the precipitation activity, the phenomenon being repeated until reaching a critical sized-form in relation to environmental tension, whereafter the multilayer corpuscles are either deposited or disaggregated. Gradually, the accumulated oolites are invaded by calcite crystals with radial disposition that will become the cement of constitution, filling the voids and forming the oolitic limestone.

In comparison with other varieties of limestone, the Repedea limestone is much more friable, having a resistance to compression from 140 to 269 kgf/cm^3 (Table 1).

In terms of geological structure, the layers of sedimentary rocks from Repedea Hill substrate have an inclination of less than 0.5 degrees, on a NNW-SSE direction.

The relief of Repedea reservation is the result of the external agents modelling the geological substrate having a monoclinal structure derived from the old Sarmatian plain of marine accumulation. Thus, subsequent to the withdrawal of the Sarmatian sea, the area was primarily subject to river erosion exerted by the new installed catchement.

Table 1 The physical-mechanical characteristics of Repedea oolitic limestone compared with some rocks within the Carpathian area (Chelărescu et al. 1956)

Petrographic types	Specific weight g/cm^3	Resistance to compression kgf/cm^3	Content in carbonate %
Tithonic Limestone	2691	963	90-99
Doamna Limestone	2700	1500	53-65
Tarcău sandstone	2770	1448	-
Repedea limestone	2690-2730	140-269	77

The fluvial geomorphological system of the area has evolved so far, noticing the formation of the subsequent valley of the Bahlui, which withdrew Southwards, forming the steep slope of Iaşi Coast, which corresponds to the cuesta escarpment. This cuesta escarpment cuts off the layer's heads of rocks from the stack of Basarabian sediments to the upper part, where the oolitic limestones and Repedea sandstones outcrop (Fig. 3).

The evolution of the catchment was carried out in parallel with large slope processes which evidenced the morphological effect of the monoclinal arrangement of the geological layers and the maintenance in relief of the sectors where the more resistant rocks outcrop (oolitic and lumashelic limestones etc.). These packages of resistant rocks favoured the formation of a karst structural plateau called Repedea plateau.

The high position of this karst plateau as compared to the entire relief of the studied area can be considered a determining factor for the formation of an authigenic suspensive karst with a vadose hydrological regime. The water coming from rainfalls enters the soil covering the karst plateau, with a vertical downward direction (within the vadose area) until it intercepts the packages of limestone from where the penetration into depth is directed by the network of litoclases (cracks) that affect the packages of lumashelic and oolitic limestones.

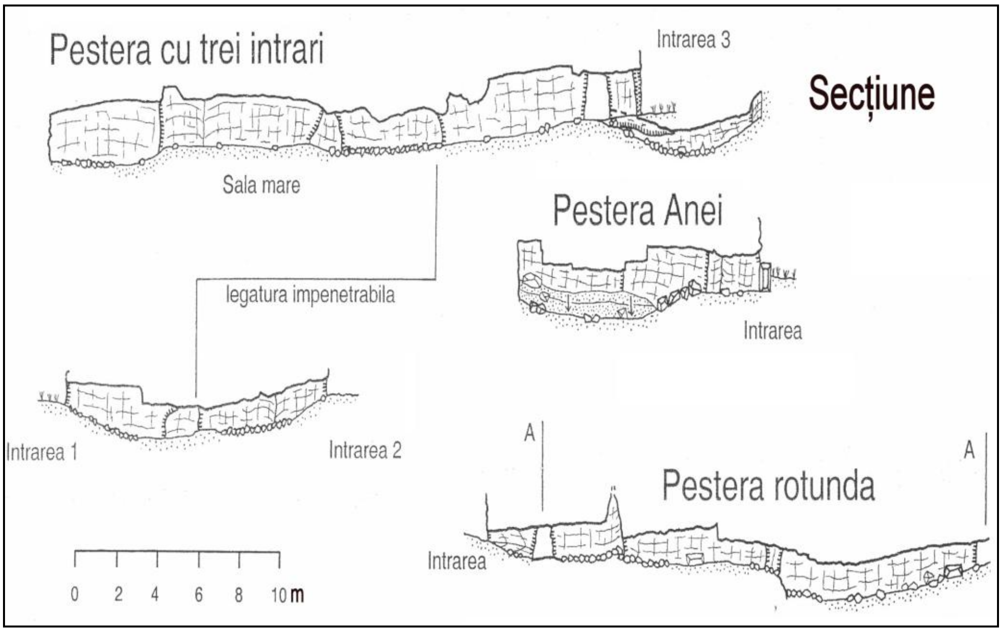

Fig. 5 The longitudinal topographical section of: the Cave with three entrances, the Round Cave and Ana's Cave

Near the slope corresponding to the escarpment of the cuesta, the limestone packages are affected by an additional network of fissures that had appeared due to the gravitational traction specific to slopes. The fissures of gravitational traction which are oriented parallel to the line of the slope are better developed and have directed the overall development of underground galleries (Fig. 7).

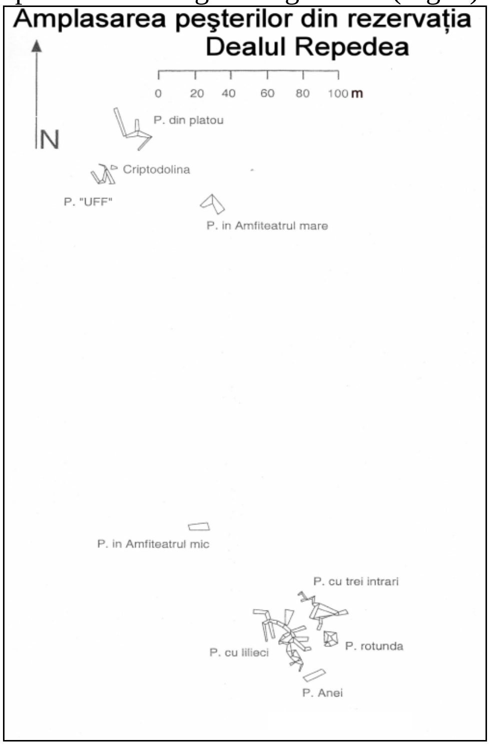

Fig. 6 The caves location from Repedea Hill reserve

Regarding the underground galleries from Repedea Hill there were and still are some discussions about the names of the grottoes or of the caves. No longer insisting on the etymology of the word *grotto*, we reproduce some views about the definition of the cave in the following.

The cave is any natural void found within the crust of the Earth (M. Bleahu, 1982).

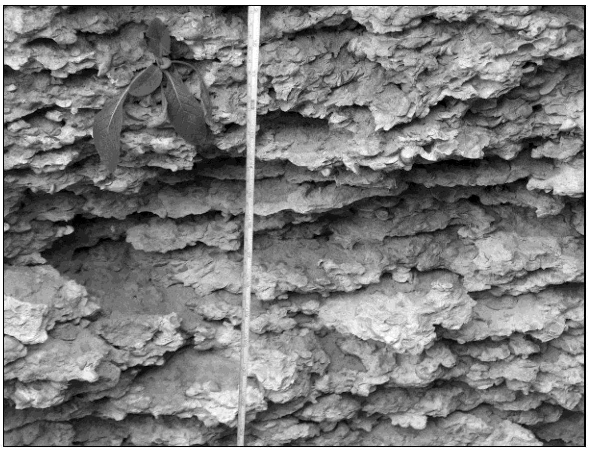

Fig. 7 Lumashelic limestone and sands (lithologic layer in which there are formed the Repedea caves)

According to the law of protected areas in 2001, the cave's definition is the following: "*The cave is a cavernament of natural geomorphological origin, whose dimensions give the interior an absolute obscurity*". A completion can be added to this definition, which singularizes the concept of *cave* with a broader sense: "*For an underground void to be considered a cave, the minimum length should be of 5 meters and the width or height should not exceed the length*." Given the opinion of most professionals in the spelaeology domain on the concept of *cave*, we believe that all the natural underground voids from Repedea reserve area fall into the generic category of caves.

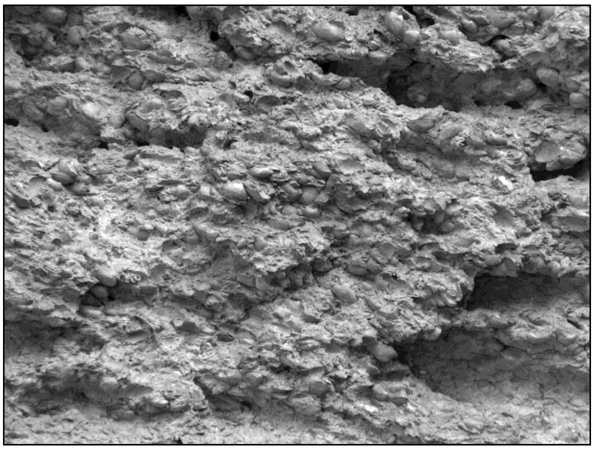

Fig. 8 The compact lumashelic limestone (the lithologic layer which limits the vertical development of the caves)

In Repedea reserve area, 9 caves were mapped, located on a relatively small surface of approx. 70 000 sqm, resulting a density of karstic holes (number of caves/ surface to be karstic) quite high compared to other karst regions of Romania in 2007: 2.32 caves/sqkm in the Occidental Carpathians; 1.92 caves/sqkm in the Meridional Carpathians, 1.22 caves/sqkm in the Oriental Carpathians and only 0.09 caves/sqkm in Dobrogea.

Fig. 9 Bats hibernating in the Cave with bats

In what concerns the density of the underground karst network (the length of the galleries / the surface to be karstic), it can be stated that on a karstic area of seven hectares the full length of the mapped underground galleries is of 401 m, resulting a density of 5.7 km/sqkm.

This density value is very high when compared with the maximum values of the Occidental Carpathians where, the density of the underground network is of 1.4 km/sqkm in the upper catchment of the Someşul Cald.

Fig. 10 Minor carbonate concretions

The peculiarity of the karstic relief’s evolution within this area is given by the infiltration of the water from rainfalls in the network of cracks and fissures, which affect the packages of carbonate rocks. The water currents concentrating on certain alignments operate by removing the sand (from the rock arrangement), contained within the rock packages, thus resulting in centimetre-sized underground voids. Under the effect of gravity, the tiny packages of carbonaceous rocks within the stratification with the sands that were washed collapse, thus enlarging the underground galleries.

The vertical development of these galleries is limited by the thickness of the lithologic packages that favour the karstification. Taking into consideration the mapping carried out on all caves in Repedea karst plateau, the observation that resulted is that most galleries have heights ranging from 2 to 3 m, except for the Cave with Two Entrances from the Great Amphitheatre having heights up to 4-5 m.

This development that exceeds 4 m vertically is mainly caused by a diaclase of gravity traction, oriented towards NNW-SSE, which favoured the caving in of a large quantity of lumashelic limestone from the compact layer of approximate 2 m thickness, situated above the stratified package formed of limestone and sand, where the cave has developed (Fig. 4 and 5).

The best developed endokarstic network within Repedea Hill belongs to the Cave with Bats totalizing 160 m length and a 6 m difference of level (Fig. 8 and 9).

The name of this cave is due to the presence of nine species of bats in the galleries, all belonging to the Vespertilionidae family (Fig. 13). The network predominantly grows on NNW-SSE direction, parallel to the slope nearby and has a rectangular layout, caused by the intersection of gravity traction diaclases with the litoclases of tectonic evolution within the area.

In some cases, large rooms can be formed through processes of caving, whose area can exceed 100sqm (The Cave within the Plateau) (Fig.16).

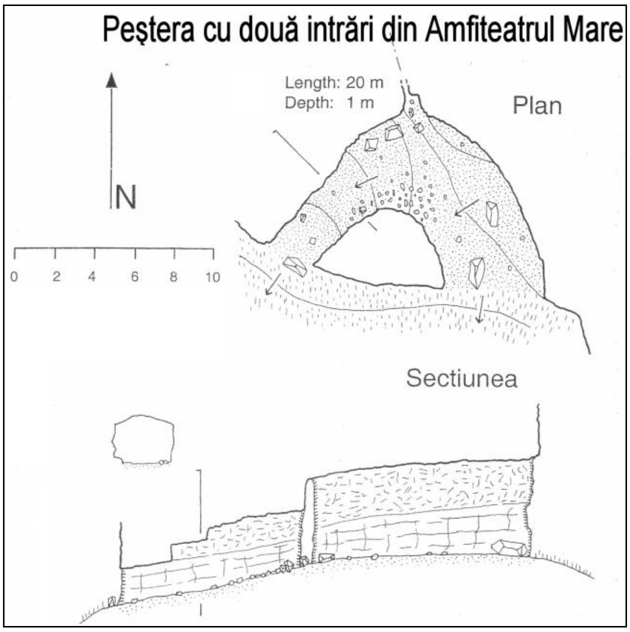

Fig. 11 The plan and the section of the cave within the Great Amphitheatre

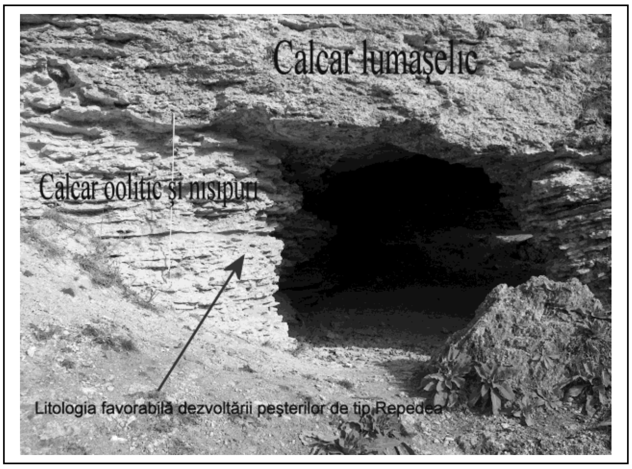

Fig. 12 Limestone alternating with sands, a favorable substrate for cave formation

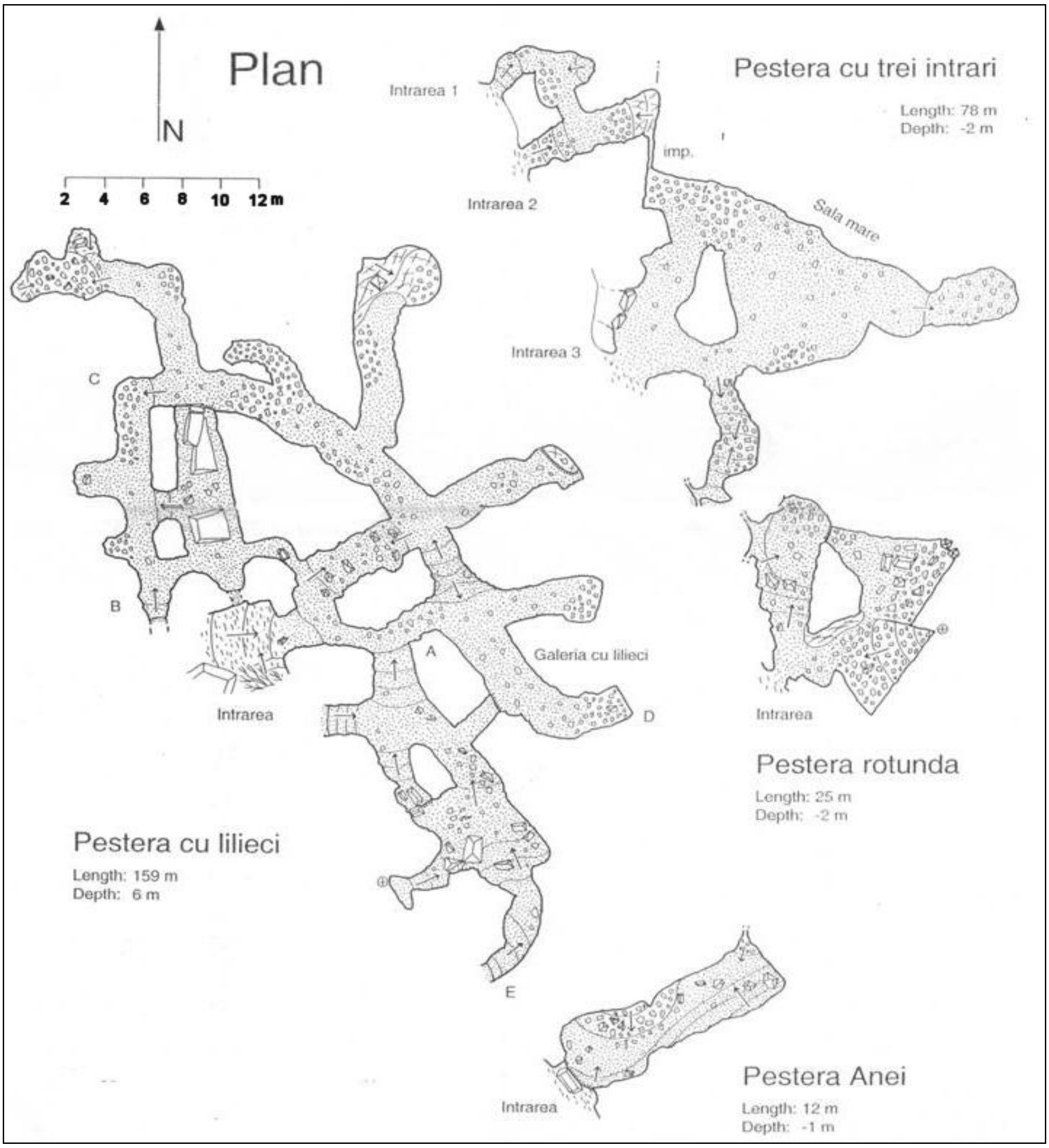

Fig. 13 Topographic plans of the caves:
The Cave with Bats, The Three Entrance-Cave, The Round Cave and Ana's Cave

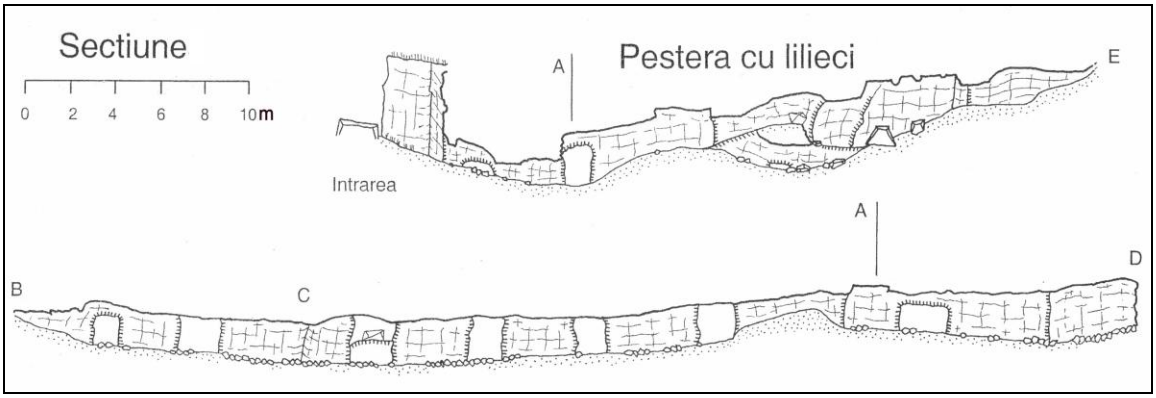

Fig. 14 The longitudinal topographical section of the Cave with Bats

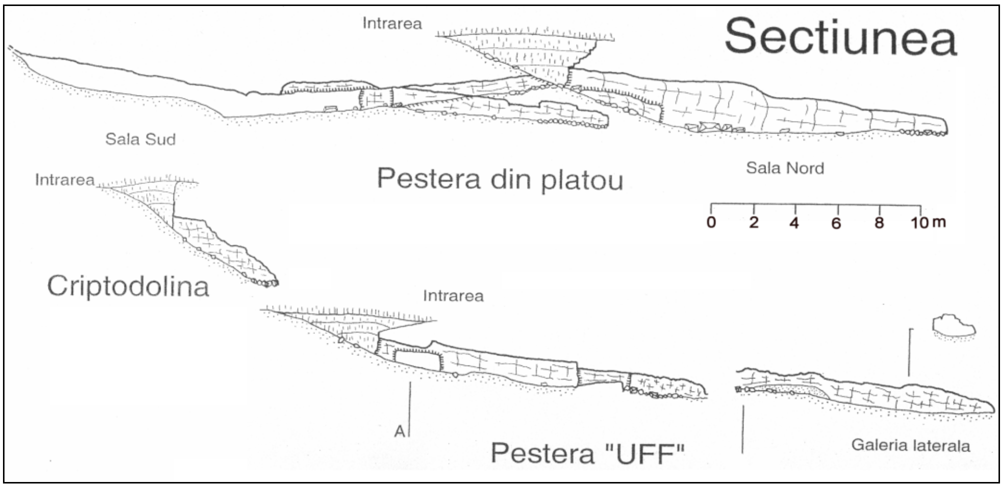

Fig. 15 The longitudinal topographical sections of: the Cave within the Plateau, Criptodolina and the UFF Cave

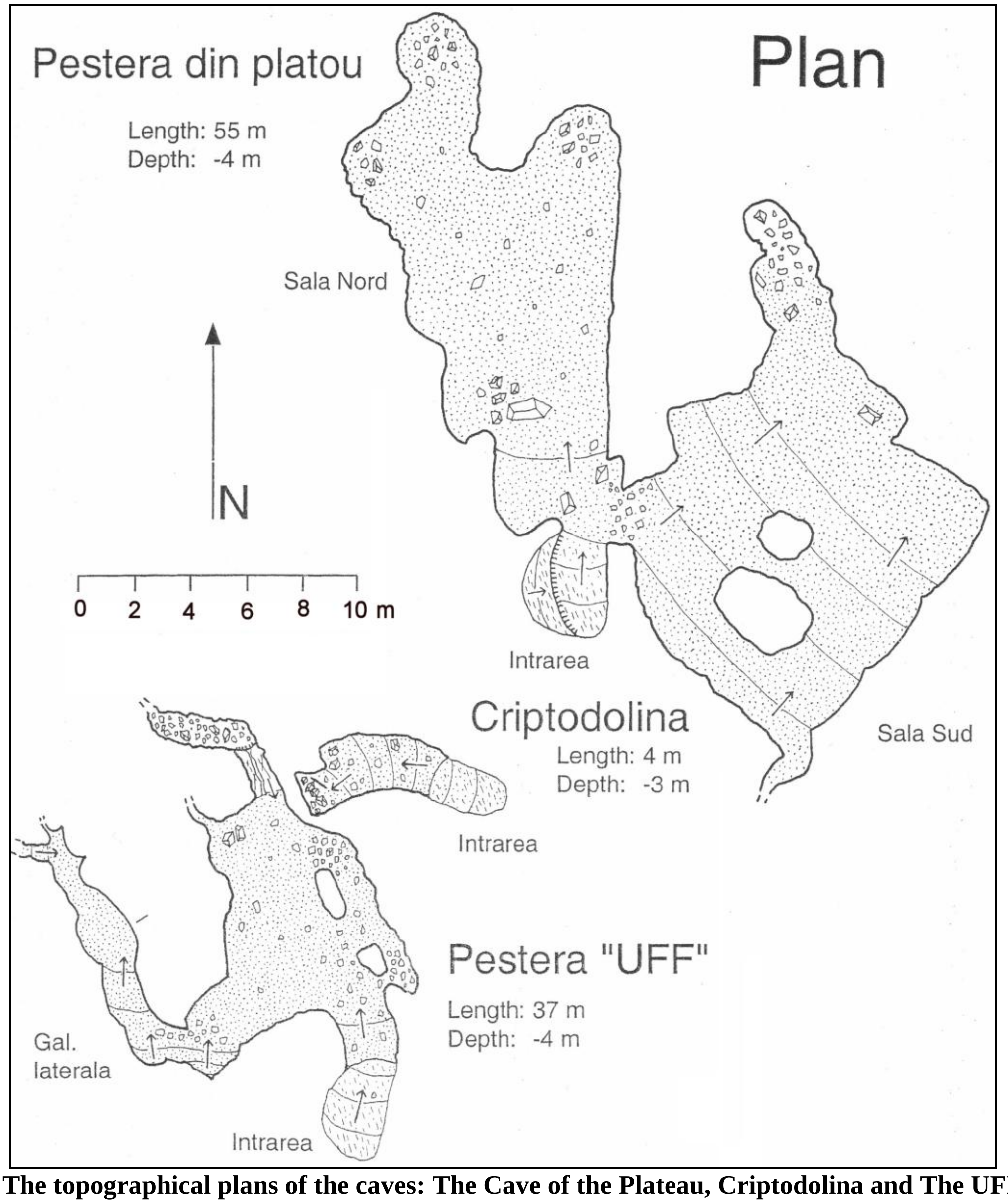

Fig. 16 The topographical plans of the caves: The Cave of the Plateau, Criptodolina and The UFF Cave

It is noteworthy that most of the cave entrances were opened by the regressive evolution of the slope which confines the Repedea karst plateau, while the rest of the entrances have been opened by a series of cavings affecting some dolines existing at the edge of the plateau (The Cave within the plateau, Criptodolina and the Uff Cave), (Fig. 16).

The morphology of the underground galleries is represented by the appearance of broken rock caused by caving.

The walls are uneven, with fragments of lumashelic limestone on the verge of being broken, in intercalations with horizons of slightly moist sand. Unlike the Carpathian caves, formed in massive limestone that allow the formation of speleothemes, at Repedea, the rock type and the local hydrological characteristics do not represent a premise for the emergence of massive carbonaceous concretions; in some places, there are some calcite concretions formed on some ceilings, but which are not maintained for long because the caves are in a continuous process of caving (Fig. 14).

The cave floor is composed of incasion detritus, consisting of sands and clays with a thickness of up to 0.5 m, in which angular fragments of limestone are embedded.

The Caves of Repedea are endokarstic formations which did not receive the erosive action of water, always remaining fossil galleries. The formation of the caving debris is primarily physical, a series of chemical processes contributing to these.

CONCLUSION

In conclusion, the genesis of the karstic relief within Repedea plateau area is highly dependent on three local physical-geographical factors:

- lithological (the presence of limestone packages in tight alternation with layers of fine sand);
- tectonic-structural (the existence of a network of cracks related to the tectonic evolution of the region and gravity traction diaclases);
- hydrological - geomorphological (processes of erosion and dissolution exerted as an effect of vadose water infiltrating in the rock mass).

Given both the particularities of the karstification conditions and the morphology of the karst specific to this protected area, there can be observed that the resulted endokarstic relief differs significantly from other karst areas in Romania.

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ASSESSMENT OF SOIL FERTILITY MANAGEMENT PRACTICES AND THEIR CONSTRAINTS IN DIFFERENT GEOGRAPHIC LOCATIONS OF NEPAL

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Abstract

A farmers' field survey was conducted in 2009 to evaluate soil fertility management practices and their constraints in certain hill and valley farming systems of Nepal. Thirty households from Okharpouwa village development committee (VDC), Nuwakot and thirty households from Fulbari VDC, Chitwan districts were surveyed using semi-structured questionnaires. In addition, key informants' interview, checklist survey, observation in the field and documentation of the individual cases were carried out during this research. The study revealed that farm yard manure (FYM) was the major source of nutrients, although the use of poultry manure, goat manure, green manure and chemical fertilizers was also common. We realized that the management of FYM and that of other types of organic manure in the manure pit and in the field was not efficient in conserving nutrients. Similarly, farmers preferred the continuous cultivation of cereal or commercial crops, without mixing the crops or rotating with legumes, the sliced terrace risers in hills, which constrained better production in hills and valleys of Nepal. The specific problems in hills included erosion and leaching of nutrients, soil acidification, while those of valley lands included the imbalanced use of fertilizers, intensive cropping, and crop failure due to improper management.

Keywords: *soil productivity, erosion, farm yard manure, crop management, soil degradation*

Rezumat

Evaluarea practicilor de management al fertilității solului și constrângerile acestora în diferite locaţii din Nepal. În anul 2009 a fost realizat un sondaj cu fermierii pentru a evalua practicile de management al fertilității solului şi constrângerile aferente în sistemele agricole din anumite zone de deal şi de vale din Nepal. La anchetă au participat treizeci de gospodării din comitetul rural de dezvoltare (CRD) Okharpouwa, districtul Nuwakot şi treizeci de gospodării din CRD Fulbari, districtul Chitwan, fiind folosite chestionare semi-structurate. În plus, pe parcursul cercetării au fost realizate interviuri cu furnizorii-cheie de informaţii, anchete prin liste de control, observaţii în teren şi documentări asupra cazurilor individuale. Studiul a evidenţiat faptul că îngrăşământul natural de fermă (ÎNF) a constituit principala sursă de nutrienţi, deşi folosirea gunoiului de la păsări, de la capre, a celui vegetal şi a fertilizatorilor chimici a fost, de asemenea, comună. A fost înţeles faptul că managementul ÎNF şi al altor tipuri de îngrăşământ natural în groapa de gunoi şi pe câmp nu este eficient pentru conservarea nutrienţilor. În mod similar, fermierii au preferat cultivarea permanentă a cerealelor sau realizarea culturilor comerciale, nefiind realizate culturi amestecate sau rotaţii cu legume, şi terasările în zona de deal, ceea ce a limitat producţiile agricole superioare din dealurile şi văile nepaleze. Problemele specifice din arealele deluroase au inclus eroziunea şi pierderea nutrienţilor, acidificarea solului, în vreme ce dificultăţile specifice zonelor de vale au inclus folosirea dezechilibrată a îngrăşămintelor, culturile intensive şi pierderile agricole determinate de managementul necorespunzător.

Cuvinte-cheie: *productivitatea solului, eroziune, îngrăşământ natural de fermă, managementul culturii, degradarea solului*

INTRODUCTION

Nepal is facing a serious problem of soil quality decline as a result of recent changes in agricultural practices and increasing resource constraints. Hartemink et al. (2008) documented several constrains in soil fertility management in Nepal because of deforestation and other land use changes. These changes include non-agricultural uses of fertile land, land fragmentation and cultivation in marginalized areas, cultivation on the slopes, overgrazing, burning of crop residues, imbalanced use of agrochemicals, and declining use of organic manure. In South and South-East Asia, the principal soil degradation processes associated with land use changes include accelerated erosion by water and wind, salinization, flooding, water logging, and soil fertility depletion (Jacinthe et al., 2004). The pace of soil degradation issue is the highest in mountains because of the fragile environment and the steep slopes (Acharya and Kafle, 2009; Rasul, 2009). Moreover, due to rugged mountainous topography, active tectonics and concentrated monsoon precipitation, Nepal is naturally highly vulnerable to soil erosion on slopes and flooding in the low-lands.

Continuous cultivation without addition of substantial amount of soil organic matter (SOM) in rugged hilly terraces causes the sharp decrease in SOC and nitrogen (Shrestha et al., 2006). It is reported that Nepal needs to increase the production of major crops to provide food for rapidly growing population (Gami et al., 2001). However, deterioration of soil by erosion, nutrient mining and fragmentation caused a decreasing trend in soil fertility (Tripathi et al., 1999). Farmers realized that continuous application of chemical fertilizers, without addition of FYM, resulted into soil degradation and ultimately, productivity decline (Mathema, 1999). The low technical knowledge of farmers regarding these problems and resource-constraints to adopt rational management practices aggravated the problems of land degradation and soil fertility deterioration in Nepal.

Crop and livestock integrated farming is common in Nepal. However, recent changes in technologies and knowledge of farmers, increasing resource constraints and decreasing availability of manpower brought significant transformations in soil fertility management practices. More profit-oriented production, with limiting resources, diverted the farming practice toward mono-cropping and reduced the number of livestock per farmer, which served as a continuous source of FYM needed for farm-crops (Shrestha et al., 2000). This further deepened the problems of soil fertility degradation and productivity decline, requiring a big leap on soil management technologies to feed mushrooming population and to meet their changing demands. Thus, we designed a study to assess the existing soil and crop management practices in the hill and valley (plain) agriculture of Nepal and the problems associated with them; this assessment provides a basis for the understanding of the possible management options for better soil fertility and increased land productivity.

DATA AND METHODS

The study was conducted in Fulbari village development committee (VDC) of Chitwan and Okharpauwa VDC of Nuwakot district, Nepal (Fig. 1). Chitwan represents the valley land system of Nepal, which has tropical to sub-tropical climate with a total annual rainfall of 2666.3 mm. The annual mean minimum and maximum temperatures are 7.5ºC and 36.4 ºC, respectively. Three-fourths of the district area are on a valley, well-known as Rapti-Dun valley, with high agricultural potential. The district is the producer of cereals (paddy, wheat, and maize), vegetables (seasonal, as well as off-season), oilseeds, legumes, fruits, and flowers. In contrast to Chitwan, Okharpauwa VDC of Nuwakot represents the mountain land system. The district has temperate to sub-alpine climate, with the average annual rainfall of 1431 mm, the maximum temperature of 26.6ºC and the minimum temperature of 6.3 ºC. Due to the climatic diversity that goes from sub-tropical to alpine, the different parts of the district are famous for evergreen to temperate fruits, vegetables (both on season and off-season), being especially recognized for the strawberry and ginger production. The major staple food crops grown in the district include rice, maize, wheat, millet, and potato (CBS, 2010).

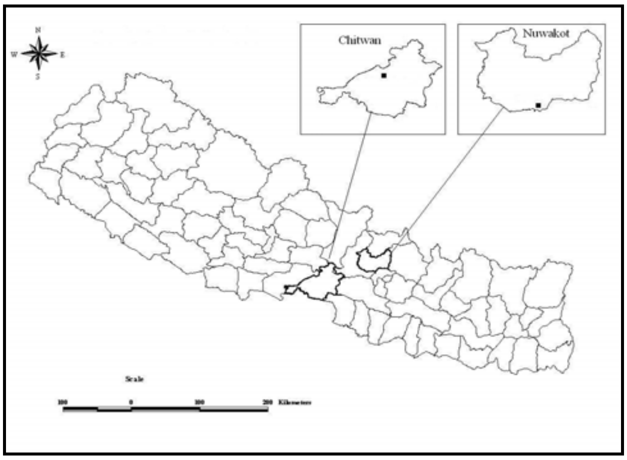

Fig. 1 Study locations in the Chitwan and the Nuwakot Districts, Nepal

Literature survey was used to select the study locations that comprised diverse land uses, notably influencing the crop productivity and the ecosystem sustainability. Information regarding soil fertility and crop management practices was recorded from the questionnaire survey of 30 households in both districts (sixty households in total). We developed several questions about the source of manure and fertilizers, manure storage and application methods, crops they grow and crop management practices associated with soil fertility. Specific questions related to slope management were developed for Nuwakot, as it was not a common problem on the valley soils of Chitwan. Similarly, checklist survey, key informants interview, focal group discussion, documentation of successful cases and direct observation in the field were used to evaluate the soil fertility management system of the study areas. We used semi-structured questionnaires for the checklist survey. The objective of the documentation of individual cases, key informants interview, and assessment in the field was to know the specific crop and soil management practices in the study location. The collected data pertaining to soil, crop and fertilizer management was coded and tabulated for computer entry and analyzed by descriptive as well as inferential statistical tools, using statgraphics plus 5.1 (Statpoint Technologies Inc.) and SPSS-16 (http://spss.en.softonic.com/) statistical packages.

DISCUSSIONS

Farm yard manure and poultry manure as source of nutrients

Soil fertility management involves soil and nutrient management operations that have direct relation with the nutrient supplying capacity of soils. Farm yard manure (FYM) is the primary source of nutrients and serves as the major means for soil fertility management in Nepal (Suresh et. al., 1999). Traditional subsistence farming in Nepal includes integration of crops and livestock in a single management structure (Neupane and Thapa, 2001) that provides FYM needed for the crops and forage needed for livestock. Thus, all farmers in Chitwan and Nuwakot used FYM to their crops, irrespective of the location or the agricultural land use types. However, there are many other sources of SOM common in the Nepalese farming (Table 1), which are based on the availability of source material and the technical know-how of the farmers.

Table 1 Number of farmers using different sources of organic manure (data presented as frequency of total survey population; survey, 2009)

Sources of Organic manures	**Frequency used by farmers (percent)**	
	Nuwakot (n=30)	**Chitwan (n=30)**
Farm Yard Manure	100	100
Poultry manure	73	83
Biogas slurry	0	75
Green manure	20	58
Compost	6	25
Fish pond manure	6	-
Goat manure	80	33
Commercial organic fertilizer	0	8

Use of poultry manure was also common in Chitwan (83 percent) and Nuwakot (73 percent) farming. This is developing as an alternative of FYM in Nepalese agriculture, as poultry industry is growing all over the country and, thus, availability of poultry manure is also increasing. The third source of manure includes goat manure. Raising few goats and local poultry breeds (hens + ducks) was the heritage in Nuwakot. Hence, 80 percent of them used the goat manure in their farms, though in small quantity. Chitwan farmers, on the other hand, used biogas slurry as a useful manure source in their agriculture, but goat farming was not common like in Nuwakot.

Green manure and other sources of nutrients

Green manure was the important source of organic manure in our study districts. Farmers grow green manure crops during spring and turned them into soil in situ to supply manure for crops in the rainy season. Farmers also practice the use of green leaves collected from forest and of alleyways as green leaf manure. The popularly grown green types of manure we documented in Chitwan were Dhaincha (*Sesbania aculeate*), Sunhemp (*Crotalaria juncea*), Til (*Sesamum indicum*), and less popularly Lentil (*Lens esculenta*) and Cowpea (*Vigna catjang*). Certain common green types of manure used in Nuwakot were Sunhem (*Crotalaria juncea*), Titepati (*Artemisia vulgaris*), Asuro *(Adhatoda vasica*), Siris (*Albizia lebbek*), Cowpea (*Vigna catjang*), Banmara (*Eupatorium adenophorum*), Velvet bean (*Mucuna sp*.), and Bhatmase (*Flemengia congesta*).

We also documented individual farmers using urine, wood ass, vermicompost, oilseed cakes, kitchen wastes and swine manure as a source of soil organic matter in their farms. Some farmers in Nuwakot turned the runoff channels from forest toward their farm, so that it carried down the nutrient rich forest litter, which supported the maintenance of soil fertility in the area. Use of compost tea, vermicompost and fish-pond compost as sources of organic manure was also recorded in the study area.

The evaluation of the sources of the organic manure used in the survey area allowed us to further investigate the crops getting priority on receiving these types of manure. The amount of manure used in crops varied on the survey sites and on the crops grown on these sites (Table 2); however, Chitwan farmers applied larger quantities of manure than Nuwakot farmers. They applied the highest quantity of FYM (19.0 $Mg.ha^{-1}$) and poultry manure (5.72 $Mg.ha^{-1}$) in vegetables, followed by rice and other cereals, whereas Nuwakot farmers applied the maximum quantity of FYM (2.86 $Mg.ha^{-1}$) in strawberry, followed by cereals and vegetables. The application of poultry manure was low for strawberry and no for other crops in Nuwakot. This difference by locations and by priority of farmers to different crops was due to the inequality in the economic value of that particular crop in the nearby market, the availability of manure, and the dissimilarity in socio-economic condition of farmers to afford the production cost.

Table 2 Types of organic manure and their amount used in the major crops of Nuwakot and Chitwan, Nepal (Field survey, 2009)‡

Location	Nuwakot				Chitwan			
Sources of organic types of manure*	Major crops				Major crops			
	Paddy	Wheat	Maize	Fruits	Paddy	Wheat	Maize	Vegetables
FYM ($Mg.ha^{-1}$)	1.71 ±0.34	0.59 ±0.08	1.48 ±0.11	2.86 ±0.06	3.97 ±0.42	2.04 ±0.18	3.15 ±0.24	19.06 ±6.26
Poultry ($Mg.ha^{-1}$)	0	0	0	0.86 ±0.12	1.23 ±0.17	4.53 ±0.42	4.43 ±0.22	5.72 ±1.85

*Values after ± indicate standard error

‡We included data of FYM and poultry manure, as they were the two major types of organic manure; other types of manure were used in negligible quantity, although they were common.

Farm yard manure preservation and application in the field

The time of organic manure application and the method of its preservation in manure pits plays an important role in its nutrient availability. The common practice in Nepal is that farmers bring organic types of manure, mainly FYM, during late winter to early spring for showing seeds after the first monsoon shower, which is not desired, from nutrient management perspective. Leaving the manure for long time in small heaps facilitates the loss of nutrients either by volatilization or leaching. More than 55 percent of the Nuwakot farmers followed that practice, which allowed maximum loss of nutrients from manure heaps either by sun or leaching by heavy down power in early monsoon (Fig. 2). Chitwan farmers were more aware of these negative consequences of early manure application in the field and only 21.5 percent of them followed that practice, not knowing the negative effects. Knowledgeable farmers followed the application of manure at the time of planting and incorporated it in soil, which was common in Chitwan (78.5 percent). Leaving manure exposed in the direct sunlight causes volatilization and oxidation of nutrients and leaching of dissolved ions (Schilke-Gartley and Sims, 1993) during summer rains. Carrying manure to the field at the time of planting and mixing it immediately with soil, on the other hand, reduces the loss of nutrients.

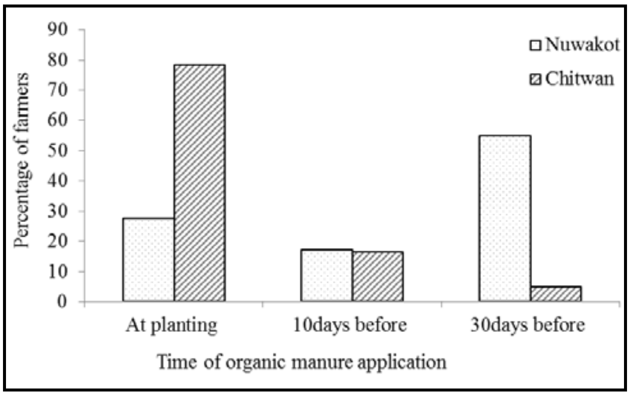

Fig. 2 Percentage of farmers bringing organic manures in the field in Nuwakot (N = 30) and in Chitwan (N = 30) (Field survey, 2009)

The loss of nutrients from the manure heap is also a common problem in Nepal. Farmers leave manure in the open heap for a long time, allowing nutrients to be lost either by sun or by rain. More than 93 percent of the farmers in Nuwakot followed the traditional method of manure piling in open piles (Fig. 3). Chitwan farmers were better in realizing the importance of manure preservation than Nuwakot farmers. One third of the survey farmers preserved manure heaps from sun light and/or rain either by making shade or by using plastic cover. The improved heap or pit method of FYM preparation, along with improved cattle sheds made by farmers helped reducing the nutrient loss from manure pits, which better supported the growth of the corps. Well decomposed FYM supplies 0.5 percent N, 0.2 percent P_2O_5, and 0.5 percent K_2O (Gaur et al., 1995), whereas FYM prepared by the improved method in heaps or pits can supply 2-3 times more nutrients than the ordinary manure and supports better yield of crops.

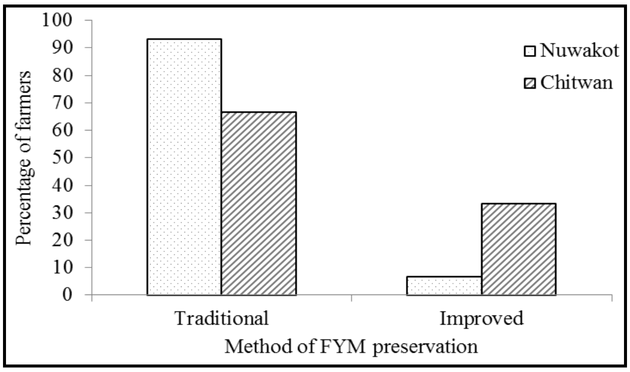

Fig. 3 Percentage of farmers adopting different methods of FYM preservation in Nuwakot (N = 30) and in Chitwan (N = 30), Nepal (Field survey, 2009)

Crop management and rotations

Most of the agricultural land in Nepal is rain-fed or furrow irrigated during the rainy season and crop water management is beyond the control of farmers. More than 66 percent of the farm area in Nuwakot was rain-fed (bari) and 33 percent was irrigated only during the rainy season (khet land). The bari land was less in Chitwan (20 percent), as compared to Nuwakot. Thus, exhaustive dry land crops dominated Nuwakot farming. The major crops grown in the study area, in Nuwakot were maize, wheat, rice, millet, potato, and strawberries. However, farmers were more focused on strawberry production because of the emerging market opportunities in Kathmandu, in last 10-15 years. Chitwan, on the other hand, had more irrigated area and rice was the primary crop. Winter maize and wheat, vegetables and legumes like pea, beans and lentil were also common crops in Chitwan.

An appreciable aspect of the traditional farming system in Nepal is that they include legumes as a part of the cropping system. However, with the increasing need of cereals as staple food, the amount of legume use has been reduced in recent years. Many farmers (47.8 percent) in Nuwakot did not include legume in their rotations; however, including legumes in the farming system was relatively higher (66.7 percent) in Chitwan. Slicing terrace rises, growing non-legume non-bushy crops and outward facing slopes in Nuwakot resulted into removal of fertile top soil during the swift monsoon rain (Table 3). Besides, more than 87 percent of the Nuwakot farmers were attracted toward commercial strawberry cultivation. Hence, they prepared the vertical outward-sloping terraces to facilitate the harvest of strawberries, a higher number of plants per unit area, the maximum efficiency in the use of sunlight, the easy weed control and easy drainage of water. However, the terraces vertically built on the slopes are prone to erosion by water, resulting into particulate, as well as dissolved nutrient losses. MOEST (2006) estimated that, out of the total agricultural land in Nepal, 2.969 million ha (10 percent) are under degradation due to poorly managed terraces. Our study revealed a similar kind of problem in the Nuwakot hills.

Table 3 Crop and soil management practices in Nuwakot and Chitwan, Nepal

Practices	Nuwakot (n=30)	Chitwan(n=30)
Routine soil analysis	26.7 percent	46.7 percent
Burning crop residue	80 percent	53.3 percent
Canal irrigation	33.3 percent	80 percent
Use of legume in crop rotation	46.7 percent	66.7 percent
Slicing of the terrace riser	86.7 percent	-

Routine soil analysis and chemical fertilization

Understanding the fertility status of soil helps farmers to design the rational fertilizer management plan. However, traditional farming relied on the soils' inherent capacity and limited availability of farm manure and fertilizers. The farmers in the study districts did not analyze their soil for the nutrient status, the crop need and they did not care about the soil nutrient balance of the system. Our survey regarding the evaluation of crop and soil management practice (Table 3) to maintain soil fertility revealed that less than 50 percent of the farmers analyzed their soils for the nutrient status. The Nuwakot farmers sliced the terrace risers and burnt or removed farm residues to make seed bed free of insect pest and diseases. However, burning or removing crop residue from field seriously depletes SOM (Lal, 2005) and, thereby, the nutrient supplying capacity of soils. This leads to the low soil fertility and crop productivity. Tiwari et al. (2010) reported that up to 90 percent of the nutrient loss occurred from the crop harvest could be recovered through incorporation of 30 percent or more crop residues back into soil.

Commercial chemical fertilizers like Urea, Diammonium Phosphate (DAP) and Muriate of Potash (MOP) were also common in the hill and valley farming system in Nepal. The most commonly applied chemical fertilizer is urea, followed by DAP. The use of micronutrient sources for crops is not very common in Nepal, except in some commercial crops. The farmers intuitively know that secondary and micronutrients released from soil are sufficient to meet the crop need whatever the crop is. The amount of different fertilizers applied in various crops in the study area is presented in table 4.

Table 4 Chemical fertilizers used in different crops in Nuwakot and Chitwan

Location	Nuwakot				Chitwan			
Inorganic manures*	Major Crops				Major Crops			
	Paddy	Wheat	Maize	Fruits	Paddy	Wheat	Maize	Vegetables
Urea (Kg/ha)	18.31 ±1.36	13.73 ±2.71	12.91 ±2.70	51.25 ±1.94	46.20 ±3.16	57.95 ±2.55	52.60 ±4.32	16.00 ±3.91
DAP (Kg/ha)	12.90 ±0.92	11.89 ±0.80	10.69 ±2.48	27.52 ±1.83	35.70 ±2.90	73.85 ±3.72	66.85 ±2.88	30.90 ±7.39
MOP (Kg/ha)	0	0	0	16.01 ±0.77	27.70 ±2.31	23.85 ±2.25	25.35 ±2.25	33.35 ±8.19

***Values after ± indicate standard error**

Chitwan farmers applied a larger amount of chemical fertilizers than Nuwakot farmers, but the average rate was below the National recommendation in both locations. Wheat in Chitwan and strawberries in Nuwakot received the higher amount of urea, as compared to other crops. Besides the major nutrients, few commercial vegetable growers of Chitwan applied borax 20-60 $kg.ha^{-1}$ and wood-ash to their crops. Synchrony of nutrient supply with crop demand is essential to ensure optimum crop yield and to avoid negative environmental impacts (Grant et al., 2002). However, farmers did not realize the fact and they applied the fertilizers recklessly, which gradually deteriorated the soil and added other associated problems.

Major soil fertility management constraints

Given the fact that Nepal is diverse from the agro-ecological viewpoint, the management strategies for soil fertility also vary in order to deal with niche specific problems. The farmers' response on the soil fertility management problems from Nuwakot hills and Chitwan valley (Table 5) indicated that soil loss and crop damage by erosion and landslide were the major problems in Nuwakot and imbalanced/excessive use of chemical fertilizer was the most grieving issue in Chitwan.

Table 5 Ranking constraints of soil fertility management in Chitwan and Nuwakot

S.N.	Constraints	Famers' response (percent)	
		Nuwakot (n=30)	Chitwan (n=30)
1	Top soil removal and crop damage by erosion	50	-
2	Increasing soil acidity by chemical fertilizer	20	44
3	Intensive cultivation	-	26
4	No sufficient supply of fertilizers	12	-
4	Lack of government support	10	17
5	Others	8	13

The high soil erosion and the acidity problem in Nuwakot might be due to the increasing attraction of the farmers towards the high value crop ‘strawberry’ in outward sloping terraces. These allowed soil to be washed from the surface by monsoon rains and the nutrients to leach from the terraces during belowground water movement. The strawberry plants flourish well in acidic environment below pH 6.5 and support in further acidification of the soils. However, if they are grown in high pH soils, some of the micronutrients become unavailable with increasing soil pH above 7 (Kassel, 2003). Thus, the acidifying nature of the strawberry plant, the poor cultural practices and the higher doses of chemical fertilizers might have caused the increasing acidity on these soils. The growing use of chemical fertilizers, especially of urea, caused soil acidity in Chitwan. Other problems we documented include exhaustion of soil by intensive cultivation, lack of technical support from government and low knowledge-base of farmers.

CONCLUSION

The study conducted in the Chitwan plain and in the Nuwakot hills revealed that the soil fertility management system involved traditional methods of soil and crop management and relied maximally on the available local resources. FYM was the main source of SOM and nutrients for the major crops, although there were many other sources and considerable differences in the amount of fertilizers applied in the fields. The Chitwan farmers had better idea of the soil and crop management than the Nuwakot ones and they were found to apply more manure and fertilizers in their crops than the Nuwakot farmers. However, there are several constraints like erosion, soil acidity and faulty management practices, which are caused by the low technical knowledge and resource compulsions and which hindered better soil fertility management in hills and valleys of Nepal.

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ECOCLIMATIC INDEXES WITHIN THE OLTENIA PLAIN

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Abstract

The Oltenia Plain represents an important agricultural region of Romania, which displays vast surfaces that can be properly cultivated if one takes into account the climatic restrictions that generates a series of dysfunctions. In order to underline the problems related to the aridization tendency within the region, as well as to determine the most adequate plants, there were calculated many indexes used in different agroclimatic and biogeographical studies. Thus, according to the processed data, the Oltenia Plain generally belongs to the steppe and forest steppe domain and, with regard to the cultivable plants, there are recommended the thermophilous and xerothermophilous ones, which can get good productions even in the pluvial-thermal conditions characteristic to the region. The thermal regime imposes itself through a slight increasing tendency because of the extremely high values registered in summer, while the pluviometric regime registers obvious fluctuations and a decreasing tendency. Consequently, the issue related to the aridization of the southern part of the Oltenia Plain is confirmed, an issue that is presently stressed by other factors, such as massive deforestation, destruction of the irrigation systems etc., which led to the reactivation of certain areas covered by sands. However, the partial results of the study do not sustain the idea of desertification in the area.

Keywords: *the Oltenia Plain, ecoclimatic indexes, pluvial-thermal regime, aridization, thermophile plants, xerothermophilous plants*

Rezumat

Indicii ecoclimatici din Câmpia Olteniei. Câmpia Olteniei reprezintă o importantă regiune agricolă a ţării, care dispune de vaste suprafeţe cultivabile, care pot fi exploatate în cele mai bune condiţii dacă se iau în calcul şi restricţiile climatice care generează o serie de disfuncţionalităţi. Pentru a evidenţia problemele legate de tendinţa de aridizare a regiunii, precum şi pentru a determina cele mai adecvate plante de cultură s-au calculat mai mulţi indici folosiţi în diferite studii agroclimatice şi biogeografice. Astfel, conform datelor prelucrate, Câmpia Olteniei se încadrează în general în domeniul stepei şi silvostepei, în privinţa plantelor de cultură recomandându-se cele termofile şi xerotermofile, care pot da producţii bune chiar şi în condiţiile pluvio-termice caracteristice regiunii analizate. Regimul termic se impune printr-o tendinţă de creştere uşoară datorată valorilor foarte ridicate din sezonul cald, în timp ce regimul pluviometric înregistrează fluctuaţii evidente, tendinţa fiind însă de scădere. Astfel, se confirmă problema legată de aridizarea sudului Câmpiei Olteniei, problemă acutizată în ultimul timp şi de alţi factori, precum defrişările masive, desfiinţarea sistemelor de irigaţii etc., care au dus la reactivarea unor areale acoperite de nisipuri. Cu toate acestea, rezultatele parţiale obţinute prin prelucrarea datelor nu susţin ideea deşertificării.

Cuvinte-cheie: *Câmpia Olteniei, indici ecoclimatici, regim pluvio-termic, aridizare, plante termofile, plante xerotermofile*

INTRODUCTION

The Oltenia plain represents the western extremity of the Romanian Plain, which is bordered by the Danube River in the west and south and by the Olt River in the east. The northern limit is sinuous, as the contact with the Getic Piedmont follows the alignment of certain settlements, such as Drobeta-Turnu Severin, Hinova, Vânju-Mare, Drincea, Pleniţa, Radovan, Podari, Balş, Slatina (Roşu, 1980, p. 430).

The Oltenia Plain was in many subunits according to different criteria – different morphostructural features, biological-pedological-climatic peculiarities etc. Thus, P. Coteţ divided the plain into three large subunits according to the way "these three individualities associate" (the Oltenia Plain is the result of the combination between two interfluves, which are genetically linked to the Getic Piedmont, and the Danube couloir) "as well as according to the constitutive elements of a plain (the plain itself, the terrace and the alluvial meadow)" (Coteţ, 1957, p. 54). Al. Roşu also mentioned three subunits the limits of which were similar to the ones previously established by P. Coteţ, but it named them differently – Blahniţa Plain, Băileştilor Plain, and Romanaţi Plain (Fig. 1).

This sector is well individualized as compared to the other sectors of the Romanian Plain because of a series of morphostructural elements. It is a typically piedmont-like plain, where all the valleys, including the Danube's, display well-developed systems of terraces. Its main feature is the presence of sand dunes, which covers almost half of the surface of the plain. The presence of the dunes is extremely important from the climatic point of view as sandy soils impose a series of restrictions. Within these areas, the precipitation amount is relatively low and the temperatures quite high, especially in summer; thus, due to the physical-chemical features of the soil the water deficit must be covered through irrigation.

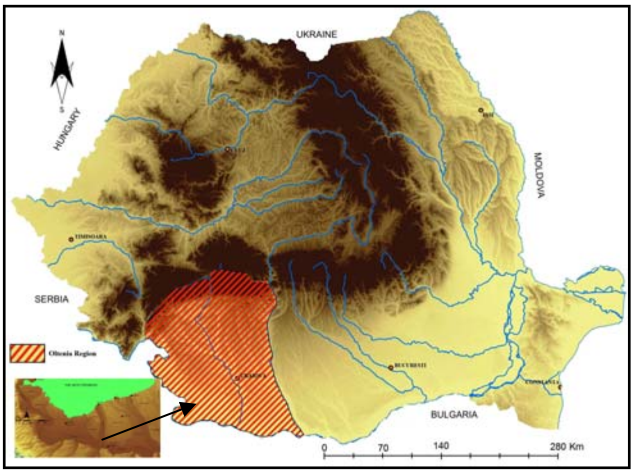

Fig. 1 Location of the Oltenia Plain within Romania and Oltenia region

In the south of the plain, there is located the Danube's Valley and Floodplain, which develops between Gura Văii and the Olt River, covering a distance of 335 kilometers. The landforms of the alluvial meadow underwent numerous modifications induced by the action of natural factors, such as the fluvial and aeolian processes, which are still quite active, and especially of the man-induced factors, as this area was highly schemed (Tomescu, 1998, p.19). Besides the terrace system, we mention the presence of the eyots (Ostrovu Mare, Dragavelu etc.) and of the lakes (Gârla Mare, Maglavit, Ciuperceni, Rast, Bistreţ etc.) within the alluvial meadow the width of which oscillates between 4 and 13 kilometers (Geografia României, vol. I, 1980, p. 347).

All features of the subjacent active surface influence the features of the main climatic parameters. The Oltenia Plain is an important agricultural region and the land use and the cultivated plants should take into account the evolution tendency of precipitation, temperature, humidity, evaporation etc.

DATA AND METHODS

The data correspond to the period 1984-2009, a problematic period from both the thermal and pluviometric points of view and they were supplied by Craiova Regional Meteorological Center. There were analysed five meteorological stations: Drobeta Turnu-Severin, Calafat, Bechet, Băileşti, Craiova, Caracal, and Slatina (Table 1).

The climatic ecometric indexes can offer important information for the adequate capitalization of the agricultural fields by taking into account the local climatic features.

Mayr tetratherm represents the arithmetic mean of the temperatures registered in May, June, July, and August.

$$T_{Mayr} = \frac{\sum(t_V + t_{VI} + t_{VII} + t_{VIII})}{4}$$

It emphasizes the thermal optimum of the vegetation during the period characterized by a maximum biological activity. Its values increase as the altitude decreases.

Table 1 The geographical position of the meteorological station

Station	Altitude (m)	Latitude	Longitude
Dr. Turnu-Severin	77	44°38`	22°38`
Bechet	36	43°47`	23°57`
Calafat	61	43°59`	22°57`
Băileşti	57	44°01`	23°20`
Craiova	192	44°19`	23°52`
Caracal	106	44°06`	24°22`
Slatina	172	44°26`	24°21`

"De Martonne" aridity index is calculated both for annual and monthly values. For annual values, it is used the following formula:

$$I_a = \frac{P}{T+10} \text{ where,}$$

P – the annual amount of precipitation

T – the mean annual temperature

10 – a coefficient that is added in order to obtain positive values

This index was firstly used by De Martonne, E. (1926). It is used for emphasizing the restrictive character of the climate with regard to certain vegetal formations: values ≤5 correspond to desert areas, those close to 10 to the steppe areas, those above 30 indicate the forest steppe area, while the values ≥40 the forest areas (Gaceu, 2002, p. 69; Dumitraşcu, 2006, p. 156). At the same time, there can be deduced a series of thermal and pluviometric features of a region, as well as certain peculiarities of the river system (Gaceu, 2002, p. 70).

Lang rain index, also called the pluviothermal index, indicates the atmospheric moisture degree, as well as its variation; it can be calculated at an annual, summer or vernal level (Gaceu, 2002, p. 70; Dumitraşcu, 2006, p. 155). It increases with the altitude up to the condensation level, as the precipitation amounts get bigger and the temperature lower.

$$I = \frac{p}{t}$$ where,

p – the annual precipitation amount

t – the mean annual temperature

The sum of precipitation in the months when the mean temperature is higher than 10ºC refers to the total amount of precipitation registered during the vegetation period. Within the Oltenia Plain, this sum corresponds to the sum of precipitation registered during the warm season, as the mean monthly thermal values are higher than 10ºC during seven months per year (April-October).

The sum of precipitation during the cold season of the year represents the total water quantity resulted from both liquid and solid precipitation. It is an important index as it underlines the water accumulation in the soil, water that can be used by the vegetal formations at least during the first phonological phases (Gaceu, 2002, p. 74).

The sum of the precipitation amounts during the maximum consumption period represents the precipitation amount corresponding to the interval July-August, when there are also registered the highest thermal values.

DISCUSSIONS

1. Mayr tetratherm is used in different agroclimatic studies being an important index for determining the most important crop plants according to the thermal optimum. As it can be noticed, the thermal means registered obvious fluctuations in the last 30 years, the values oscillating between 18 and almost 24°C. At the same time, there is a clear tendency of increase of the values after 1990. The 22°C threshold was frequently exceeded at the level of the entire analysed region, the years with the highest values being 2000, 2003, and 2007 (22.6°C and 23.9°C) (Fig. 2).

According to these values, within the Oltenia Plain, there are recommended heat-loving plants (thermophilous and xerothermophilous), which can adapt to high temperatures and drought conditions characteristic especially in the last years.

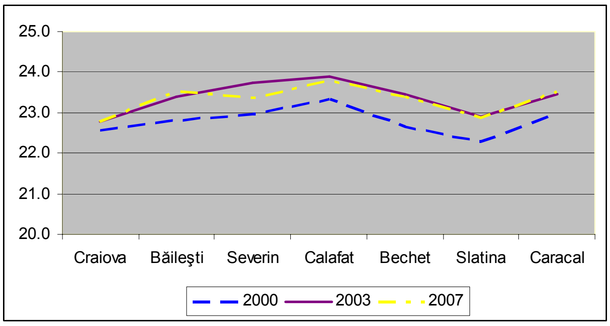

Fig. 2 Mayr tetratherm values within the Oltenia Plain in 2000, 2003, and 2007

With regard to the spatial distribution of the Mayr tetratherm values, the differenced are quite reduced, both from north to south and from east to west, which is not extremely surprising if we take into account that the altitudinal differences are not relevant and the surface is quite homogenous, as well as the exposure to distinct climatic influences. However, there is a slight difference from north to south, meaning that the most homogenous and the lowest values registered at Craiova, in the north, where the 22°C threshold was exceeded only in 2000, 2003, and 2007. As we go southwards, the values increase, the same tendency being noticed from east to west because of the intensification of the southwestern influences. The multiannual mean values are very homogenous, oscillating between 20.9 at Craiova and 21.9 at Caracal.

2. "De Martonne" aridity index eloquently emphasizes the features of the vegetal cover. Its mean annual value is relatively homogenous (Table 2). Thus, the highest mean values are registered in the western and northern parts of the plain, namely at Drobeta Turnu-Severin and Craiova (above 28), while the lowest values correspond to the southern part of the plain (Bechet, Calafat, Caracal – about 23) (Fig. 3). These mean values indicate that the analysed region belongs to the dry steppe, which is real problem for agriculture.

Table 2 Mean values of "De Martonne" aridity index

Station	"De Martonne" aridity index
Dr. Turnu-Severin	28.47
Bechet	23.10
Calafat	23.96
Băileşti	24.86
Craiova	28.09
Caracal	23.38
Slatina	25.51

By analyzing the annual values of this index, it resulted great variations, especially after 1998, the differences between 2000 (values below 15), for example, and 2005 (values above 38) being of about 30. In the central and eastern sides of the plain, the highest values correspond to 2005, while in the west to 1999. Thus, in 2000, the highest value was registered at Craiova, but it did not exceed 16, while the lowest correspond to Băileşti, 11.96. In 2005, even if there were registered the highest values, there should be noticed a great difference from north to south, namely from 52.77 at Craiova to 38.65 at Bechet.

The territorial differences are clear, meaning that in the western and northern sides, the aridity index displays high values underlining the passage towards forest steppe as compared to the southern and eastern sides, where the values are lower. Here, together with a slight decrease of the precipitation amounts and with a visible deterioration of the precipitation pattern, there occurred an increase of the mean monthly temperatures, which makes the aridization and even the desertification issue be one of great importance.

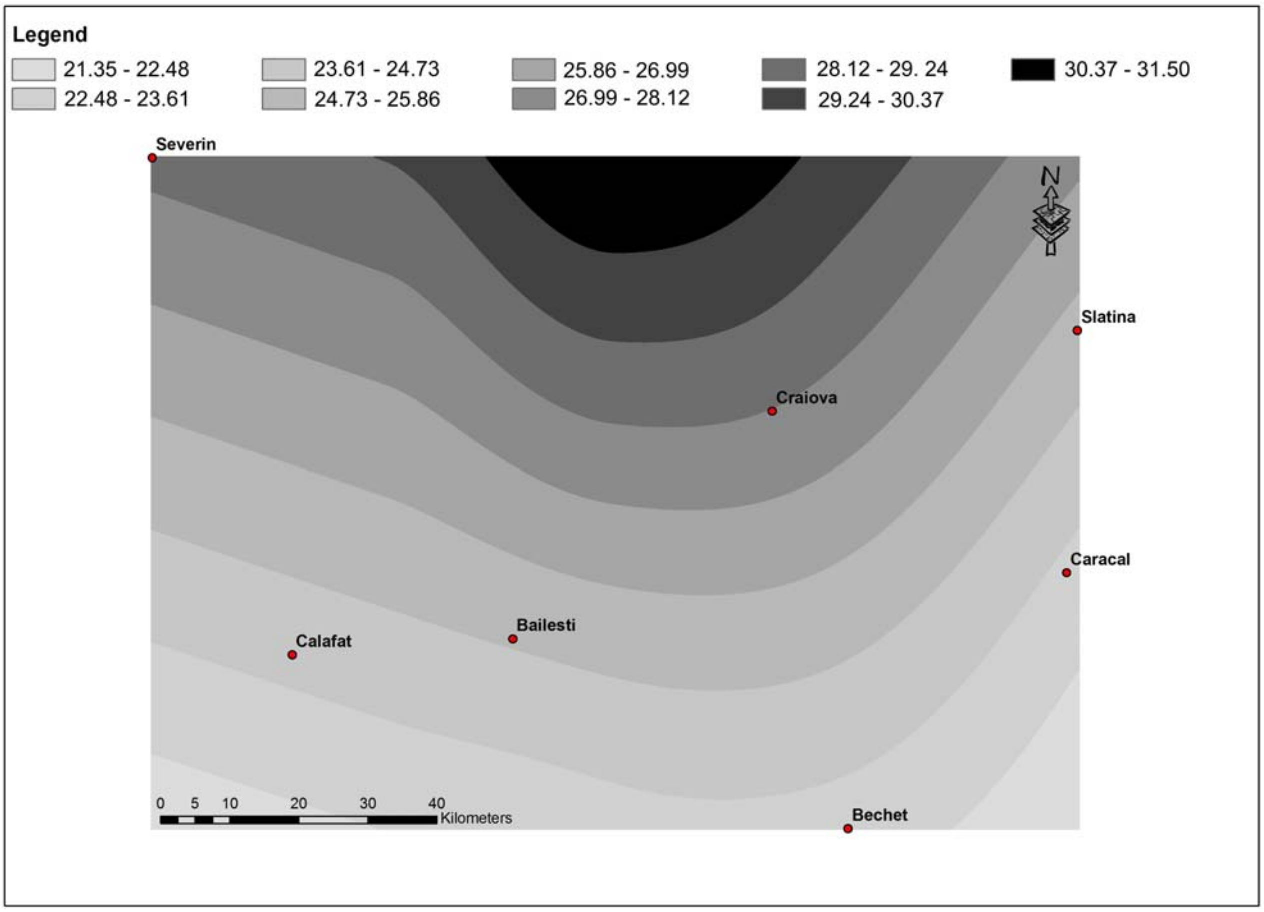

Fig. 3 Territorial distribution of the mean values of "De Martonne" aridity index (1984-2009)

3. Lang rain index (pluviothermal index) or the pluvial factor displays higher values with the increase of the altitude. Thus, within the Oltenia Plain, according to the altitude, the highest values correspond to the northern and western sides, while the lowest ones to the Danube Valley and to the central part of the plain. At Craiova, the annual mean reaches 53.55, while at Drobeta Turnu-Severin, it is 52.15. These values are 10 units higher than in the south (Calafat – 44.26, Bechet 43.32), where they do not exceed 45 units (Fig. 4), which certifies the favorability of the region to thermophilous and xerothermophilous species. As for the evolution during the analysed period, we also mention the years 1992 and 2000 with extremely reduced values (in 2000, the highest value was only 27.12 at Craiova, the rest of the values being lower), while the year displaying the highest values is by far 2005 (103.2 at Craiova, this value being about 30 units higher than at the other meteorological stations).

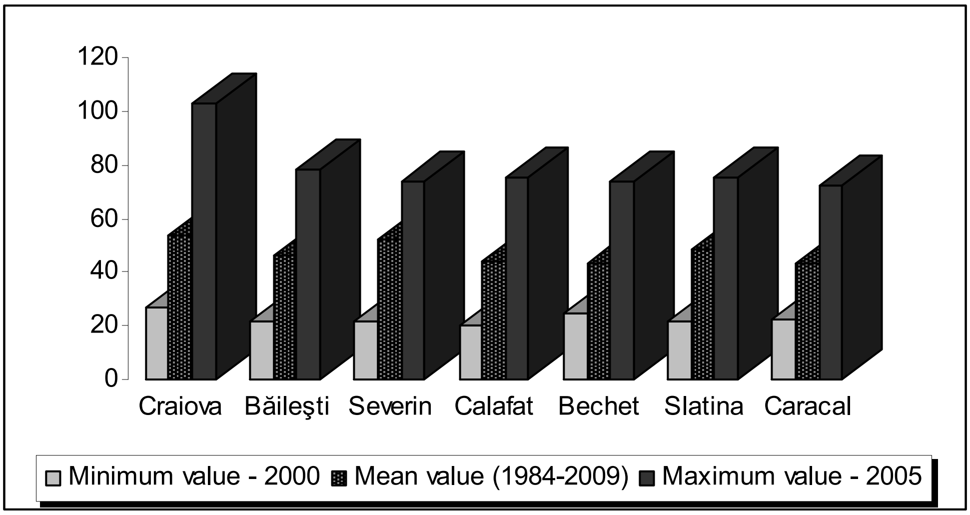

Fig. 4 Lang rain index (1984-2009)

4. The sum of precipitation in the months when the mean temperature is higher than 10ºC refers to the precipitation amount registered during the vegetation period. As within the analysed region the interval with monthly temperatures above 10ºC is of seven months, the precipitation amount corresponding to this interval represents more than 60 percent of the mean annual amount. These amounts are higher than 300 mm within the entire plain, but they are not enough for supporting the optimal development of the culture plants and this is why irrigation is a necessity, especially in July and August, when temperatures exceed 22ºC (Table 3, Fig. 5). For example, sun flower needs an optimum water quantity of 650 mm during the vegetation period, even if we can get good productions at 400-450 mm, maize about 400 mm, sugar beat 400-600 mm. The main issue is the great temporal variability of precipitation: Craiova – 220.1 mm in 1992 and 802.2 mm in 2005; Băileşti – 172.2 mm in 1993 and 614.6 mm in 2005; Drobeta Turnu-Severin – 186.3 mm in 2000 and 704 mm in 1999; Calafat – 183.2 mm in 1984 and 568.2 mm in 2005; Bechet – 162 mm in 1993 and 613.8 mm in 2005. There can be also mentioned the fluctuations from one month to another, which are extremely important for agriculture.

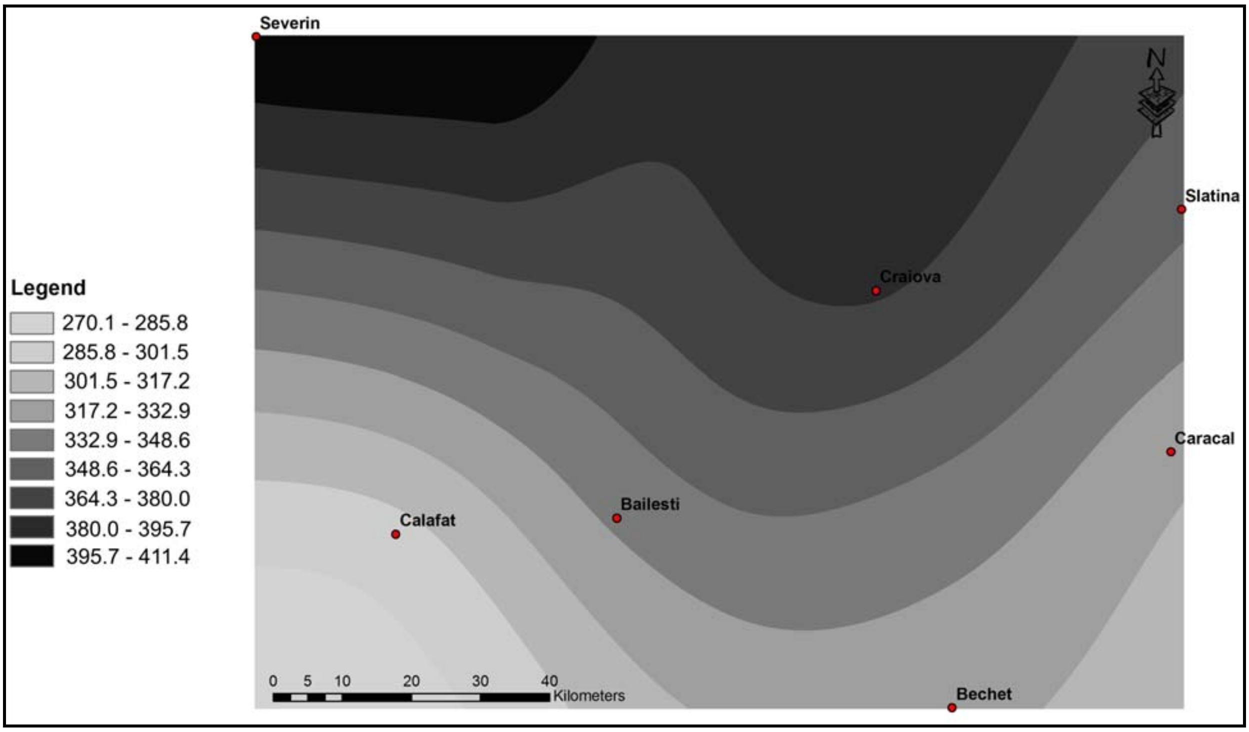

Fig. 5 The sum of precipitation in the months when the mean temperature is higher than 10ºC

5. The sum of precipitation during the cold season of the year represents the total water amount resulted from both solid and liquid precipitation. The cold season is as important as the warm one from the pluviometric point of view, as it ensures the water reserve in the soil that is then used during the first phonological phases. The amounts registered during this interval represents about 35-40 percent of the annual mean, which is about 200 mm. The only station displaying higher values is Drobeta Turnu-Severin, where there are reached 249.3 mm (Table 3, Fig. 6). Generally, the amounts are higher in the central and western part of the plain, due to the increased amounts from November and December and, thus, the soil water reserve is high enough. There are also particular cases generated by special synoptic situations, such as the one registered in 2001-2002, when the amounts did not generally exceed 60 mm within the entire plain or in 1991-1992 with values below 100 mm in the central and western parts.

6. The sum of the precipitation amounts during the maximum consumption period represents the precipitation amount corresponding to the interval July-August, when there are also registered the highest thermal values. These amounts represent about 19 percent of the annual mean. Generally, this interval is characterized by long and intensive drought periods. The values decrease southwards, from 112.4 mm at Craiova to 95 mm at Bechet, while westwards the variations are so reduced that they can be ignored (Fig. 6).

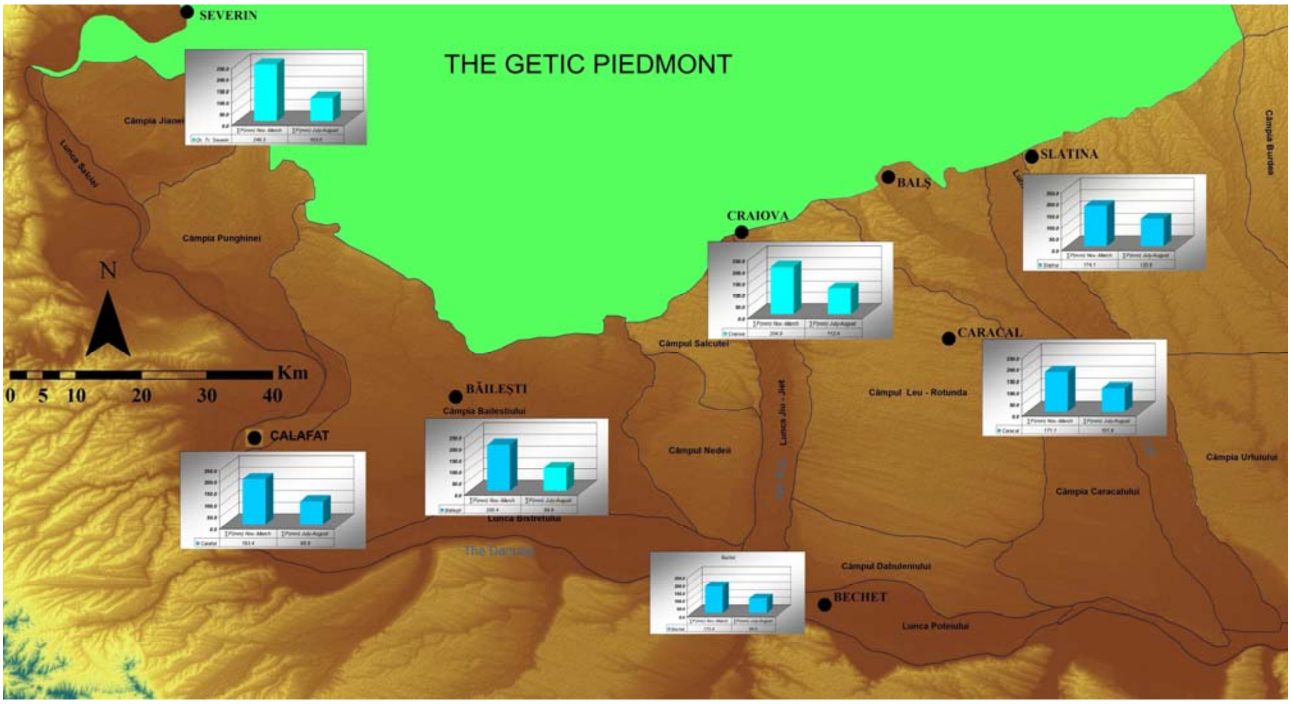

Fig. 6 Rate of different precipitation amounts (∑P(mm) November-March, ∑P(mm) July-August) mean annual values

In the western extremity, at Drobeta Turnu-Severin, the lowest amount corresponds to 1988 – 25.6 mm, while the highest to 1999 – 342.8 mm. In the north-eastern part of the plain, at Slatina, the minimum value was registered in 1987 – 24.9 mm, while the highest in 1991 – 240 mm. So, according to the analysed data, in spite of a relative uniformity at the level of mean values, the Oltenia Plain is characterized by a great temporal variability, imposed by different synoptic situations affecting only certain parts of the plain.

Table 3 Rate of different precipitation amounts, mean annual values

Station	∑P(mm) when t≥10°C	∑P(mm) Nov.-March	∑P(mm) July-August
Craiova	381.4	204.9	112.4
Băileşti	335.7	200.4	99.8
D.T. Severin	409.7	249.3	103.0
Calafat	331.0	193.4	98.9
Bechet	322.5	173.4	95.0
Slatina	352.7	174.1	120.6
Caracal	322.6	171.1	101.9

CONCLUSION

In spite of the homogeneity of the active surface, at the level of the Oltenia Plain there can be noticed a series of regional particularities imposed by the exposure at different climatic influences. By calculating certain ecoclimatic indexes, we aimed at identifying certain climatic dysfunctions, which jeopardize the agricultural activities.

Thus, according to the thermal and pluviometric values registered between 1984 and 2009, the Oltenia Plain faces a deterioration of the regime of the above-mentioned parameters. Precipitations registered a decrease tendency after 1990, tendency slightly marked by the exceptionally high amounts from 1999 and 2005; the annual thermal values frequently exceeded 12-13°C, which means that in summer the temperatures were close or even much higher than 25°C.

According to the results obtained from the processing of the climatologic data, the Oltenia Plain faces an aridization tendency ("de Martonne" aridity index), especially in the southern and southeastern extremities, as well as in the central part, where the frequency of the drought periods is high (Vlăduţ, 2004, p. 90).

From the biogeographical point of view, the area belongs to the steppe with graminaceous plants (southeast, east, and center), to the steppe with high plants (southwest), and to the forest steppe (north and west). The obtained values (Mayr tetratherm) indicate that agriculture should direct towards thermophilous and xerothermophilous plants able to get good crops even in these pluvial and thermal conditions. At the same time, for optimum crops there are strongly recommended irrigations, in order to supply the necessary water amount during the warm season as the precipitation is clearly insufficient. There should not be ignored the problem of the strong evapotranspiration, as well as the sandy soils, which impose numerous restrictions. Thus, the Oltenia Plain disposes of a great agricultural potential, but it cannot be well-capitalized if the climatic problems of the region are ignored.

ACKNOWLEDGEMENTS

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COMPARISON BETWEEN THE OLTENIA PLAIN AND THE SOUTHERN DOBROUDJA PLATEAU IN TERMS OF PLUVIOMETRIC DEFICIT

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Abstract

The Oltenia Plain and the Southern Dobroudja Plateau are two regions located in the two southern extremities, namely the south-western and the south-eastern extremities of Romania, which display distinct climatic features imposed by multiple climatic influences. The climatic evolution, especially in the last three decades, and the regional manifestations of the climatic phenomena related to global warming induced significant changes within the mentioned regions. In this context, we mention the pluviometric deficit. In the present paper, we have analysed the pluviometric deficit (annual and the warm semester of the year) within the Oltenia Plain and the Southern Dobroudja Plateau registered in the last half of the century (starting with 1961). We made a comparative analysis. The significant differences clearly emphasize the aridization tendency of the regional climate. The paper is useful for climatologists, as well as for students, master and PhD students.

Keywords: *rainfall deficit, drought, anticyclone regime, climatic influences, aridization*

Rezumat

Comparaţie între Câmpia Olteniei şi Platoul Dobrogei de Sud în funcţie de deficitul pluviometric. Câmpia Olteniei şi Podişul Dobrogei de Sud sunt două regiuni situate în cele două extreme sudice, sud-vestice şi respectiv sud-estice ale României cu caracteristici climatice distincte, ca urmare a multiplelor influenţe climatice care se exercită asupra lor. Evoluţiile climatice, mai ales din ultimele trei decenii şi manifestările regionale ale fenomenelor climatice în legătură cu încălzirea climatică globală au determinat mai ales în aceste regiuni schimbări semnificative. În legătură cu aceste aspecte este şi regimul pluviometric deficitar. În lucrarea de faţă am analizat regimul pluviometric deficitar (anual si cel din semestrul cald al anului) în Câmpia Olteniei şi Podişul Dobrogei de Sud din ultima jumătate de secol (începând cu anul 1961), tratând comparativ această problematică. Diferenţierile semnificative găsite de noi, demonstrează clar tendinţa de aridizare a climatului în aceste regiuni. Lucrarea este utilă specialiştilor din domeniul climei, studenţilor masteranzilor şi doctoranzilor.

Cuvinte-cheie: *deficit de precipitaţii, secetă, regim anticiclonic, influenţe climatice, aridizare*

INTRODUCTION

The Oltenia Plain and the Southern Dobroudja Plateau are two Romanian regions located in the two southern extremities of the country – Oltenia in the south-west and Dobroudja in the south-east; they display different climatic features.

Due to the significant differences of the climatic regime (Marinică, 2006, Văduva, 2005), rainfall patterns are also distinct in the two extreme southern regions of Romania. Our study aims at emphasizing these contrasts registered by rainfall regime. Within this framework, we stopped upon the pluviometric deficit (at the annual and warm semester level), as this has severe consequences upon environment and economy over long periods of time.

DATA AND METHODS

For the Oltenia Plain we used the pluviometric data from the present meteorological stations – Craiova, Băileşti, Bechet, Calafat, Dr. Tr. Severin, Caracal, and Slatina (Fig. 1).

For the Southern Dobroudja Plateau we used the pluviometric data supplied by the following meteorological stations (Fig. 1): Mangalia, Adamclisi, Medgidia, Constanţa, Hârşova, which are representative for all landforms of the region. The processed data generally covered the interval 1961-2008. The main used method was Hellmann's criterion, which gives us the opportunity of rendering the pluviometric deficit, allowing both a quantitative and qualitative analysis.

DISCUSSIONS

In Oltenia, atmospheric precipitation varies within the territory (as well as within the entire country), from south to north, variation imposed by the altitudinal differences among relief units.

The lowest annual precipitation amounts registered in different years and oscillated between 200 and 300 mm (l/sq m).

The lowest annual amount of precipitation registered in the entire observation period within the Oltenia Plain was 262.7 mm at Băileşti and Slatina, in 1992, which means a negative deviation of -305.7 mm, respectively -324.4 mm, namely a pluviometric deficit of 53.7% and 55.2% compared to the mean (568.4 mm is the normal value at Băileşti and 586.9 mm at Slatina). Such an amount is comparable to the amount registered on the seashore, at Mihail Kogălniceanu, in 1924 (176.9 mm). Due to the lower multiannual mean (considered normal) (451.0 mm) the negative deviation is also lower (-274.2 mm), which means an annual deficit of about 61% of the normal amount.

The territorial variation of the precipitation amounts from south to north emphasizes negative deviations from the normal, which are extremely important, from -191.8 mm in 2000 at Craiova, the lowest, to -405.1 mm in 2000 at Dr. Tr. Severin, the highest; this illustrates how great precipitation variability in time and space is (Marinică, 2006; Bogdan, Marinică, 2009).

In the Southern Dobroudja Plateau, at Constanţa for example, the lowest annual value registered between 1895 and 2008 was 213.7 mm, in 1921, with a negative deviation of -180.4 mm (37.6% of the multiannual mean) compared to the multiannual mean. The highest precipitation amount was 674.6 mm, in 2004, meaning a positive deviation of + 280.5 mm (41.6 % of the normal) (Văduva, 2008).

At Craiova, the lowest annual precipitation amount was 269.4 mm, registered in 1907, which means a negative deviation of -271.4 mm (-51.1% of the normal). The highest amount was 1,082.3 mm registered in 2005. The positive deviation reached 551.5 mm (103.9% compared to the normal). Consequently, there are notable differences between the pluviometric regime of the Oltenia Plain and the Southern Dobroudja Plateau. We may also notice that, in the worst case, negative deviations may be -100% (in exceptional situations of total lack of precipitation), while the positive deviations may exceed the normal value.

3.1. Pluviometric deficit for annual values

For the Oltenia Plain, a first *global evaluation* may be assessed according to the percentage means of weather types[1] according to the pluviometric deficit, calculated for annual precipitation values.

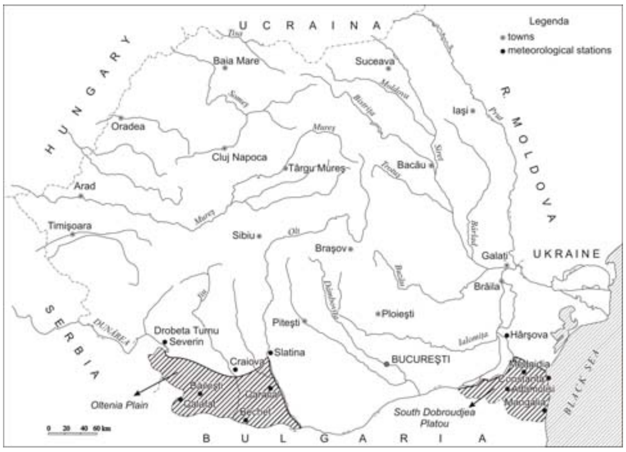


Fig. 1 Location of the meteorological stations

For the annual values (Fig. 2), we may notice that the excessively dry weather (ED, 18.0%) holds a double percentage compared to the very dry weather (VD, 9.2%). This situation is also available if we compare its percentage to the ones registered by dry and less dry weather. The average of the weather with pluviometric deficit for the entire region is 43.3%.

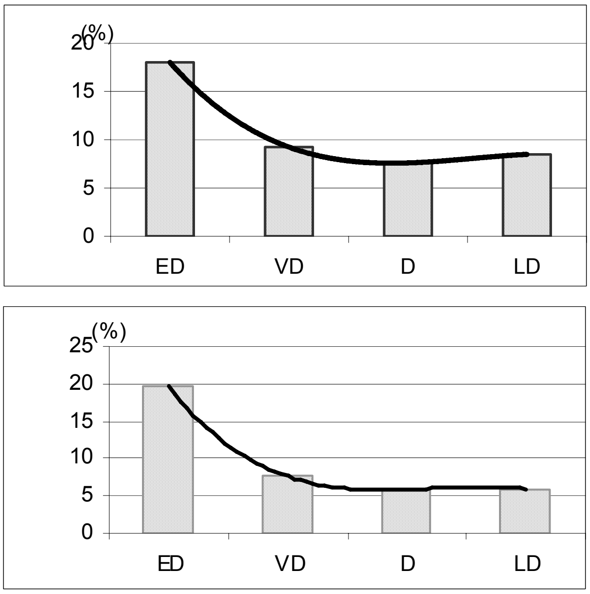


Fig. 2 Percents of the years with pluviometric deficit within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

Complex drought predominated with a percentage of 27.2% (about a quarter of the total number of years), while moderate drought registered 16.1%.

According to the distribution of the weather with pluviometric deficit at each station, the lowest percentage was registered in the central part of the Oltenia Plain, at Craiova (at the southern limit of the hilly area) 25.0%, while the highest percentage in the southern part of the plain, at Bechet, 66.7%. High percentages of the weather with pluviometric

[1] **ED**=excessively dry, **VD**= Very dry, **D**= dry, **LD**= less dry; **Complex drought** is estimated according to the sum of the percentage held by excessively dry and very dry weather; **Moderate drought** is assessed according to the sum of the percentage held by dry and less dry weather.

deficit were also registered at Calafat 50.0% and Dr. Tr. Severin 45.9%.

Complex drought registered the highest percentage, 37.5%, at Bechet, in the south of the region, while the lowest percentage, of only 10.4% was held by Craiova.

Moderate drought registered the highest percentage, 29.2%, at Bechet, as well and the lowest at Slatina, only 6.2%. However, in this last case, complex drought represents 34.4%, the second highest value after Bechet.

Excessively dry weather (ED) registered the highest percentage at Calafat and Bechet (22.9%), where local conditions favours pluviometric deficit, and the most reduced at Craiova, only 8.3%. *As for the Southern Dobroudja Plateau*, the percentage of excessively dry weather (ED, 19.6%) is almost three times higher than that of the dry weather (7.58%). It oscillates between 16.7% at Adamclisi and Medgidia and 25.0% at Constanţa (Fig. 2), which means higher values than within the Oltenia Plain (a difference of 1.6%). The same predominance of the excessively dry weather can be noticed at all the meteorological stations from the Dobroudja Plateau, except for Constanţa where excessively dry weather is almost 10 times higher than the very dry weather. This situation is induced by the seashore location as breeze and air descent imposed by the Black Sea influence frequently lead to the dissipation of the cloud systems, which is also illustrated by the mean annual amount of precipitation of 396.2 mm, the lowest of all the analysed meteorological stations.

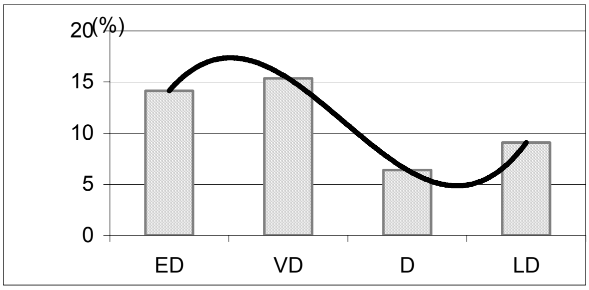
VD, D, and LD weather register insignificant differences.

The distribution of complex drought is comprised between 25.0% at Mangalia and Adamclisi and 33.3% at Hârşova, which means it appears in a quarter up to 1/3 of the analysed years. Moderate drought displays a reduced temporal extension in percents, starting from 2.5% at Constanţa (but here complex drought is registered in 27.5% of the years) to 16.6% at Medgidia, located in the interior of the Southern Dobroudja Plateau.

On the whole, the cases of pluviometric deficit (DW) (DW = ED + VD + D+ LD) oscillate between 30.0% at Constanţa and 45.8% at Hârşova, located in the western extremity, where the continentalism degree is also higher. Taking into account the more reduced precipitation amounts registered within the studied area (between 396.1 mm at Constanţa and 459.9 mm at Adamclisi located towards the southern limit of the plateau) than the ones from the Oltenia Plain (where they oscillate between 531.7 at Craiova and 567.6 mm at Băileşti) we may conclude that droughts are more intense in the Southern Dobroudja Plateau than in the Oltenia Plain.

3.2. Pluviometric deficit during the warm semester (April – September)

In April, within the Oltenia Plain, the general average of the month with pluviometric deficit was 45.0%. The percentage values registered at the meteorological stations oscillated between 35.4% at Calafat and 50.0% at Băileşti and Slatina (located in the south-west and north-east of the region.



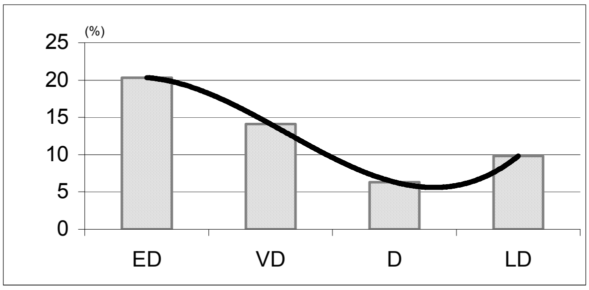


Fig. 3 Pluviometric deficit (%) in April within the Oltenia Plain (left) and the Southern Dobroudja Plateau (right)

The mean general percentage of excessively dry months was 14.1% (about 4% lower than the percent of very dry months) (Fig. 3). At the meteorological stations it was comprised between 10.4% at Caracal and Craiova and 21.9% at Slatina. Complex drought registered in April held a mean percentage of 29.5% (a little more than a quarter of the total number of months). At the meteorological stations, their percentage oscillated between 25.0% at Dr. Tr. Severin and Calafat and 37.5% at Slatina. The mean general percentage of the months with moderate drought was 15.5%, while at the meteorological stations it oscillated between 10.4% at Calafat and 20.9% at Dr. Tr. Severin.

In April, within the Southern Dobroudja Plateau, the general mean of the months with pluviometric deficit for the entire territory was 50.5%, namely 5.5% higher than within the Oltenia Plain. According to the values registered at the meteorological stations, the mean oscillated between 42.5% at Constanţa and

60.4% at Mangalia (both stations with extreme values being located on the seashore). The mean percent of excessively dry months was 20.34% (Fig. 3), while the extreme values were 18.8% at Adamclisi and Hârşova and 22.5% at Constanţa. The mean percentage of very dry April months was 14.1%. It varied between 10.0% at Constanţa and 20.8% at Mangalia (values comparable to the ones registered within the Oltenia Plain).

The mean percentage of April months with complex drought was 34.44%, namely about 5% higher than within the Oltenia Plain. Territorially, the values oscillated between 31.3% at Medgidia and 41.6% at Mangalia. The percentages of the months with moderate drought were about twice smaller than those with complex drought.

We may conclude that in April, the pluviometric deficit is higher in the Southern Dobroudja Plateau than in the Oltenia Plain, while the percentage of the months with different intensity degrees of drought is significantly greater than within the Oltenia Plain (with about 5%). Taking into account that the multiannual amounts of precipitation are lower within the Southern Dobroudja Plateau, spring drought (when plants' water requirements are important) is more intense and frequent here than within the Oltenia Plain.

In May, within the Oltenia Plain the mean general percent of the months with pluviometric deficit reached 54.9%. With regard to the distribution of the meteorological stations, it oscillated between 41.6% at Craiova and 62.5% at Băileşti and Slatina. The mean percentage of the excessively dry weather was 21.9% (Fig. 4), while, in the territory it varied between 14.6% at Craiova and 27.1% at Dr. Tr. Severin, Bechet, and Băileşti.

The percentage of very dry months was on average 14.9% for the entire region, while territorially, the values were comprised between 4.2% at Caracal and 21.9% at Slatina.

The percentage of the months with complex drought was on average 36.8% (about 1/3 of the number o months). Within the territory, the values oscillated between 20.8% at Craiova and 45.9% at Bechet and Băileşti (a similar value was registered at Dr. Tr. Severin, 44.8%), which confirms the increased frequency of spring drought in the south of the Oltenia Plain.

Moderate drought registered in 18.1%; at the stations, it varied between 8.3% at Bechet and 25.0% at Slatina.

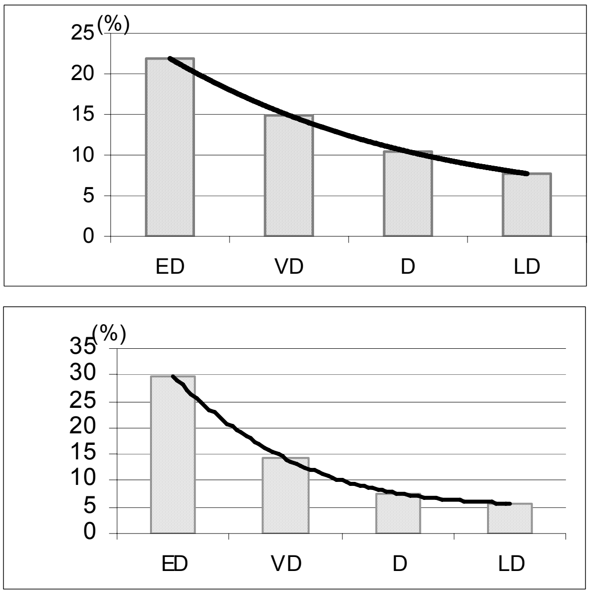


Fig. 4 Pluviometric deficit (%) in May within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

In May, within the Southern Dobroudja Plateau, the mean general percentage of the months with pluviometric deficit was 57.3% for the entire territory. As distribution on meteorological stations, it oscillated between 54.1% at Mangalia and 58.3% at Adamclisi, Medgidia, and Hârşova. Compared to the Oltenia Plain, the general mean was about 4% higher than within the Southern Dobroudja Plateau and there were not registered values ≥60.0%. The percentage of excessively dry months registered a mean of 29.76% (Fig. 4), about 7% higher than within the Oltenia Plain, while the values from the meteorological stations were comprised between 20.8% at Mangalia and 35.4% at Hârşova. We may also notice that the variability of these values was lower than within the Oltenia Plain.

The mean percentage of the months with complex drought was 44.0%, about 3% higher than within the Oltenia Plain. Within the territory, the values were comprised between 33.3% at Mangalia and 50.1% at Medgidia, being more homogenous than within the Oltenia Plain, which suggests climatic conditions of generalized moderate drought in certain months.

Moderate drought reached a mean percentage of 13.3% (much less than in Oltenia). It oscillated between 8.2% at Medgidia and 20.8% at Mangalia, the reduced percentage suggesting that here ***moderate drought rapidly transforms in complex drought.***

In June, within the Oltenia Plain, the mean general percentage of the months with pluviometric deficit was 52.1%; the values varied between 45.8% at Bechet and 56.3% at Slatina.

In June, drought is more intense in the southern half of the region, where multiannual monthly amounts of precipitation are lower.

The mean percentage of excessively dry months was 26.5% (Fig. 5), while at the stations it oscillated between 20.8% at Craiova and 37.5% at Slatina, in the south-east, where continental influences are more intense.

The mean percentage of very dry months was 12.3% and the values varied between 3.1% at Craiova and 27.1% at Calafat.

The mean percent of the month with complex drought was 38.8%; territorially, it varied between 31.2% at Craiova and 52.1% at Calafat (the only meteorological station where this percentage exceeds 45%). Thus, we notice the south-western part of Oltenia, with sands (the so-called "Sahara" of Oltenia), where complex drought appears in more than half of the number of June months.

The mean percentage of the month with moderate drought was 13.3%, namely about 1/3 of the months with complex drought, which indicates that, in June, ***complex drought*** predominates compared to other types of drought. Within the territory, the percentage held by the months with moderate drought varies between 6.3% at Calafat and 16.7% at Craiova.

In June, within the Southern Dobroudja Plateau, the general mean percentage of the months with pluviometric deficit was 52.5%, only 1.4% higher than that registered within the Oltenia Plain; the values oscillated between 43.7% at Mangalia and 60.4% at Adamclisi, being higher and more homogenous than those registered within the Oltenia Plain.

The general mean percentage of the excessively dry months was 20.9% (a little more than 1/5 of the total number of months) (Fig. 5), while within the territory the percentage varied between 15.0% at Constanţa and 25.0% at Adamclisi in the south of the plateau. Compared to the Oltenia Plain, the mean general percentage was about 5.5% lower.

The general mean percentage of very dry months was 14.3%; the spatial distribution oscillated between 12.5% at Mangalia and Adamclisi and 18.8% at Hârşova, increasing from south to north; the percentage is just a little lower than that registered within the Oltenia Plain (with only 1.9%).

The mean percentage of the month with complex drought reached 35.2%, while within the territory, the percentage of the months with complex drought was 30.0% at Constanţa and 37.6% at Hârşova, about 3% lower than that registered within Oltenia.

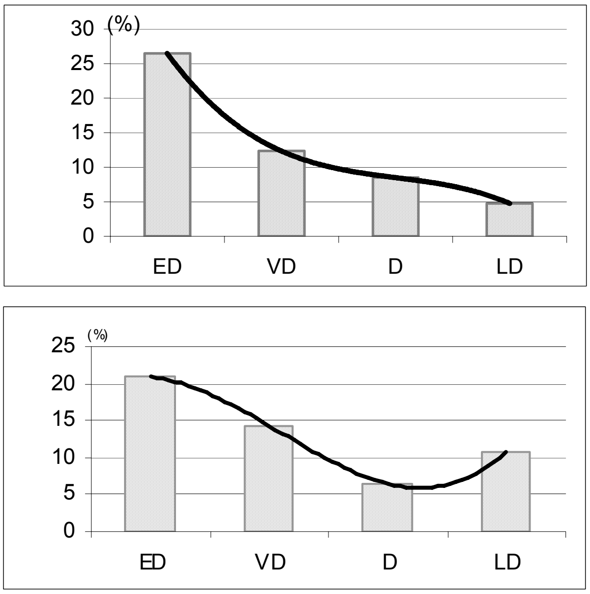


Fig. 5 Pluviometric deficit (%) in June within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

The percentages held by dry (D) or less dry month (LD) months were relatively reduced; this is why it would be better to discuss their sum, namely the percentage of the months with moderate drought (MD) (Fig. 5).

The general percentage mean of the months with moderate drought was 17.3%; within the territory, they varied between 8.3% at Mangalia and 22.9% at Adamclisi, namely higher than in Oltenia.

Even if these values are a little lower or comparable to those registered within the Oltenia Plain, in our opinion, ***droughts registered in June are more intense*** within the Southern Dobroudja Plateau than within the Oltenia Plain. First of all, it is *a lower multiannual monthly amount of precipitation* than within the Oltenia Plain and, thus, the percentage deficits emphasize a more acute lack of precipitation. Secondly, it is about *wind regime* within the Southern Dobroudja Plateau, which is more "alert" than within the Oltenia Plain leading to the increase of the evapotranspiration intensity.

In July, within the Oltenia Plain, the general mean percentage of the months with pluviometric deficit was 49.9% (about 2% lower than that of June), while within the territory, it varied between 41.7% at Craiova and 56.3% at Dr. Tr. Severin.

The general mean percentage of excessively dry months (ED) was 24.9% (Fig. 6) (about 1/4 of the total number of months); territorially, the excessively dry months oscillated between 20.8% at Băileşti and Craiova and 31.3% at Calafat and Caracal.

The percentages of dry (D) and less dry (LD) months were generally lower and this is why it is enough to discuss the regime of the months with moderate drought (MD). For the Oltenia Plain, the general mean percentage of the months with moderate drought (MD) was 14.5%, while within the territory it varied between 10.4% at Calafat and 21.9% at Slatina.

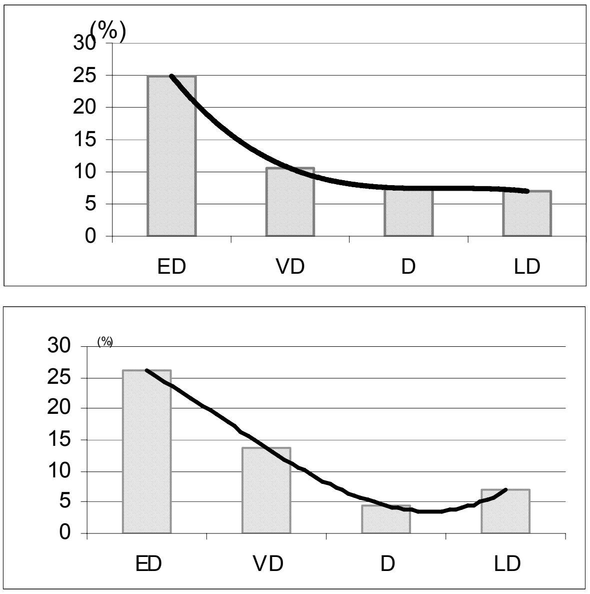


Fig. 6 Pluviometric deficit (%) in July within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

In July, within the Southern Dobroudja Plateau, the general mean percentage of the months with pluviometric deficit was 51.3%, higher than within the Oltenia Plain with about 2%. The values oscillated between 43.8% at Adamclisi and 62.5% at Constanţa (a deviation of about 9%), which means a greater homogeneity than within the Oltenia Plain.

The general percentage of excessively dry months was 26.2% (Fig. 6), also about 2% higher than within the Oltenia Plain, while territorially, it varied between 22.5% at Constanţa and 29.2% at Hârşova (deviation of about 7%), in the north-east of the studied area, the previous conclusion being available in this case too.

The general percentage of very dry months within the Southern Dobroudja Plateau was 13.8%, namely almost half of the excessively dry months and only about 2% higher than within the Oltenia Plain.

The percentage of the months with complex drought was 39.9% (about 40%), about 5% higher than within the Oltenia Plain; the values varied between 33.4% at Adamclisi and 47.5% at Constanţa (deviation of about 14%), indicating a lower variability than within the Oltenia Plain, where the deviation is of about 19%.

The general percentage of the months with moderate drought (MD) is 11.3% (less than 1/3 of that of the months with complex drought), about 1.2% lower than that registered within the Oltenia Plain; territorially, the percentages oscillated between 8.3% at Hârşova and 15.0% at Constanţa (deviation of about 7%) indicating a lower variability than within the Oltenia Plain.

We may conclude that ***the number of the months with pluviometric deficit within the Southern Dobroudja Plateau is greater than within the Oltenia Plain***, as well as the number of the months with complex drought.

In August (Fig. 7)*, within the Oltenia Plain,* the general mean percentage of the months with pluviometric deficit for the entire area was 54.9% (more than half of the total number of analysed months). In the territory, the percentage oscillated between 45.8% at Caracal and 62.5% at Bechet, the deviation being of 16.7%. Compared to July, it was higher, which emphasizes that summer drought increases and becomes persistent in August.

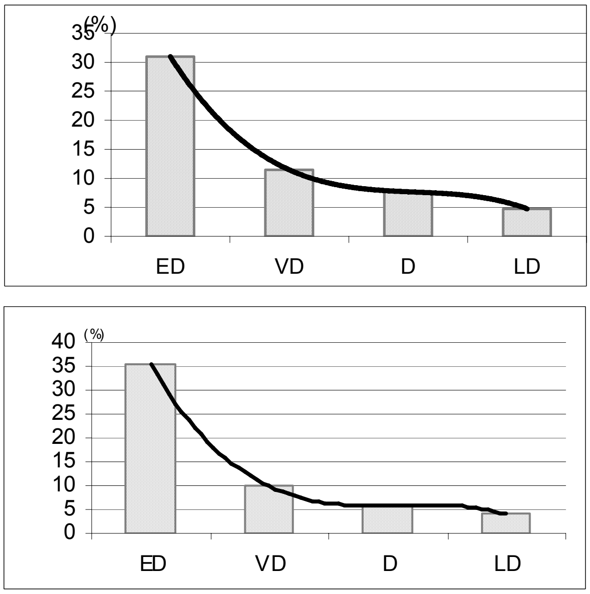


Fig. 7 Pluviometric deficit (%) in August within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

The general mean percentage of excessively dry months was 31.0% (Fig. 7), (a little more than ¼ of the total number of months), while within the territory, the percentage oscillated between 25.0% at Slatina and 37.5% at Bechet, located in the southern extremity of Oltenia (a deviation of 12.5%).

The general mean percentage of very dry months was 11.5% (less than half of the excessively dry months); the percentage varied between 8.3% at Caracal and Craiova and 14.6% at Calafat and Bechet.

The general mean percentage of the months with complex drought reached 42.4%, while at the meteorological stations it was comprised between

34.4% at Slatina and 52.1% at Bechet (deviation of about 17%).

The general mean percentage of the months with moderate drought was 12.4% (about 1/3 of the percentage of months with complex drought); for the stations, it varied between 6.3% at Caracal and 20.8% at Craiova (deviation of about 14%).

In August (Fig. 7)*, within the Southern Dobroudja Plateau,* the general mean percentage of the months with pluviometric deficit reached 55.0%, namely approximately equal to the one registered within the Oltenia Plain; the pluviometric deficit varied between 50% at Constanţa and Hârşova and 60.4% at Mangalia and Adamclisi. All the values exceeded ≥50%; the deviation was 14%, lower than within the Oltenia Plain, which means a smaller variability.

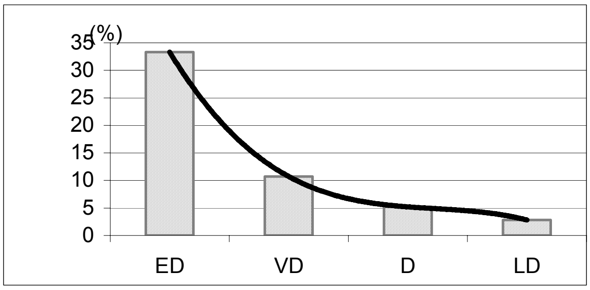
The general mean percentage of excessively dry months was 35.34%, about 5.3% higher than in Oltenia, while within the territory, it was comprised between 33.4% at Medgidia and 37.5% at Adamclisi (deviation of 4%), thus emphasizing a lower variability. The general mean percentage of the months with complex drought (CD) was 45.16%, about 3% higher than within the Oltenia Plain. The monthly percentage values of complex drought were between 42.5% at Constanţa and 47.9% at Adamclisi, with a deviation of about 5%.

The general mean percentage of the months with moderate drought was 9.84%, about 35% lower than that of complex drought (and 2% lower than within the Oltenia Plain). In the territory, the percentage held by the months with moderate drought oscillated between 6.3% at Hârşova and 14.6% at Mangalia, increasing from north-west to south-east to more than double. This means that, within the Southern Dobroudja Plateau ***complex drought predominates in the last summer month***; as a general conclusion, in August ***one of two months registers pluviometric deficit***.

In September (Fig. 8), *within the Oltenia Plain,* the general mean percentage of the month with pluviometric deficit for the entire territory was 52.1%, a little lower than that registered in August (with 2.8%); the values oscillated between 43.8% at Craiova and 64.6% at Bechet.

The general mean percentage of the excessively dry months was 33.3% (about 1/3 of the total number of months), namely about 2% higher than in August. At the meteorological stations it varied between 25.0% at Dr. Tr. Severin and 43.8% at Bechet, with a deviation of about 19%.

The mean percentage of very dry months was 10.7% (about three times lower than that of the excessively dry months); at the meteorological stations, the percentage oscillated between 6.2% at Bechet and Slatina and 18.8% at Băileşti, with a deviation of about 12%.



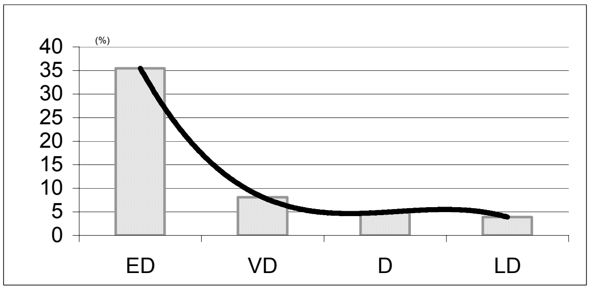


Fig. 8 Pluviometric deficit (%) in September within the Oltenia Plain (above) and the Southern Dobroudja Plateau (below)

The general mean percentage of the months with complex drought was 44.1%, namely about 8% lower than that of the months with pluviometric deficit, which offers us *an image regarding the extension of the months with complex drought*. The percentages of the months with complex drought oscillated between 37.5% at Slatina and 50% at Calafat, Băileşti, and Bechet, with a deviation of about 13%. We notice the increased frequency of the months with complex drought within the entire plain.

Moderate drought registered relatively low percentages (about 8%).

We may conclude that ***in the last summer month and the first autumn month there are the most numerous months with pluviometric deficit, and after the installation of drought it evolves rapidly and becomes complex drought affecting the entire Oltenia Plain***.

In September (Fig. 8)*, within the Southern Dobroudja Plateau,* the general mean percentage of the month with pluviometric deficit reached 52.4%, approximately equal to that from the Oltenia Plain. Within the territory, the months registering pluviometric deficit oscillated between 43.8% at Adamclisi and 62.5% at Medgidia (a deviation of about 19%). The second value was 56.3% at Mangalia marking an important precipitation deficit in the seashore area. We also notice that the maximum percentage in Dobroudja reached 62.5% at Medgidia, but it is lower than the maximum values from Oltenia, which reached 64.6% at Bechet, situation induced especially by the climate evolution in the last two-three decades (Bogdan, Marinică, 2009).

The general percentage of the excessively dry months was 35.4%, about 2% higher than within the Oltenia Plain. Within the territory, it varied between 25.0% at Constanţa and 43.8% at Medgidia, with a deviation of 18.8%, the previous conclusion being still available.

The general percentage of very dry months was 8.1%, about 2% lower than in Oltenia 2%, while at the stations, it varied between 6.2% at Hârşova and 10.4% at Mangalia, with a deviation of about 4%. This aspect confirms the great uniformity registered within the Southern Dobroudja Plateau.

The general percentage of the months with complex drought was 43.6%, approximately equal to that registered within the Oltenia Plain. Territorially, the percentage varied between 32.5% at Constanţa and 52.1% at Mangalia and Medgidia, with a deviation of about 20%.

The general mea percentage of the months with moderate drought was 8.9%, namely a little higher than in Oltenia (just 0.8%), while at the stations, it varied between 4.2% at Mangalia and 15.0% at Constanţa, with a deviation of about 11%.

CONCLUSION

Within both studied areas, the months with pluviometric deficit registered quite different percentage values.

Within the Oltenia Plain, the driest months, in a decreasing order of the general percentage values are: May, August (54.9%), June, September (52.1%), July (49.9%), and April (45.0%).

Within the Southern Dobroudja Plateau, the driest months, in a decreasing order of the general percentage values are: May (57.3%), August (55.0%), June (52.5%), September (52.4%).

The relief structure and its interaction with the general circulation of the atmosphere, the geographical location and the multiple climatic influences decisively contribute to explaining the differences mentioned in the paper.

Within the Southern Dobroudja Plateau, although the values seem to be comparable to the ones registered within the Oltenia Plain, pluviometric deficit is more acute and droughts are more intense, due to the lower multiannual amounts of precipitation.

The increased frequency of excessively dry weather is the results of the influences of the continental anticyclones registered during the entire year (but especially in summer, winter, and the beginning of autumn), as well as of the Black Sea, which contributes to the diminution of the precipitation amounts. Thus, within the Southern Dobroudja Plateau, we may state that "the normal state is drought".

Within the Oltenia Plain, there are noticed both months and years with pluviometric deficit. The effects of the deficit are severely felt especially during the warm season, when the maximum temperature values are high, there are dog days, and the water reserve in the soil decreases to the wilting point.

Within the Southern Dobroudja Plateau, the general mean percentage of the months with pluviometric deficit, for the entire studied period of about half a century, is 53.3% (52.9% for the warm season), while within the Oltenia Plain, it is 49.4% (respectively 51.4% for the warm season). Consequently, ***the aforementioned percentages (both for annual values and the values registered in the warm season) reflect a clear tendency of climatic aridization in both regions, tendency which is however more clear within the Southern Dobroudja Plateau.***

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THE DETERMINATION OF THE DEGREE OF TROPHICITY OF THE LACUSTRINE WETLANDS IN THE EASTERN CARPATHIANS (ROMANIA)

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Abstract

The lakes over Romania's territory are relatively uniformly distributed within most physico-geographical regions. A low density is specific to the West, where significant drainage works have been realized, while the highest density is characteristic to the North-East, with numerous ponds, registered since the 14th-15th centuries. Most of the lakes within the Romanian territory, especially those analyzed in the present study, are anthropic. Most of the natural lakes are small-dimensioned and they do not have a special ecologic or economic importance. Although situated in different physical-geographical conditions, the analyzed lakes are mostly included in the category of good waters from a qualitative point of view, and within the eutrophic, mesotrophic or hipertrophic category, from a trophic point of view. Because of the fact that most lakes are anthropic, it is obvious that they are artificially maintained at this stage. Most of the mountain lakes and those in the volcanic areas are ultra-oligotrophic and oligotrophic. The lacustrine wetlands in the mountainous units are relatively meagrely developed, as their distribution is limited by the morphology of the landforms.

Keywords: *lacustrine wetlands, geographic distribution, genetic type, water quality, pollution.*

Rezumat

Determinarea gradului de troficitate a zonelor lacustre umede din Carpaţii Orientali (România). Lacurile de pe teritoriul României sunt relativ uniform distribuite, în majoritatea regiunilor fizico-geografice. O densitate redusă este specifică vestului ţării, unde au fost realizate lucrări de desecare semnificative, în timp ce densitatea cea mai mare este caracteristică nord-vestului, cu numeroase iazuri, înregistrate încă din secolele XIV-XV. Marea majoritate a lacurilor de pe teritoriului României, şi în special cele analizate în acest studiu sunt antropice. Cele mai multe lacuri naturale sunt reduse ca dimensiuni şi nu posedă o importanţă ecologică sau economică deosebită. Deşi situate în condiţii fizico-geografice diferite, lacurile analizate sunt incluse în categoria apelor bune din punctul de vedere al calităţii şi în categoriile eutrofic, mezotrofic sau hipertrofic, din punctul de vedere al troficităţii. Din cauza faptului că majoritatea lacurilor sunt antropice, este evident că sunt menţinute în mod artificial în acest stadiu. Cele mai multe dintre lacurile de munte şi cele situate în arii vulcanice sunt ultra-oligotrofice şi oligotrofice.

Cuvinte-cheie: *mlaştini lacustre, distribuţie geografică, tip genetic, calitatea apei, poluare.*

INTRODUCTION

The interdisciplinary studies regarding wetlands in Romania are almost inexistent. This is why, at a local level, the analysis of water quality in the main lake basins and their correlation with the existence of the main wetlands of national and local ecological importance, is being done.

In the present study all the great natural lakes (lacustrine wetlands) and most of the artificial lakes from almost all river basins have been analysed. We wanted to emphasize, for each region, river basin and aquatic surface, the quality of the lacustrine waters in order to use them in different fields of activity as well as a life support for the biologic component.

The major difficulty, for such a study, was represented by the relatively big dimension of the surface of Romania, the relatively great number of lakes (136), and the extremely varied and fragmented landforms. Some lakes are situated in hardly accessible places, and as a result, the present study could not be realized during one single year. For the Eastern Carpathians the most representative 19 lacustrine wetlands have been analyzed.

We performed a complex analysis of the physico-chemical characteristics of the lacustrine waters and of their role in maintaining life. Such a study, for the whole territory of Romania (especially for the Eastern Carpathian Mountains), has rarely been done, and even then, there were important gaps for some river basins and for the isolated lakes. In places where the lakes within a small area had the same characteristics, only the most important aquatorium was mentioned, as being typical and representative for that territory and for those types of lakes.

Within the rich literature in the field, only the materials referring strictly to the issues concerning the lakes in the Eastern Carpathians or water trophicity worldwide have been mentioned: Brenner et al., 1996; Daraba, 2008; Dumitran, 2002; Dumitran et al. 2005; Dumitran et al., 2006; Godeanu and Galatchi, 2007; I.N.M.H., 2000, 2006; Jonasson, 1996; Jorgensen, 1996; Karatayev, 1995; Neagu and Miron, 2008; Porumb, 1986; Romanescu, 2006; Romanescu and Romanescu, 2008; Romanescu et al., 2005, 2008; Shchur, 2009; Zanovschi and Porumb, 1979 etc.

Regional setting

The Eastern Carpathians represent the Eastern segment of the Carpathian Mountains, and they are situated between the Ukrainian border (in the North) and Prahova Valley (in the South) (Fig. 1).

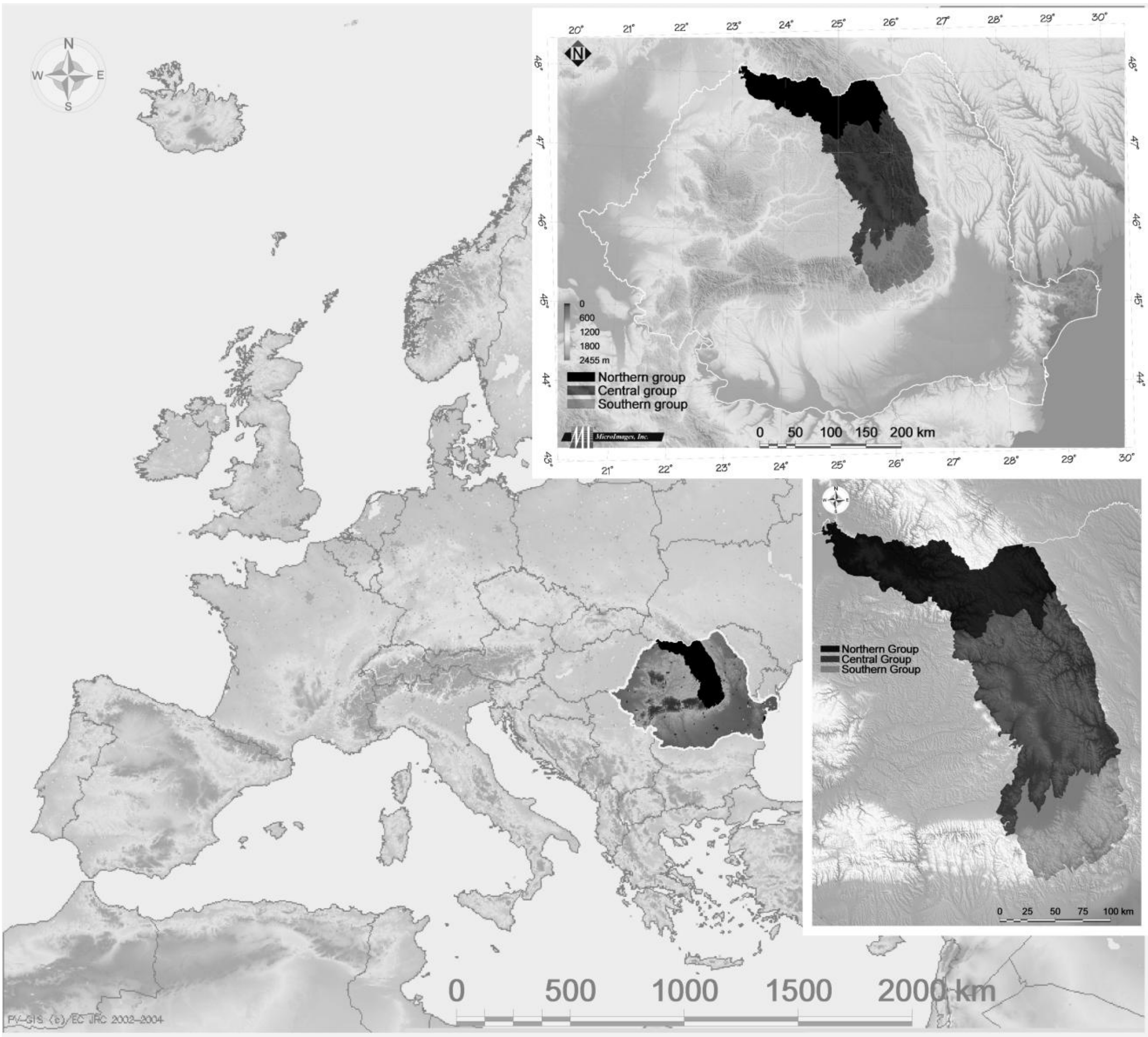

Fig. 1 Geographical location of the Eastern Carpathians in Europe and Romania

They are divided in three main groups: the Northern Group, between the Ukrainian border and Tihuţa Pass, the depression corridor Vatra Dornei-Câmpulung Moldovenesc (in the South); Central Group, between Tihuţa Pass, the depression corridor Vatra Dornei-Câmpulung Moldovenesc (in the North) and Oituz Pass and Brasov Depression (in the South); Southern Group, between Oituz Pass and Braşov Depression (in the North) and Prahova Valley (in the South) (Fig. 2).

It is the largest Carpathian sector on the territory of Romania and the second highest after the Southern Carpathians.

From a geological point of view, it is made up of three distinct stripes, with a NW-SE orientation: the volcanic stripe (in the West), the crystalline stripe (in the centre) and the sedimentary stripe (in the East).

METHODOLOGY

There are 3450 lakes in Romania, with a cumulated surface of 2,620km^2, covering 1.1% of the total surface of Romania. Unfortunately, most of the lakes are anthropic, while the natural lakes, apart from being fewer, they have an insignificant surface (Gâstescu, 1971; Romanescu, 2006).

The seasonal campaign during a four-year period (2003, 2004, 2005, 2006, 2007, and 2008) had as a main purpose the complex characterization of lacustrine waters quality, by interpreting the results of the field measurements, with reference to their classification in quality classes. A complex measurement set (Multisampler HACH) was used for the measurement of the physico-chemical parameters, and at the same time, we took samples of phytoplankton, specific to the lacustrine waters.

The trophicity of the lacustrine waters (wetlands) required the characterization of several physico-chemical and biological indicators, having determined and favoured its evolution: pH, CCO-Cr, CC=-Mn, CBO_5, total mineral nitrogen, total phosphorous, temperature, dissolved oxygen, transparency, nutrients, structure of aquatic biota (value of phytoplankton biomass, percentile value V90% of the plankton biomass, coli form bacteria).

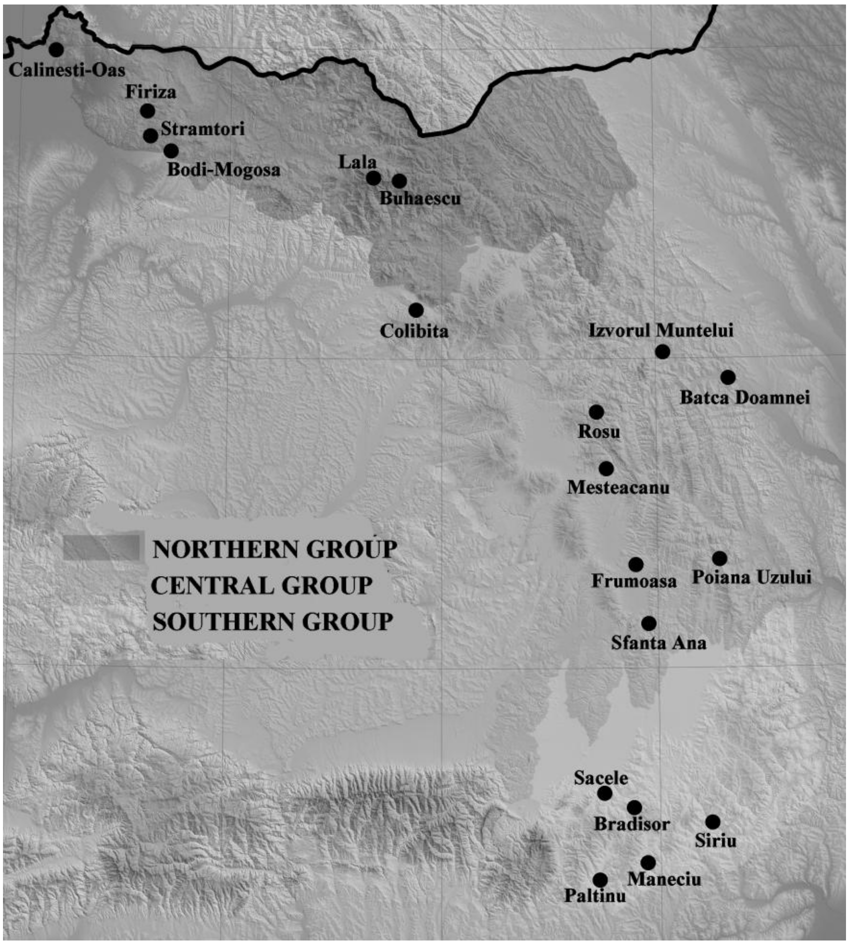

Fig. 2 Geographical position of the main lakes in the Eastern Carpathians

The global characterization of water quality was made by interpreting the results obtained during the seasonal campaigns, with reference to the establishing of the quality categories. The water trophicity degree was determined by following the evolution of the physico-chemical and biological indicators: temperature, transparency, oxygen regime, nutrient regime, biocenosis evolution (phytoplankton biomass and trophicity degree) according to the limits stipulated by the standards.

The situation of the global quality, the establishing of the quality category and trophicity quality of the lakes in Eastern Carpathians was done by cumulating the results obtained in each river basin.

The physico-chemical parameters were interpreted at the Hydrology Laboratory of the Faculty of Geography and Geology, University "Al. I. Cuza" in Iaşi, while the biological parameters were interpreted by the Natural Sciences Museum in Tulcea.

At first, some data were missing from our analysis, in the cases of some lakes mentioned above, but they could eventually be taken from the Headquarters of Water Supply in Bucharest or from the regional hydrologic offices (I.N.M.H. – the National Institute of Meteorology and Hidrology, 2006).

The data we obtained were reported to Order 1146/2002 into five quality classes, and the classification of the lakes was established by using the percentile system V (90%).

RESULTS AND DISCUSSIONS

The analysed area refers to the whole territory of Romania (especially to the East Carpathian Mountains), especially to the natural lakes with ecologic and economic importance, as well as the most important anthropic lakes.

While in the Western part of Romania hydro-technical works have been built and a large part of the flood plain lakes were eliminated, in the Eastern part of Romania the situation is reversed. In Moldova, some of the oldest and most numerous anthropic lakes are registered, most of them having small dimensions. Still, some of these lakes cover significant areas and they have a complex role (Romanescu et al., 2005).

Fig. 3 Izvorul Muntelui reservoir on the Bistriţa river

As a result of the fact that Romania's landforms are very diverse (delta, extended flood plains, arid and wet plains, hills with high fragmentation, low and high mountains etc.), the genetic types of lakes and the hydrologic balance specific to these areas are various as well.

The complex analysis of the lakes was done on the following river basins: Tisa (Buhăescu, Călineşti-Oaş); Someş (Colibiţa, Firiza, Lala, Strâmtori, Bodi-Mogoşa), Olt (Mesteacănu, Sfânta Ana, Frumoasa, Săcele, Bradişor); Ialomiţa (Paltinu, Măneciu); Siret (Izvorul Muntelui, Bâtca Doamnei, Poiana Uzului, Siriu, Roşu).

The most important lakes within all river basins were analysed. The present study does not refer to the salt lakes in the salt massifs (natural and

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anthropic) as they present different characteristics and they are used only therapeutically (Ocna Şugatag, Coştui, Telega, Slănic Prahova etc.).

Analysing the distribution of the lakes within Romania's territory, one can notice their absence in the Western part of the country and an increased number in the East (Moldova, Bărăgan, and Dobrudja). The absence of lakes in the Someşului, Crişurilor and Timişului Plains is caused by the drainage hydro-technical works having been used in order to convert the land into agricultural fields.

The great number of lakes in Moldova (the Siret and the Prut river basins) is explained by the reduced hydrological resources and the need to preserve them. For that reason, artificial lakes were built since antiquity; they had small dimensions and multiple usage. In the 15^{th} -16^{th} centuries, about 3,500 ponds were recorded, while nowadays their number decreased to 350 (the Romanian Academy, 1983). Some of them were abandoned, others were silted because of the high rate of soil erosion (friable sub-stratum) (Romanescu et al., 2008).

Table 1 Morphometric characteristics and trophicity of the lakes in Romania (data processing, I.N.M.H. Bucharest, 2006)

Lake	Genetic type	Water course	Usage	Volume Mln.m^3	Surface ha	Maximum depth	Water quality (category)	
							Nutrients (total nitrogen, total phosphorous)	Biology
Tisa river basin								
Buhăescu	Glacial	-	-	0.004	0.2	5	M-E	O
Călineşti-Oaş	Human made	Tur	complex	29.0	160	9	E	E
Someş river basin								
Colibiţa	Human made	Bistriţa	complex	101.2	314	50	E-H	O
Firiza	Human made	Săsar	complex	-	110.0	37.5	E	O
Lala	Glacial	-	-	-	0.6	2	UO	UO
Strâmtori	Human made	Firiza	complex	16.6	113.0		E	M
Bodi-Mogoșa	Floodplain	Săsar	complex	0.3	1.6	7	E-H	UO
Olt river basin								
Mesteacănu	Human made	Olt	Water supply	1.1	15	16	M-E	UO
Sfânta Ana	Volcanic	-	Tourism	0.250	19.5	7.5	M	M
Frumoasa	Human made	Frumoasa	Water supply	10.6			O-M	UO
Săcele	Human made	Târlung	Water supply	18.3	-	37	M-E	UO
Brădişor	Human made	Lotru	Complex	38.0	-	-	M	H
Ialomiţa river basin								
Paltinu	Human made	Doftana	Water supply	62.3	215	107	E-H	O
Măneciu	Human made	Teleajen	Complex	58.0	192	-	H	O
Siret river basin								
Izvorul Muntelui	Human made	Bistriţa	Complex	1230.0	3000	90	M	M
Bâtca Doamnei	Human made	Bistriţa	Energy	10.0	235	16	E	O
Poiana Uzului	Human made	Uz	Water supply	90.0	335	75	E-H	M
Siriu	Human made	Buzău	Complex	158.0	360	-	E	O
Roşu	Natural barrage	Bicajel	Tourism		13	7.5	M-E	UO

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

The trophicity degree of the lakes within Romania's main river basins was determined by the analysis of the chemical aspects (according to the value of the nutrients) and the evolution of the aquatic cenoses (according to the value of the phytoplankton biomass). The given qualifications range among the following categories: hypertrophic, eutrophic, mesotrophic, oligotrophic and ultraoligotrophic, intermediate categories being added.

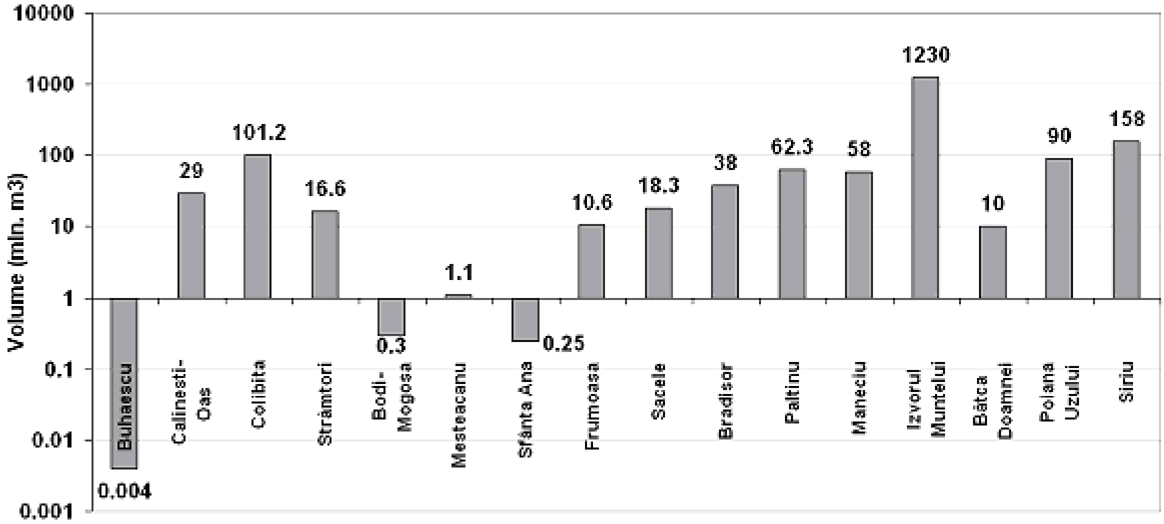

Fig. 4 Size of the lakes in the Eastern Carpathians according to water volume

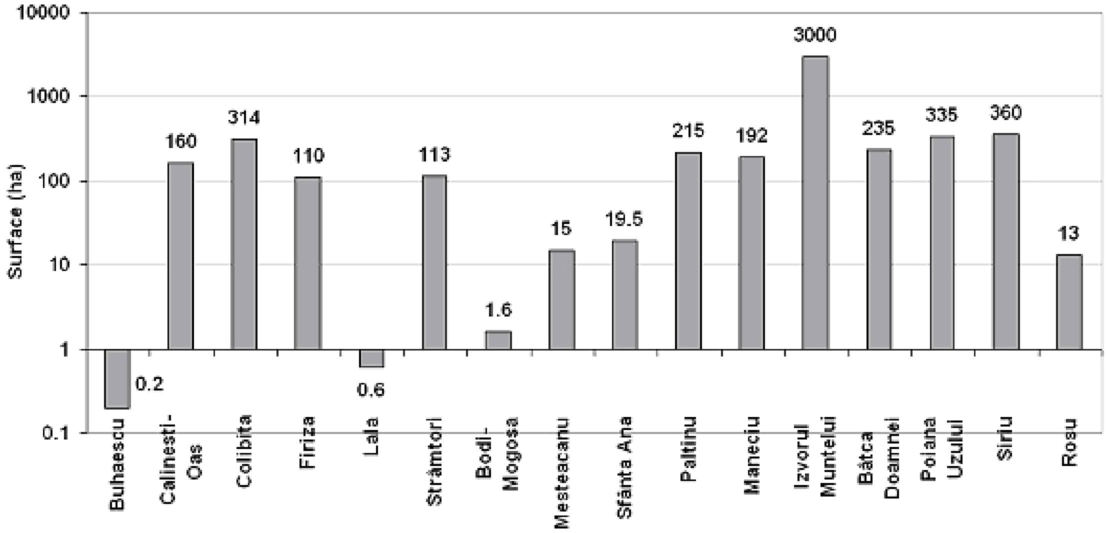

Fig. 5 Size of the lakes in the Eastern Carpathians according to surface

The eutrophic lakes are characterized by an important primary productivity, resulting in a high nutrient content. On the other side, the oligotrophic lakes have very reduced nutrient content, resulting in a low productivity. The mesotrophic lakes are situated between the two categories, with intermediate productivity. The hypertrophic and ultraoligotrophic lakes are situated at the two extremes.

**Table 2 Lacustrine waters trophicity according to the nutrients value
(Nutrients - total nitrogen, total phosphorous)**

River basin	Total number of lakes	Trophicity degree															
		UO		O		O-M		M		M-E		E		E-H		H	
		Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Tisa	2	-	-	-	-	-	-	-	-	1	50.00	1	50.00	-	-	-	-
Someș	5	1	20.00	-	-	-	-	-	-	-	-	2	40.00	2	40.00	-	-
Olt	5	-	-	-	-	1	20.00	2	40.00	2	40.00	-	-	-	-	-	-
Ialomița	2	-	-	-	-	-	-	-	-	-	-	-	-	1	50.00	1	50.00
Siret	5	-	-	-	-	-	-	1	20.00	1	20.00	2	40.00	1	20.00	-	-

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

The geographical location of the lakes within distinct landform units (mountains, hills and plains, littoral) creates a different background for the manifestation of the trophicity. We can notice the fact that, according to the value of the nutrients, most of the lakes (wetlands) are situated within the mesotrophic, meso-eutrophic, eutrophic, eutro-hypertrophic, and hypertrophic categories (17 of 19, meaning 88.49%). It is only in the mesotrophic category that 3 lakes (wetlands) are included (15.78%). Within the two extreme categories, 1 lake (wetland) is ultraoligotrphic (5.26%) and 1 lake (wetland) is hipertrophic (5.26%).

Fig. 6 Lala Lake in Rodna Mountains

Table 3 Trophicity of lake waters according to the phytoplankton biomass value (Biology)

River basin	Total no of lakes	Trophicity degree															
		UO		O		O-M		M		M-E		E		E-H		H	
		Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Tisa	2	-	-	1	50.00	-	-	-	-	-	-	1	50.00	-	-	-	-
Someş	5	2	40.00	2	40.00	-	-	1	20.00	-	-	-	-	-	-	-	-
Olt	5	3	60.00	-	-	-	-	1	20.00	-	-	-	-	-	-	1	20.00
Ialomiţa	2	-	-	2	100.00	-	-	-	-	-	-	-	-	-	-	-	-
Siret	5	1	20.00	2	40.00	-	-	2	40.00	-	-	-	-	-	-	-	-

*H-hypertrophic; E-eutrophic; M-mesotrophic; O-oligotrophic; UO-ultraoligotrophic.

According to the phytoplankton biomass value, a large number of lakes are included in the categories: ultraoligotrophic, oligotrophic and oligo-mesotrophic (13 of 19, representing 68.42%). In the mesotrophic category, 4 lakes are included (21.05%). A number of 6 lakes are included in the ultraoligotrophic category (31.57.5%) and 1 lake in the hypertrophic category (5.26%).

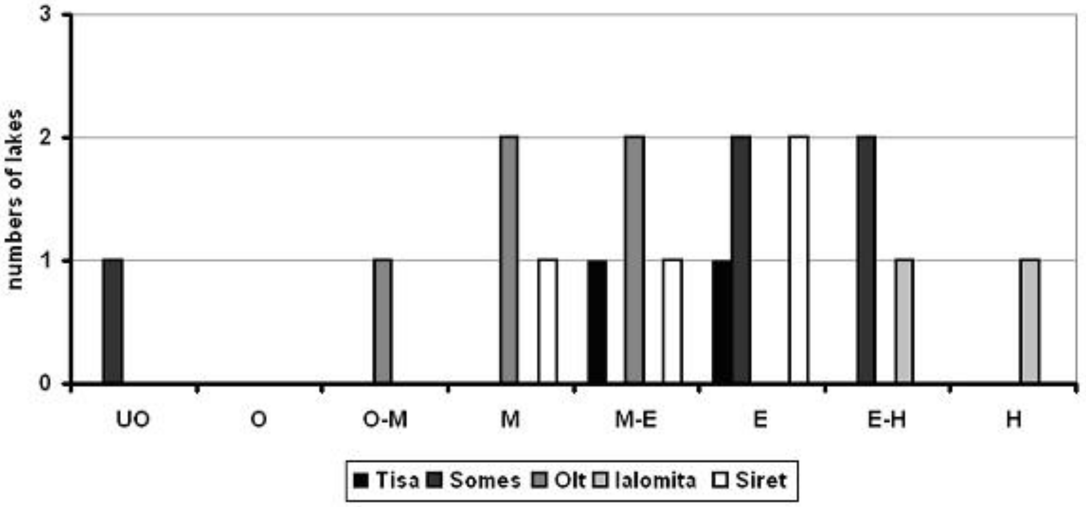

Fig. 7 The number of lakes distributed on river basins

Fig. 8 Roşu (Red) Lake in Hăghimaş Mountains

Most hypertrophic lakes are situated in low landform units, where temperatures are high and quantity of nutrients is extremely high (Maneciu). The most favourable area for a high trophicity is represented by the Danube flood plain (Romanian Academy, 1967).

The most ultra-oligotrophic lakes are found in the high mountain area. All the glacial lakes are included in this category (Lala). To these, the reservoirs with cold water, developed on hard rocks can be added.

In the area with the highest density of lakes there are lakes (aquatoriums) with good and very good trophicity (see the Siret and Olt river basins). Because of this reason, many of the accumulation lakes in the Siret and Olt basins are the most important aquatoriums for fishing industry.

Besides the climate, the trophicity is strongly influenced by the nature of rocks within the drained river basin, by the erosion rate, by transparency and turbidity etc.

From the point of view of trophicity, according to the data obtained by I.N.M.H. (2000), out of 95 lakes on the whole territory of Romania, 20 (21.05%) were oligotrophic, 20 (21.05%) oligo-mesotrophic, 33 (34.74%) mesotrophic, 11

(11.57%) meso-eutrophic and 11 (11.5%) eutrophic. As compared to the average value for Romania, the lakes in Eastern Carpathians include a higher proportion of the oligo-mesotrophic and mesotrophic category.

Fig. 9 Sfânta Ana Lake in Ciomatu Mountains

The general analysis of the lakes on Romania's territory (especially from the Eastern Carpathian Mountains) clearly demonstrates the fact that they are included, to the greatest extent, into the category of lakes with medium and high trophicity.

CONCLUSIONS

The number of the lakes (wetlands) in Romania and the Eastern Carpathian Mountains is relatively great, but their area is often reduced. Most lakes are anthropic, being mainly situated in the Northern Moldova and Transylvania. The most important analysed lakes (wetlands) were limited within river basins. In the present study the salty lakes in the salt massifs were not analysed, as they present different characteristics and they are used only therapeutically (Ocna Şugatag, Coştui etc.).

The trophicity degree is given by 5 main qualifications (hypertrophic, eutrophic, mesotrophic, oligotrophic, ultraoligotrophic) and separates the lakes on the territory of the Eastern Carpathian Mountains according to landform units and climate. The trophicity can also be influenced by the nature of rocks. According to the value of the nutrients, most of the lakes are included in the mesotrophic, mesoeutrophic, eutrophic, eutro-hypertrophic and hypertrophic categories. The lakes with the best trophicity are used for fishing as well.

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PARTICULATE MATTER AND NITROGEN DIOXIDE IN THE BRUSSELS AMBIENT AIR. TO WHAT EXTENT LOCAL EMISSION REDUCTIONS NEED TO BE DRASTIC TO ENABLE COMPLIANCE WITH THE EU LIMIT VALUES

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Abstract

Over the past 40 years ambient air quality in Brussels improved significantly. This was especially true for sulfur dioxide, lead, nitrogen monoxide, carbon monoxide, benzene and Benzo a pyrene. With respect to the air quality objectives imposed by the most recent European directive on air quality, 2008/50/EC, two major problems remain: nitrogen dioxide (NO2) and particulates (PM10 and PM2.5). Although the air quality objectives are met at several measuring sites in Brussels, a thorough analysis of data shows that it will be impossible to become fully compliant, in due time, in all of the different urban environments. A comparison of the average concentration levels in the Brussels Capital Region with those in the surrounding regions, the interpretation of the average daily and weekly concentration profiles and some special observations (e.g. car free Sundays) make clear that drastic emission reductions will be needed if compliance is to be assured solely by measures on the local scale.

Keywords: *air quality, particulates (PM10 and PM2.5), air quality objectives*

Rezumat

Microparticulele şi dioxidul de azot din aerul mediului ambiant din Bruxelles. Cât de drastice trebuie să fie reducerile locale de emisii pentru a respecta valorile limită impuse de UE. În ultimii 40 de ani calitatea aerului din Bruxelles s-a îmbunătăţit semnificativ. Acest lucru s-a remarcat mai ales la dioxidul sulfurat, plumbul, monoxidul de azot, monoxidul de carbon, benzenul şi benzo-pirenul. Obiectivele pentru calitatea aerului impuse de directivele europene recente referitoare la calitatea aerului, 2008/50/EC sunt dioxidul de azot (NO2) şi microparticulele (PM10 şi PM2,5). Deşi obiectivele referitoare la calitatea aerului sunt îndeplinite în câteva dintre locurile de măsurare din Bruxelles, o analiză minuţioasă a datelor indică faptul că este imposibil ca acestea să fie respectate. O comparaţie a nivelurilor medii de concentraţie din regiunea capitalei cu cele din regiunile înconjurătoare, interpretarea profilelor concentraţiilor zilnice şi săptămânale medii şi a câtorva observaţii (ex. duminicile când circulaţia maşinilor este interzisă) reflectă clar faptul că reducerea emisiilor este necesară dacă trebuie asigurată respectarea doar prin măsurile luate la nivel local.

Cuvinte-cheie: *calitatea aerului, microparticule (PM10 şi PM2,5), obiective pentru calitatea aerului*

INTRODUCTION

The Brussels Capital Region, situated in the centre of Belgium, has a population of 1,048,000 people (2008) and a surface of 161,4 km^2 and it represents about 19% of the Belgian GDP (gross domestic product). Due to the political reform of the Federal State in 1988, the three Regions in Belgium, Flanders, Brussels and Wallonia, have obtained full responsibility over Environmental matters. Air quality objectives imposed by the European Directives have to be transposed by the Member States and, in the case of Belgium, the legislation has to be adopted by the three Regional Parliaments. Thus, since 1988, meeting the environmental objectives on their territory is the responsibility of the Regional Governments.

On May 21, 2008, the European Commission sorted a new directive on ambient air quality and a cleaner air for Europe (*2008/50/EC*), integrating the former frame directive on air quality (*1996/62/EC*) and the subsequent daughter directives on SO_2, NO_2, PM10 en Pb (*1999/30/EC*), benzene and CO (*2000/69/EC*) and O_3 (*2002/3/EC*). The new directive confirms all previous defined air quality objectives limit values as well as target values and, for PM2.5, new air quality objectives are imposed. The subtle difference between the two types of objectives is hat limit values must be attained within a given period and may not be exceeded again once attained and that target values are to be attained where possible. The target values for arsenic, cadmium, nickel and Benzo a pyrene, imposed by the directive *2004/107/EC*, will be integrated at a later stage.

The state of the art and the compliance with the European objectives in the Brussels Capital Region are described in this paper. Two major problems remain: limit values concerning nitrogen dioxide (NO_2) and Particulate Matter (PM10) are still not respected.

2. EVOLUTION OF AIR QUALITY IN BRUSSELS - COMPLIANCE WITH EC-DIRECTIVES

2.1 Air Pollution Network

Systematic measurements for air pollutants in Brussels started in 1968 with the realization of a semi-automatic network for SO_2 and "Black Smoke". In the year 1973 a second semi-automatic network for "heavy metals" (e.g. lead) was added. From 1978 on, the telemetric network for the surveillance of the ambient air quality in real time became operational. Actually the Brussels telemetric network counts for 11 sites, located in different types of urban environments, measuring a selection of several pollutants: nitrogen oxide and dioxide, ozone, sulfur dioxide, carbon monoxide, carbon dioxide, benzene, mercury vapor and the PM10 and PM2.5 fraction of the suspended particulates (particulates with an equivalent diameter up to 10 or 2.5 µm). The presence of nitrogen oxides is measured in all 11 measuring sites, PM10 and PM2.5 respectively in 6 and 5 locations. More recently, in 2002, the network was extended with 2 traffic road tunnel stations for measuring NO, NO_2 and CO. Other semi-automatic networks for other classes of pollutants were also installed: measurements for VOC (volatile organic components) started in the period 1987-1994 and for PAH (polycyclic aromatic hydrocarbons), a few years later in 1999.

2.2 State of the art: Air Quality in Brussels

In the period 1970-1990 the observed concentrations for certain pollutants, especially SO_2 and lead (Pb) decreased drastically. For SO_2 this was mainly due to the lowering in several stages, of the sulfur content in combustion fuels and the gradual replacement of coal and liquid fuels by sulfur free natural gas for domestic heating. For lead, this result was obtained by limiting the quantity of Pb-additives in gasoline and, from 1989 on, by the use of Pb free gasoline. The evolution of the Pb concentration since 1973 for different types of stations is given in Fig. 1.

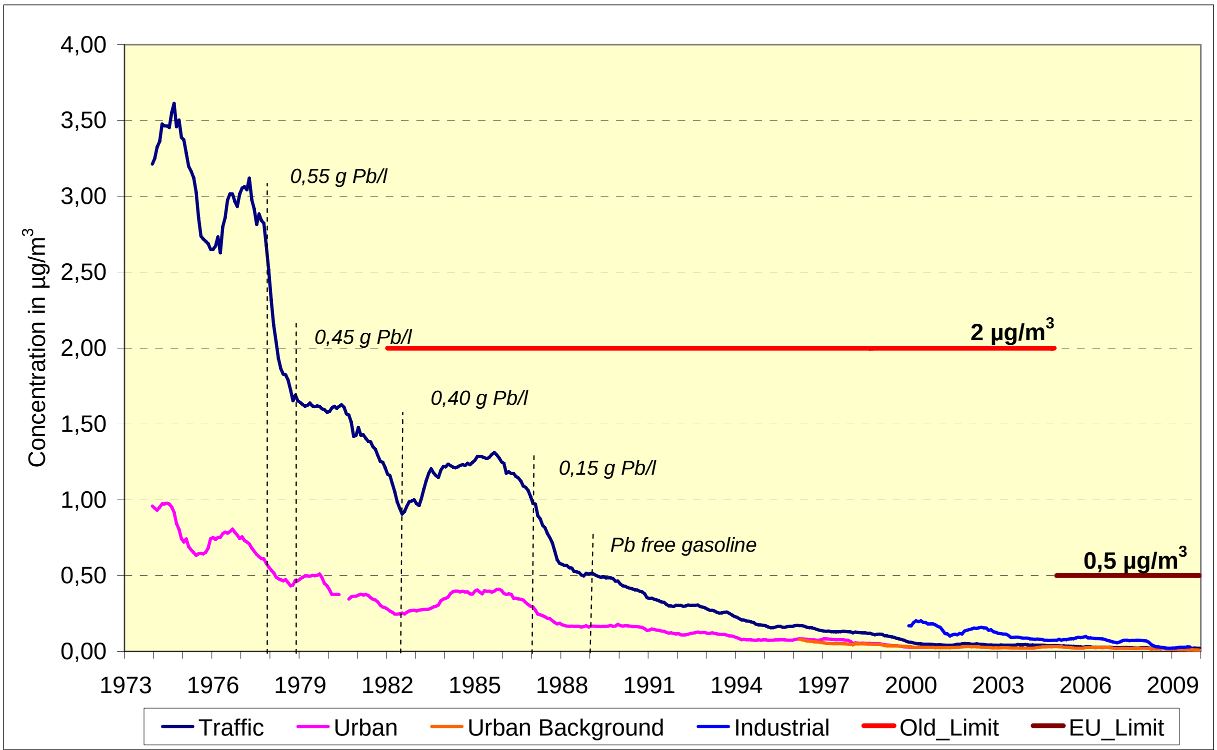

Fig. 1. Evolution of the Pb concentration [µg/m3] in Brussels between 1973 and 2009

Although these two problems seemed easily to solve, mainly by the systematic reduction of the pollutant content in the fuel, it took almost two decades to alter, on a large scale, the technology and production processes in use in some of the most important industrial and economic sectors such as power generation, refineries and the production of automotive engines.

In the same period traffic intensity increased significantly and the presence of traffic related air pollutants became the priority problem: nitrogen monoxide (NO), nitrogen dioxide (NO_2) and associated to it, ozone (O_3), volatile hydrocarbons (VOC) and suspended particulates. The pollutants are not necessarily present in the fuel, but may be formed as a by-product of the combustion processes. Nitrogen monoxide is formed by recombination, at high temperature, of small quantities of nitrogen and oxygen present in the combustion air. Other pollutants are generated by atmospheric reaction processes as it is entirely the case for ozone (secondary pollutant) and partially for NO_2 and particulates (secondary aerosol). Therefore, measures to reduce the concentration of these pollutants are not as easy to implement as it was the case for SO_2 and Pb. Moreover, the obtained concentration benefits will most certainly not be proportional to the local emission reduction efforts. For NO_2 and the related O_3 problem, a supplementary difficulty lies in the fact that NO_2 is thermodynamically the more stable component of the nitrogen oxides at ambient temperature and pressure.

Therefore NO_2 is always and anywhere present in sufficient quantities so that excessive ozone formation can take place when meteorological conditions are favorable to it. A decrease by more than 50% of the nitrogen oxides (NO_X) emissions from road traffic between 1990 and 2007, mainly due to the introduction of the 3-way catalyst on gasoline cars, and a concurrent shift towards diesel engines, led to a significant decrease of the NO-concentrations in traffic oriented measuring sites. Despite this favorable evolution, no clear tendency for the NO_2 concentrations (near status quo) has been observed so far.

Furthermore, the increasing number of diesel powered vehicles over the past decade did and does not help to reduce the ambient NO_2 concentration level. Up to now diesel engines do not have de-NO_X systems installed and, compared to gasoline engines, they have a higher NO_2/NO_X output ratio. In a Brussels road tunnel, the mean average NO_2/NO_X ratio (volume/volume) raised from 0.12 to 0.24 over the period 1989-2008.

In 1989, the year of introduction of the 3-way catalyst in Belgium, about 20% of the car fleet was composed of diesel cars. The increased prices for catalyst equipped gasoline cars and especially the continuation of the lower taxation on diesel fuel by the Federal State has led to a changeover to diesel cars. In 2008, about 80% of new sold cars were diesel cars and they now represent about 60% of the total car fleet.

A rough estimate based on the evolution of the composition of the car fleet between 1989 and 2008, the increase of the traffic volume and the total mileage, the relative importance of NO_X emissions from gasoline cars compared to those from diesel cars and the evolution of the NO_2/NO_X ratio measured in road tunnels, learns that an opportunity has been missed to lower significantly the NO_2 emissions originating directly from road traffic. If the composition of the car fleet would have stayed unchanged since the introduction of the 3-way catalyst in 1989, then the NO_2 traffic emissions should have been lowered by approximately 35% compared to the actual situation.

Over the period 1990-2007 the overall NO_X emissions in the Brussels Capital Region decreased from 10,388 to 4,848 tons/yr and the traffic related NO_X emissions from 6,974 to 2,391 tons/yr. The 3-annual average concentrations measured in a traffic oriented site, situated in a canyon street, respectively for the periods 1990-1992 and 2006-2008 showed a nearly proportional decrease for NO from 118 to 37 $\mu g/m^3$, but for NO_2 only a limited decrease from 58 to 54 $\mu g/m^3$ was observed. These evolutions are represented in Fig. 2. For the particulates (PM10 and PM2.5) the problem is even more complex. Besides the anthropogenic emissions (combustion, traffic, production processes, etc.), major contributions to the total mass concentration of the particulates in the Brussels ambient air are coming from airborne aerosol (formation of secondary particulates) and from the (re)suspension of the coarser PM fraction, particulates with an equivalent diameter between 2.5 and 10µm.

The introduction of the 3-way catalyst had also beneficial effects on the CO concentration in a traffic environment, with a nearly 80% decrease between 1991 and 2008 (1.62 to 0.33 mg/m^3 CO). Together with a reformulation of the gasoline it also led, since 1997, to a 75% decrease of the benzene levels from 8.4 to 1.9$\mu g/m^3$ in a traffic station.

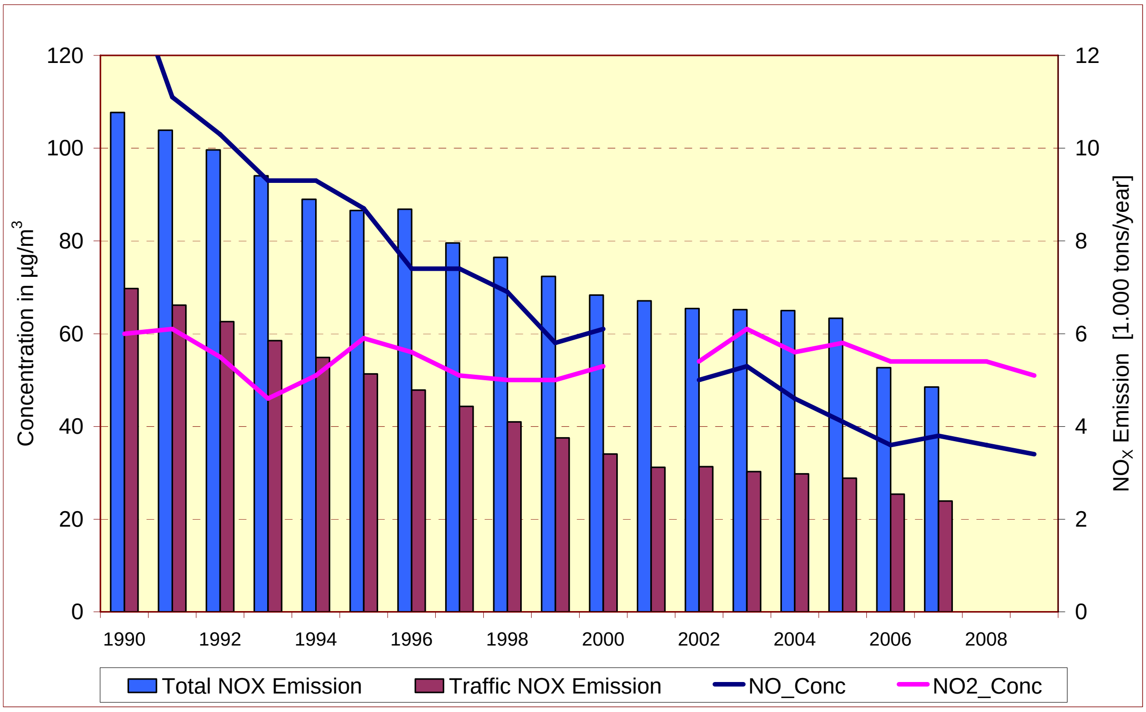

Fig. 2. NO and NO_2 – Evolution of the annual average concentration in a street canyon (1990-2009) and of the total and the traffic NOX emissions in Brussels (1990-2007)

The evolution of the benzene concentration between 1987 and 2008, for some stations in Brussels, is given in Fig.3. Over the past years (1999-2008), a clear decrease in the PAH levels originating from traffic was also observed.

2.3 Compliance with EC-directives

In the Brussels Capital Region the limit values for SO_2, Pb, CO (all had to be attained by 2005) and benzene (by 2010) are respected and they will stay respected in the coming years. The target values for arsenic, cadmium, nickel and Benzo a pyrene (all to be attained by 2013) are also respected. Problems remain with one limit value for NO_2 and one target value for O_3, both to be met by 2010, and one limit value for PM10, which had already to be met by 2005. In agreement with the regulations of the directive 2008/50/EC, a request for a postponement of the attainment date up to 2011 was send to the Commission, but by lack of proof of the efficiency of the proposed measures, this postponement was not granted to Belgium.

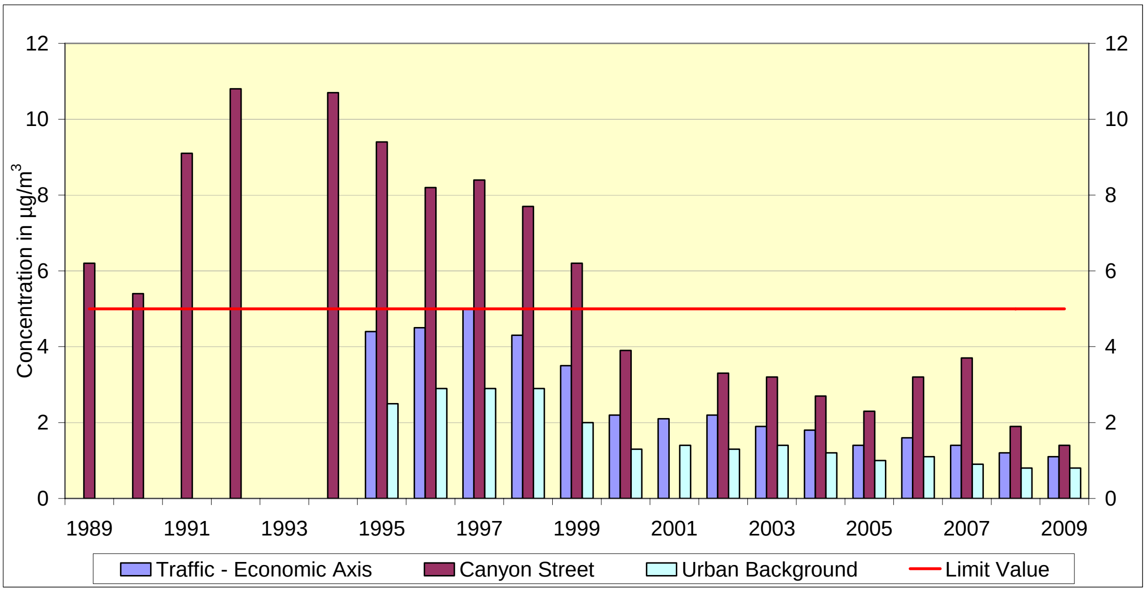

Fig. 3. Benzene concentration at different sites in Brussels

2.3.1 Nitrogen dioxide (NO_2)

The air quality directive specifies two limit values to be respected by 2010. First, the hourly value of 200µg/m^3 may not be exceeded more than 18 times during the calendar year. Second, the annual average concentration may not exceed 40µg/m^3. The limit value for the hourly values is respected up to now and it will probably stay so in the immediate future. The limit value for the annual average concentration however is not respected in all the measuring sites of the Brussels Capital Region. In 2010, the limit value will certainly be exceeded in at least 3 traffic oriented sites, while still no guarantee can be given for 5 other urban sites. The limit value will only be respected in 3 urban background sites that are protected from the direct influence of the local traffic.

Over the past few years (2004-2009) the annual average NO_2 concentration level reaches about 50 to 55µg/m^3 in a street canyon, about 42 to 46µg/m^3 at sites exposed to the traffic but situated in a better ventilated environment and about 37 to 43µg/m^3 in urban sites. The annual average concentration at urban background sites is about 27 to 30µg/m^3. If the emission activities of all working days would be replaced by the activities of the 'average Saturday', then the annual mean concentration would be around 48 to 52µg/m^3 in the street canyon, about 38 to 42µg/m^3 in the exposed sites and about 24 to 28µg/m^3 at the urban background sites as it can be seen in Fig. 4.

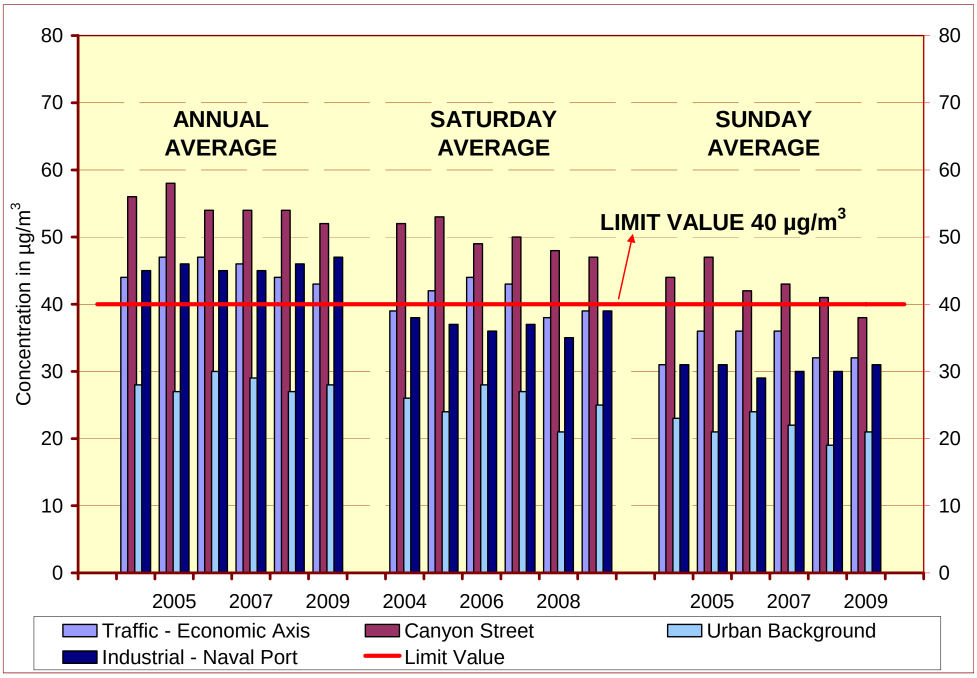

Fig. 4. NO_2 at different stations in Brussels - Comparison between the annual average concentration (left) and the mean concentration for Saturdays (middle) and Sundays (right) for the period 2004-2009

For the 'average Sunday' situation, the mean concentration would still be around 40 to 42µg/m^3 in the street canyon, about 30 to 35µg/m^3 in the exposed sites and about 20 to 24µg/m^3 in the urban background sites. The experience with the car free Sundays, organized in the second half of September (2002-2009), introducing a nearly complete ban of all private motorized traffic over the entire Brussels Region between 9:00 and 19:00 h local time, has clearly demonstrated the potential of reducing NO_2 concentrations significantly. It is important to state that this result has been and can be obtained by a drastic emission reduction that has its application only inside the Brussels Capital Region (Vanderstraeten, 2009); (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006).

Nevertheless, the realization of a permanent equivalent to such drastic emission reductions (e.g. car fleet virtually free of NO_X emissions) in the near future seems not very realistic. The obligation of lowering the NO_X emissions from diesel cars (EURO 6) by 2014, combined with different measures to reduce the traffic and the related NO_X emissions gradually but in a sustainable way, could be the start of an evolution that may lead to a significant decrease of the NO_2 levels and hence to compliance with the EU directive in all types of urban stations, traffic as well as non traffic oriented locations. However, before such drastic reductions will be realized, the NO_2 problem will probably stay on the agenda for the next decade. Taking into account that the lowering of the NO_X emissions from diesel cars will start only by 2013/2014 (EURO 6) and that, considering an average lifetime of 10 to 12 years for the vehicles, a minimum period of 4 years is to be counted before a substantial part of the diesel cars are replaced, a significant decrease in the NO_2 levels leading to compliance may not be expected before 2017/2018.

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2.3.2 Ozone (O_3)

The European directive specifies two target values for ozone, both to be met by 2010. First, during the calendar year, there may not be more than 25 days, averaged over 3 consecutive years, with a maximum daily 8-hour value above 120µg/m^3 ozone. Second, the AOT40 value, computed from the 1 hour values in the period May till July may not exceed 18.000µg/m^3.h, averaged over 5 years. This second obligation is respected and will probably stay respected during the following years. Up to now there is no absolute guarantee for respecting the first target value. The evolution over the past years shows indeed a decrease in the frequency of the peak values, e.g. the evolution of the number of hourly values higher than the information threshold of 180µg/m^3, but a slight increase in the annual average concentration.

During the period 1994-2008, the number of days with a maximum 8-hour value higher than 120µg/m^3 assessed at the urban background stations indicating the highest ozone levels, ranges between 13 and 39, resulting in a 3-year average between 17 and 25 days as is illustrated in Fig. 5.

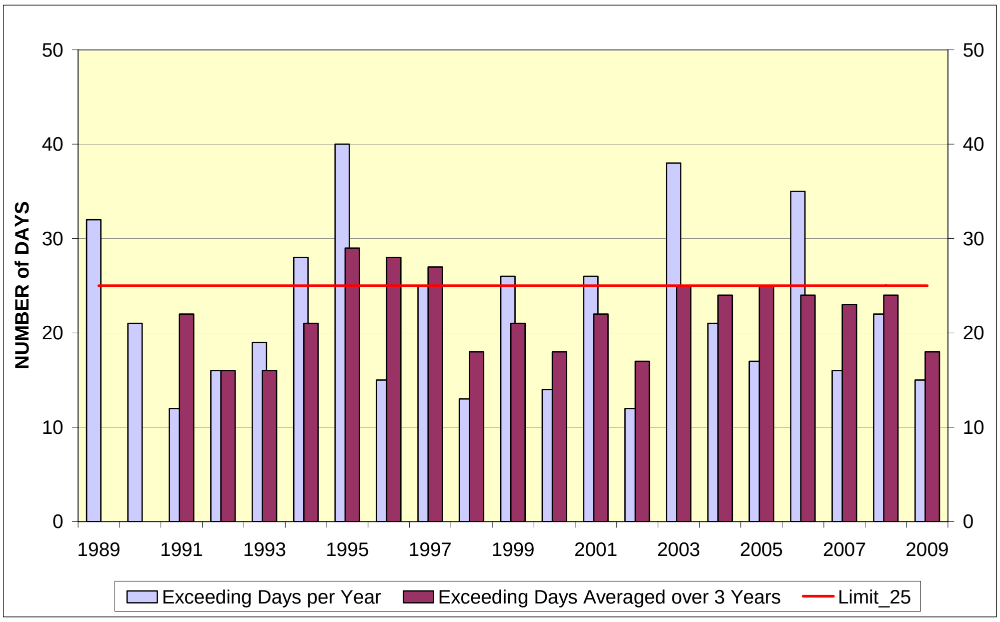

Fig. 5. Ozone at an Urban Background Site – Number of days, per Year and Averaged over 3 Years, with the maximum 8-hour value exceeding 120µg/m3 (Target Value)

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In view of the threat of global warming, with the risk for more frequent hot summer periods, and considering the already increasing average ozone concentration, some non compliances may eventually be expected in the forthcoming years. Because of the link with NO_2 and due to the non linearity of the ozone formation process, a solution for this problem will only be possible if the emissions of the ozone precursors (NO_2, VOC) are reduced significantly, on a large scale, and in a sustainable way. 2.3.3 Particulate Matter (PM10).

The air quality directive foresees two limit values for PM10 in ambient air, both of them had to be met by 2005. First the annual average concentration may not exceed 40µg/m^3. Second, during a calendar year, there may be no more than 35 days with a daily average concentration higher than 50µg/m^3. The limit value for the annual average is respected at all Brussels measuring sites since 2005. The limit value for the daily average is not respected now and it will probably remain so during the following years. This daily limit value is respected in the typical urban background sites, but it is systematically exceeded in the two measuring sites located along the industrial and economic axis of the Region. For these sites the annual number of exceeding days is ranging between 45 and 65. For the urban background site the number is between 15 and 40 and for the urban sites it is between 25 and 40.

For 2005, 2006, 2007 and 2009 it seems that the weekend days are well represented amongst the exceeding days, indicating that the limit value could eventually not be respected even for a year having a permanent weekend emission regime. For a selection of measuring sites and for the calendar years 2005 till 2009, the real number of exceeding days is represented at the left side of Fig. 6.

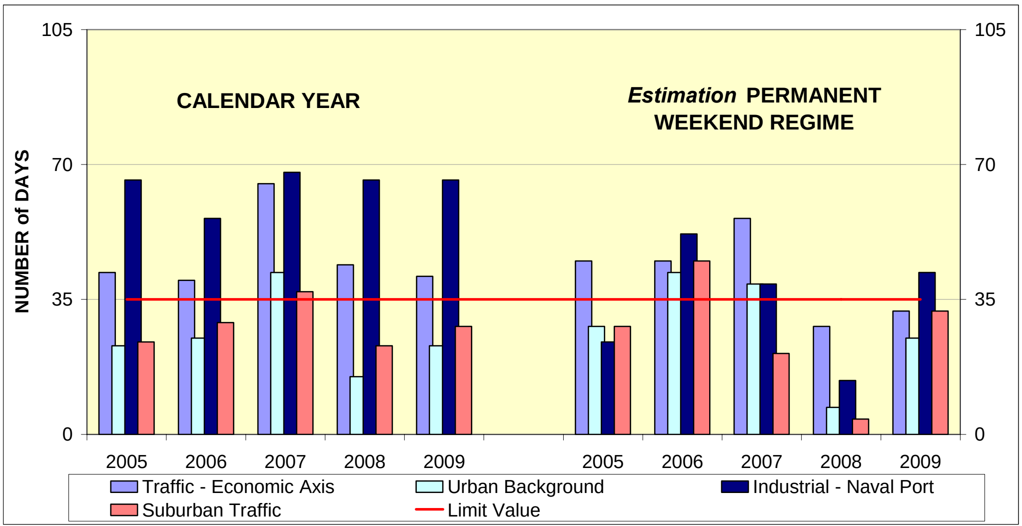

Fig. 6. PM10 – Number of exceeding days (left) for different measuring sites and the estimated result (right) for a permanent weekend emission regime (2005-2009)

These results are compared with, at the right of the graph, the number of exceeding days expected under a permanent weekend emission regime, as estimated by extrapolating the number of weekend exceeding days. In the Brussels Capital Region at least 3 different phenomena may lead, separately or by combination, to elevated PM10 concentrations and to an increased risk of exceeding the 50µg/m^3 limit value for the daily mean concentration.

- Meteorological conditions with poor dispersion, due to a temperature inversion and low wind speed, are a common factor resulting in high concentration levels for different pollutants. Under these conditions, mainly occurring in winter time, between December and February, high concentration levels are detected at all sites, inducing simultaneous PM10 exceeding values at several locations. In these cases the temporal evolution of the mass concentration for PM10 and for the gaseous pollutants (NO, NO_2) are quite similar.
- A second phenomenon, very important and still largely underestimated, is the formation of secondary aerosol during the period March-April and, to a lesser extent, September-October. The spreading of manure on a large scale, in the surrounding regions, before and after the agricultural season, releases a massive source of ammonia coming from the agricultural fields. At conditions of moderate temperature (8-20°C) and high Relative Humidity (80-90% RH) a stable secondary aerosol (Stelson, Seinfeld, 1982, pp. 983-992) is formed with ammonium nitrate as a main component. In these cases nearly 80 to 90% of the total PM10 mass concentration consists of

PM2.5, including volatile and/or possibly dissociating components that are mainly present within the PM2.5 fraction (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006). The concentration increases gradually and high PM10 concentrations, exceeding the daily limit value, are detected simultaneously over an extended area, much larger than the Brussels Capital Region. Furthermore, the temporal evolution of the PM mass concentration may be quite different from the temporal pattern followed by components that are more directly linked with the local traffic emissions, such as NO and NO_2 (Vanderstraeten, 2009); (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006). In April 2007, and again in April 2009, between 8 and 16 exceeding days were counted at the different measuring sites in Brussels, with secondary aerosol as a main contributor. Since the application of the daily limit value in 2005, PM10 exceeding values are most frequently observed (Fig. 7) during the spring, especially during the months March and April.

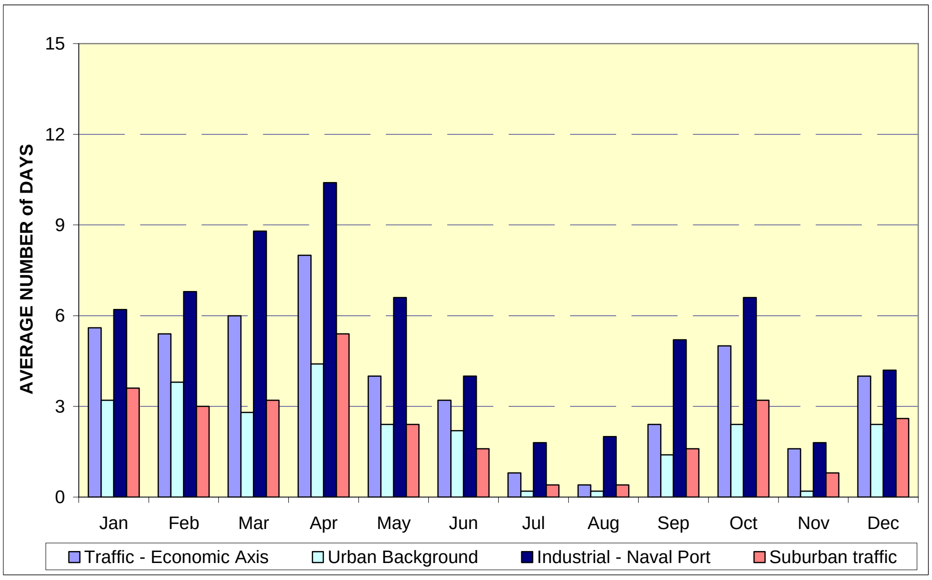

Fig. 7. PM10 – Averaged number of exceeding days per month. Period 2005-2009

- The third phenomenon, (re)suspension of the coarser fraction, is linked with the advection of dry air coming from the large sector East. Under these conditions and in the presence of a local source of the coarser fraction, these particulates (2.5 to 10µm) are suspended by a local activity, by the wind and/or by the turbulences created by the traffic. This may lead to the detection of high PM10 concentrations at a limited number of sites, situated close to the street or to a local source. In these cases PM2.5 represents only 40 to 50% of the total PM10 mass concentration and no volatile or dissociating material is detected. In the Brussels Capital Region, the second limit value for PM10, not more than 35 days with a daily concentration higher than 50 $\mu g/m^3$, is systematically violated at two different sites, the industrial site at the Brussels naval port (N043) and the traffic site (R001 - Molenbeek) located along the industrial and commercial axis. An analysis of the wind direction and classes of relative humidity, corresponding to the exceeding days, makes clear that, for these two sites, the excess of exceeding values is strongly correlated with the presence of dry air coming from the sector East. In Fig.8, for all six measuring sites and all exceeding days for the period 2006-2008, the percentage of the exceeding time for each of the main wind sectors is represented by the solid lines. The results are quite similar for four of the six PM10 stations, but they are much higher, for the large sector East, at the two sites situated along the commercial and industrial axis. Results much closer (hashed lines) to those of the four other sites are obtained when recalculating the percentages with omission of the exceeding days that are exclusive for one or both of these two sites, meaning that the additional number of exceeding days are strongly correlated with the large sector East. A similar exercise also reveals a strong correlation with the lower classes of Relative Humidity. The local presence of the coarser fraction is related to the storage and the handling of bulk material for construction purposes.

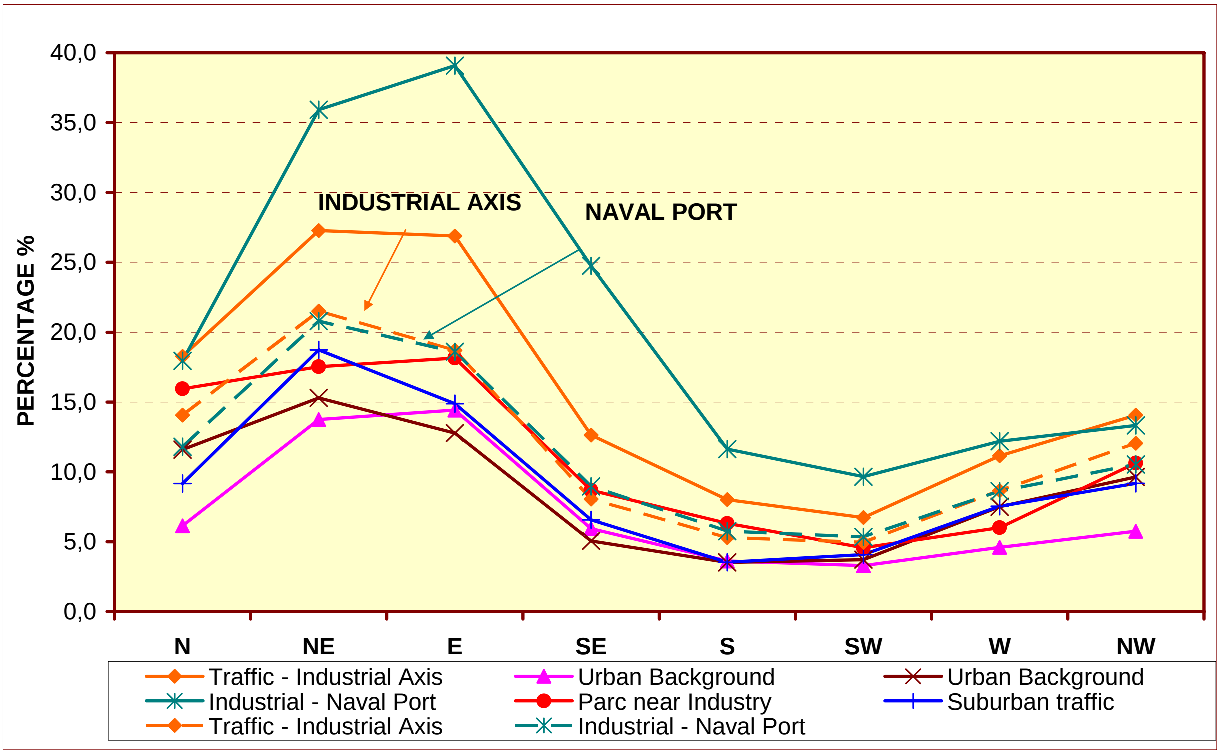

Fig. 8. PM10 – Percentage of Exceeding Time for the main Wind Sectors, computed at all six stations for all exceeding days during the period 2006-2008 (solid lines) – Percentage at the two sites along the industrial axis with omission of the exceeding days that are exclusive for these two sites (hashed lines)

These comprehensive observations do accentuate the complexity of the PM10 problematic. Due to the frequent formation of secondary aerosol, meeting the daily limit value in the near future, in all urban sites, may probably not be attainable solely by local emission reductions.

2.4 Traffic Impact on Concentration Levels for NO, NO_2 and PM10

From 1997 till 2007, the overall PM10 emissions from the Region have decreased from 496 to 280 tons/yr and the traffic related PM10 emissions from 345 to 202 tons/yr. During the same period the 3-annual average PM10 concentration in a traffic oriented station, situated in a well ventilated area, respectively for the period 1997-1999 and 2006-2008 has dropped from 46 to 32 µg/m^3. The emission inventory attributes 72% (in 2007) of the local PM10 emissions originating from traffic. However, the analysis of the measured concentrations, showing no linear link with the local emissions, indicates that the PM problematic is much more complex: major contributions are coming from anthropogenic emissions (traffic, combustion processes) but also from natural sources, from the suspension of the coarser PM fraction and from airborne aerosol (secondary particulates).

Figure 9 represents the normalized weekly pattern for the NO, NO_2, PM10 and PM2.5 concentrations during the period 2006-2008, averaged over 5 different measuring sites, excluding the results from the industrial site at the naval port. The result is obtained by dividing the mean concentration for each day of the week by the average concentration for working days. Compared to the situation for the working days of the week (Monday to Friday), the NO concentration falls by 40% on Saturday and by 60% on Sunday, corresponding to the order of magnitude of the decrease in traffic intensity. The NO_2 concentration falls only by 20 to 30% and the PM10 and PM2.5 concentrations only by 7 to 15%. The decrease of the concentration for NO_2 and PM during the weekend confirms that there is no proportionality with the local traffic emission reductions.

From the experience with the car free Sundays it became obvious that there was no clear sink in the concentration for PM10 or PM2.5 during the traffic ban hours and, unlike it is the case for the gaseous pollutants related to traffic, one could not observe a sharp and sudden concentration change at the begin nor at the end of the traffic ban period (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006).

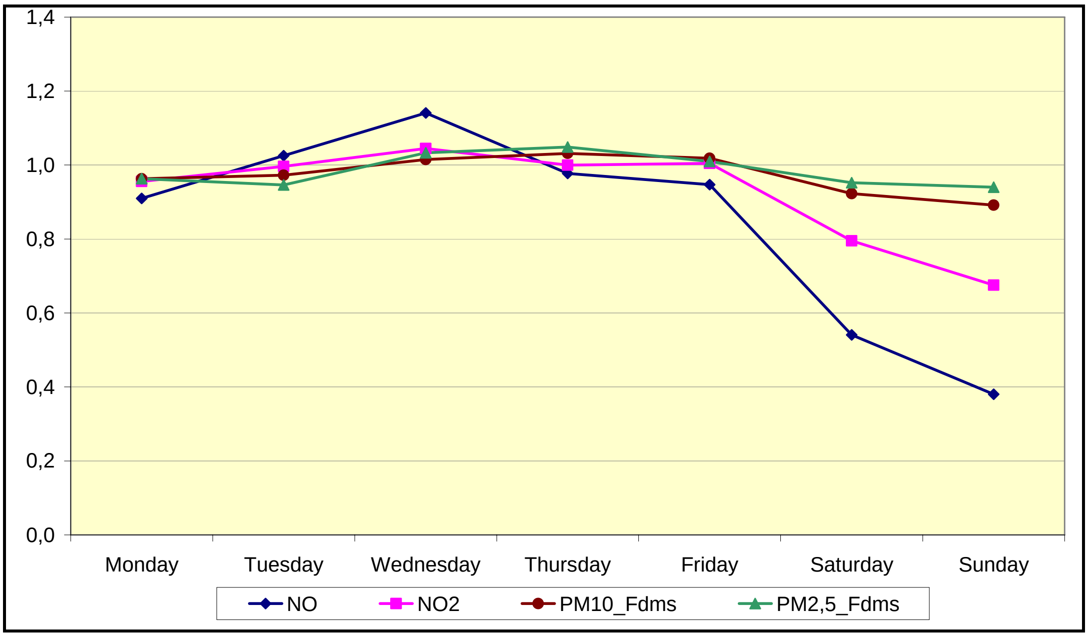

Fig.9. Average Weekly pattern for NO, NO_2, PM10 and PM2.5 – Average situation over 5 different measuring sites and 3 calendar years (2006-2007-2008)

The average concentration during the interdiction period (09:00-19:00 h local time) of the car free Sundays stayed at the same level as on an average Sunday.

The concentration difference between the more exposed sites close to the city centre and the urban background sites gives an indication of the PM10 quantity originating from the activities inside the city (about 30% coming from local activity). A comparison, over the past few years, of the average concentrations obtained at rural background sites and regional stations outside Brussels with those of the urban background and traffic stations inside the Brussels Capital Region enables to estimate the relative contributions to the local measured overall NO_2 and PM10 values. Estimated results for the average situation as well as for a winter pollution peak of poor dispersion are given in Tables 1 and 2.

On an average, for a canyon street, about 50% of the NO_2 concentration is related to the traffic inside the city and, at a well ventilated traffic environment, about 37% is from local origin. For PM10 this represents respectively 34.2% and 15.6%. For a pollution peak during the winter period, related to poor dispersion conditions of temperature inversion and low wind speed, the part of the PM10 concentration explained by local PM emission may increase, due to the accumulation effect, to about 42.3 and 22.7% respectively.

Table 1 Estimation of the relative contribution to the overall NO_2 concentration

Origin NO_2	Average situation	Winter Pollution Peak
Rural background	16.4%	15.7%
Trans regional	23.6%	39.2%
Urban background	10.9%	10.8%
Urban traffic	29.1%	31.4%
Street Canyon	20.0%	2.9%

Table 2 Estimation of the relative contribution to the overall PM10 concentration

Origin PM10	Average situation	Winter Pollution Peak
Rural background	39.0%	26.3%
Trans regional +Urban background	26.8%	31.4%
Urban traffic	12.2%	16.9%
Street Canyon	22.0%	25.4%

3. ACHIEVING COMPLIANCE BY LOCAL EMISSION REDUCTIONS?

Analysis of the NO_2 concentration levels in the city shows the relative importance of the local NO_X emissions, but it confirms also the relative high percentage already present in the incoming air masses. Therefore solutions to the problem should be shared by the different actors and authorities concerned. However a strict interpretation of the air quality directive by administrators risks to put the entire responsibility at the zone where a non compliance is established.

Analysis of the weekend situations have made clear that, in order to respect the limit values at all Brussels sites, NO_X emissions should be reduced permanently to those of the average Sunday activities, inside the city (~60% traffic reduction), as well as in the surrounding areas. If compliance is to be attained solely based on local emission reductions, then the local traffic, representing about 50% of the yearly average NO_X emissions (a higher percentage during summer) and probably more in a typical traffic environment, should become virtually free of NO_X emissions. With the introduction of EURO 6 by the year 2013/2014, NO_X emissions from diesel cars should start to decrease. Taking into account that the car fleet is renewed by approximately 10% each year, significant improvements of the annual average NO_2 concentration may only be expected beyond the year 2017/2018.

Analysis of the PM10 concentration showed that only about 30% of the total PM10 mass concentration in the Brussels urban area is related to the local particulate emissions. Assuming that the differences between the centre of the city and the cities background, for both the average concentration and the number of exceeding days, are mainly due to the local emissions activity, for which about 70 to 75% is originating from traffic, a reduction of at least 70 to 80% of the local traffic emissions should be realized in order to become compliant with the daily limit value. This is illustrated in Figure 10, comparing the number of exceeding days and the average PM10 concentrations between an urban background station (R012 – Uccle) and the traffic station situated near the city centre and along the economic axis (R001 – Molenbeek). Since particulate emissions from traffic are not limited to the direct emissions by the tailpipe, even such drastic reductions may not give full guarantee.

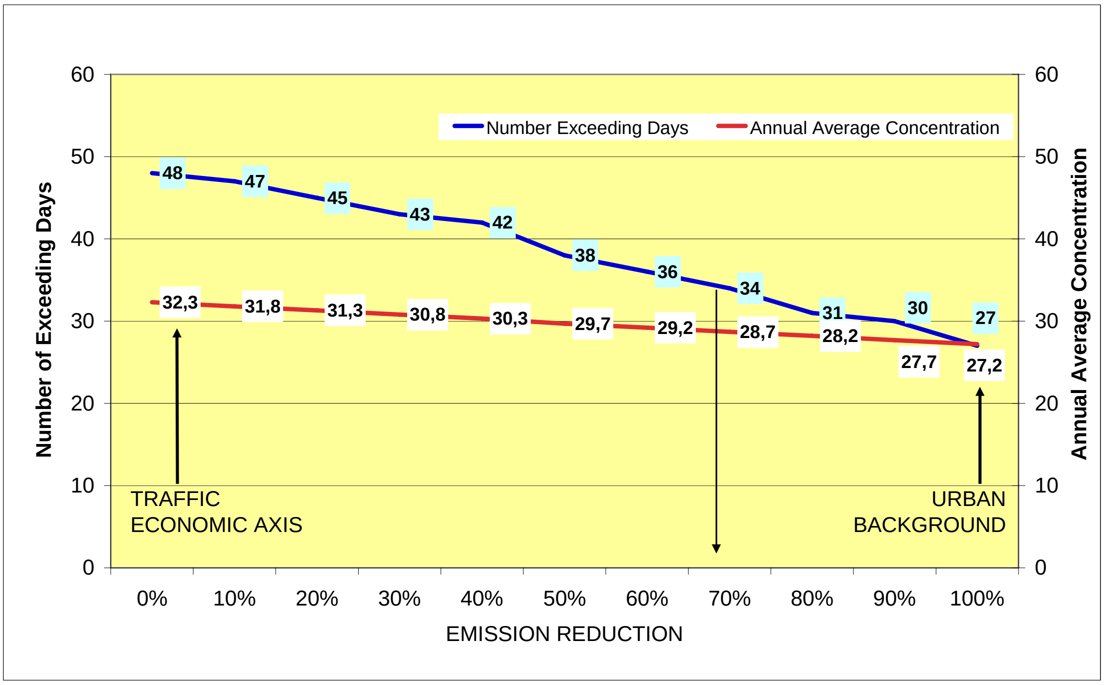

Fig. 10. Estimation of Local PM10 Emission Reduction needed for compliance at the traffic site along the commercial and industrial axis of Brussels

4. CONCLUSION

Considering the related health effects and its important role in the formation of ozone and secondary aerosol, together with the nearly unchanged concentration levels after 20 years of NO_X emission reductions, NO_2 can be seen as a key pollutant and meeting its air quality objectives as a major problem. Lowering the NO_2 concentration levels will be the challenge for the next decade. Compliance with the air quality objectives for NO_2 in all kinds of urban environments will hopefully be in reach by the end of the next decade. However lowering the NO_2 concentrations much further will probably be needed to meet the objectives for the related problems such as ozone and PM10. Up to now, no clear decrease of the NO_2 concentrations could be achieved. Therefore, drastic emission reductions, equivalent with a tendency to move towards a car fleet free of NO_X emissions, will be needed everywhere. In the Brussels Capital Region several measures have already been taken, but additional actions will be needed in order to limit the traffic related emissions.

To enable compliance with the EU limit values for NO_2 and PM10 in the future, solely based on local emission reductions, the Brussels NO_X emissions should be lowered by at least 60% and the PM emissions by 70 to 80%. A realization of such drastic emission reductions in the short term seems unrealistic because of the associated socio economic consequences. Nevertheless, a more ambitious emission reduction plan should be prepared. But in the attendance, one should be aware of the shared responsibility, especially when assessing non compliancy. Considering the significant role played by the background concentrations, even important local emission reductions will probably not be sufficient to meet the air quality objectives in the near future. Therefore drastic emission reductions on the national and international scale should also be considered in order to lower significantly the contribution of medium and long range transport of pollutants.

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HEAVY METALS IDENTIFIED IN AIRBORNE PARTICLES DURING WEEKEND PERIODS IN BRUSSELS URBAN ENVIRONMENT

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Abstract

There has recently been growing interest in the study of atmospheric particulate matter, specifically towards improved understanding of the long-term transport and impact of different elements of the lithosphere on atmospheric pollution. Close to the ground level, a fairly thin layer of the lithosphere and atmosphere, on both sides of their interface, serves as the major platform for human life and activity. Both the lithosphere and the atmosphere are mutually responsible for sustaining their natural equilibrium.

Investigations related to the studies of atmospheric particulate matter are intended to provide information that is still required for the implementation and the eventual revision of European standard tolerance norms for environmental protection. To this aim, WHO (the World Health Organization) and the EU (European Union) Working Groups on airborne particles are requiring additional information in this field.

Airborne particles of heavy metals, especially in overdose, may harm population health in a long or a short term. Our objective in the present study is to describe and compare the presence of heavy metals in the Brussels atmosphere during three days periods including Saturdays, Sundays and Mondays and their possible effect on human health. The heavy metals were divided into three main groups for: "high dangerous elements" (Pb, Sb, Cd and As); "non dangerous and low dangerous elements" (Sn, Cu, Ti, Cs, Bi, Zr, W, Ag, V, Ni and Al) and "micro-elements" (Co, Zn, Mn, Mg and Cr).

This study has been carried out during the period extending from September 2002 up to October 2003.

Keywords: *pollution, human health, atmospheric airborne particles*

Rezumat

Metalele grele identificate în particulele în suspensie în mediul urban din Bruxelles în week-end-uri. În ultima perioadă, a existat o preocupare mai intensă pentru studiul particulelor atmosferice, mai ales pentru o cunoaştere mai aprofundată a transporturilor pe termen lung şi sub aspectul impactului diverselor elemente ale litosferei asupra poluării atmosferice. În apropierea nivelului suprafeţei terestre, un strat destul de subţire al litosferei şi atmosferei, pe ambele laturi ale interfaţei lor, servesc drept bază a activităţii şi vieţii umane. Atât litosfera, cât şi atmosfera sunt reciproc responsabile pentru păstrarea echilibrului lor natural.

Investigaţiile legate de studiul particulelor atmosferice sunt menite să furnizeze informaţii care să fie necesare pentru implementarea şi eventuala revizuire a standardului european vizând normele de toleranţă pentru protecţia environmentală. În acest scop, OMS (Organizaţia Mondială a Sănătăţii) şi grupurile de lucru ale UE (Uniunii Europene) care se ocupă de particulele în suspensie solicită informaţii suplimentare în acest domeniu.

Particulele în suspensie ale metalelor grele, în special peste limita normală admisă, pot dăuna sănătăţii populaţiei pe termen lung şi mediu. Obiectivul nostru în cadrul studiului de faţă este să descriem şi să comparăm prezenţa metalelor grele în atmosfera oraşului Bruxelles pe parcursul a trei zile, incluzând sâmbăta, duminica şi lunea, dar şi posibilele lor efecte asupra sănătăţii umane. Metalele grele au fost divizate în trei grupe mari: „elemente foarte periculoase" (Pb, Sb, Cd and As); „elemente puţin dăunătoare sau deloc dăunătoare" (Sn, Cu, Ti, Cs, Bi, Zr, W, Ag, V, Ni and Al) şi micro-elemente (Co, Zn, Mn, Mg and Cr).

Acest studiu a fost realizat pe parcursul unei perioade cuprinse între Septembrie, 2002 până în octombrie, 2003.

Cuvinte-cheie: *poluare, sănătatea umană, particule atmosferice în suspensie*

INTRODUCTION

Airborne particles, or particles in suspension, are the common name for all kinds of solid particles freely floating in the surrounding air. In contrast with the gaseous components in the air, these particles are not made of pure substances, but, they may be constituted of several components that may be slightly different chemically (atomic elements), physically (shape, color, size, reflectance) as well as from the standpoint of their origin (Florig, 1997).

Smaller particles penetrate deeper in the respiratory system. Larger particles can reach only the pharynx or/and the larynx. In contrast, they are found in the atmosphere as suspended particles that penetrate the living bodies via the respiratory systems or, more generally, via their gas exchanges with the environment. The fraction of smaller particles (the thoracic fraction) penetrates farther in the rib-cage, in the wind-pipe and in the whole network of smaller radius airways up to the pulmonary alveoli (Fergusson, 1990). The heavy metals tend to concentrate in the body and cause damage in the kidneys, lungs, brain and nervous system and in the body metabolism (Fergusson 1990).

When the 1999/30/CE European Commission directive came into effect, the PM10 fraction of airborne particles has been declared an essential parameter for evaluating the quality of air and its effects on human health. At that time, the PM2.5 fraction of airborne particles was not a mandatory parameter although its evaluation was strongly recommended. The more recent EU directive 2008/50/CE however clearly imposes air quality objectives to be met for PM2.5 in the near future.

The choice of the PM10 fraction as a health parameter can be defended as it includes both the PM2.5 fraction of thin particles (diameter < 2.5 μm) that penetrates deeply in the respiratory system and the larger particles (from 2.5 μm to 10 μm).

Heavy metals are defined as metals having specific gravity greater than $5gr/cm^{-3}$. Heavy metals elements are frequently associated to harmful influence on the environment (Fergusson, 1990, Alloway, 1990). Among these elements, metals such as cobalt, chromium, molybdenum, iron, nickel, selenium, tin, vanadium and zinc, are consumed in very low amounts by living organisms for their metabolism. Other elements, however, may become toxic in higher concentrations. As for cadmium, mercury and lead, these elements have no metabolic function in the human body (Sawidis et al., 2004). The importance of heavy metals in the environmental conditions comes from their harmful effects on public health. These health effects are due to the carcinogenic and mutagenic properties of these metals when they are in overdose in the environment. Regarding the exposure time and concentration level, these effects and their intensity may be quite different.

Furthermore, when concentrated in industrial products such as paints, chemicals, glasses, batteries, cars, electronics, textile or engines, these chemical elements may reach the aquifers through water sewage systems, thereby leading to their consumption by living organisms (Rühling and Tyler, 2004).

In the present study, we limited our scope to the quantitative investigation concerning the presence of heavy metal elements in the airborne particles found in Brussels urban area. More precisely, we compared the amount of these elements during consecutive Saturdays, Sundays and Mondays, i.e. days of reduced activity, days of inactivity and days of normal activity. This study has been carried out during the period extending from September, 2002 up to October, 2003.

METHODS AND EXPERIMENT DESIGN

PM10 measurements in Brussels-Capital Region, using continuous monitoring, are more recent than the measurements for the gaseous pollutants. Established in 1996 with two PM10-systems (oscillating microbalance R&P TEOM 1400-Ab), the network now contains six PM10 monitors. These analyzers are installed in Molenbeek, Uccle, Haren, Berchem, Meudon Park and Woluwe. By 2005 all TEOM PM10 analyzers were equipped with FDMS systems. With the exception of the Woluwe site, PM2.5 analyzers of the same type are installed at all PM10 measuring sites. The PM2.5 sampler consists of a PM10 impact or connected to a PM2.5 cyclone.

At two of these stations, Uccle and Woluwe (IBGE-BIM) and also at the University of Brussels (ULB-Campus Plaine), additional 24-hour sampling (Airborne Particle Samplers) was carried out on filter membranes for the chemical and physical speciation of the airborne particles (Vanderstraeten et al., 2007). For the present research, a SEM (Philips Scanning Electron Microscope) was used for determining the composition of the particulates sampled on Saturdays, Sundays and Mondays. Because the SEM energy dispersive technique can focus on very small particles and resolve even trace amounts, we consider this determination to be reliable.

RESULTS AND DISCUSSIONS

The present investigation deals only with the percentage of the above-described heavy metals among all the elements found during the study period, extending from September, 2002 up to October, 2003.

The objective was to compare the variation of the heavy metal percentage in airborne particles in Brussels urban area between days of partial activity

- Saturdays, days of very low activity - Sundays and days of full activity - Mondays.

Heavy metals identified in airborne particles during weekend periods plus Mondays in Brussels Urban Environment (Fig. 1) were divided to three main groups according to their effect on human health: 'high dangerous', 'non dangerous' and 'low dangerous elements' and 'micro-elements' (Table 1).

When a concentration is higher on Monday than during the weekend (f.i. Pb, Cu and Zn), then traffic could be a main reason (in Brussels there is no large non ferrous industry) – this can be seen when looking at the differences between Uccle site (background) on one hand and Woluwe and ULB site on the other – this should be developed and discussed.

Table 1: Heavy metals in airborne particles as divided to three groups by their effect on human health

Category	Elements
High dangerous elements	Pb and Sb
Non dangerous and low dangerous elements	Sn, Cu, Ti, Cs, Bi, Zr, W, Ag, V, Ni and Al
Micro-elements	Co, Zn, Mn, Mg and Cr

The elements of the first group, Pb and Sb are toxic to human body and therefore are highly dangerous (no Cd and As were found in the particles of the airborne atmospheric samples). Within this first group, lead (Pb) is a poisonous metal that can damage nervous connections (especially at young children) and cause blood and brain disorders. Lead poisoning typically results from ingestion of food or water contaminated with lead; but may also occur after accidental ingestion of contaminated soil, dust, or lead-based paint. Long-term exposure to lead or its salts (especially soluble salts or the strong oxidant PbO_2) can cause nephropathy and colic-like abdominal pains. The effects of lead are the same whether it enters the body through breathing or swallowing (Needleman et al., 1990). Antimony (Sb-Stibium) and many of its compounds are toxic. Clinically, antimony poisoning is very similar to arsenic poisoning. In small doses, antimony causes headache, dizziness and depression. Larger doses cause violent and frequent vomiting, and will lead to death in a few days. The EU upper limit for tap water is 5 µg/L (Shotyk et al., 2006).

The second group contains: Sn, Cu, Ti, Cs, Bi, Zr, W, Ag, V, Ni and Al. These elements are biocompatible (non-toxic and they are not rejected by the body). Tin (Sn) plays no known natural biological role for humans. As tin itself is not toxic, most tin salts are (Blunden and Wallace, 2003). Copper (Cu) toxicity can occur from eating acidic food that has been cooked with copper cookware. Cirrhosis of the liver in children has been linked to boiling milk in copper cookware. A genetic defect is associated with this cirrhosis. Since copper is actively excreted by the normal body, chronic copper toxicosis in humans without a genetic defect in copper handling has not been demonstrated. However, large amounts (gram quantities) of copper salts taken in suicide attempts have produced acute copper toxicity in normal humans. Equivalent amounts of copper salts (30 mg/kg) are toxic in animals (Merck Manuals, 2005). Titanium (Ti) is used in a gamut of medical applications including surgical implements and implants, such as hip balls and sockets (joint replacement) that can stay in place for up to 20 years. Caesium (Cs) salts have been evaluated as antishock reagents to be used following the administration of arsenical drugs. Because of their effect on heart rhythms, however, they are less likely to be used than potassium or rubidium salts. They have also been used to treat epilepsy (Butterman et al., 2004). Bismuth (Bi) is not bio-accumulative. Its biological half-life for whole-body retention is 5 days but it can remain in the kidney for years in patients treated with bismuth compounds (Fowler, 1986). Short-term exposure to zirconium (Zr) powder can cause irritation, but only contact with the eyes requires medical attention. OSHA recommends a 5 mg/m^3 time weighted average limit and a 10 mg/m^3 short-term exposure limit (NIOHS, 2008). Tungsten (W) has not been found to be necessary or used in eukaryotes, but it is an essential nutrient for some bacteria (Lassner, 1999). Silver ions and silver compounds show a toxic effect on some bacteria, viruses, algae and fungi, but without the high toxicity to humans that are normally associated with these other metals (Chopra, 2007). Vanadium (V) plays a very limited role in biology. A vanadium-containing nitrogenase is used by some nitrogen-fixing micro-organisms (Schwarz and Milne, 1971). Nickel (Ni) plays important roles in the biology of microorganisms and plants. In fact urease (an enzyme which assists in the hydrolysis of urea) contains nickel. Exposure to nickel metal and soluble compounds should not exceed 0.05 mg/cm^3 in nickel equivalents per 40-hour work week. Nickel sulfide fume and dust is believed to be carcinogenic. Sensitized individuals may develop an allergy to nickel, affecting their skin, also known as dermatitis (Barceloux and Barceloux, 1999a; Sigel et al. 2008). Despite its natural abundance, aluminium (Al) has no known function in living cells and presents some toxic effects in elevated concentrations. In very high doses, aluminium can cause neurotoxicity, and is associated with altered function of the blood-brain barrier.

The third group includes Co, Zn, Mn, Mg and Cr. These elements are needed by human body and plant tissues in limited quantities (ppm or less) (Table 1). Cobalt (Co) is essential to all animals, including humans. It is a key constituent of cobalamin, also known as vitamin B_{12}. A deficiency of cobalt leads to pernicious anemia, a lethal disorder. Pernicious anemia is however very rare, because trace amounts of cobalt are available in most diets. The presence of 0.13 to 0.30 mg/kg of cobalt in soils markedly improves the health of grazing animals (Kobayashi and Shimizu, 1999). Zinc (Zn) is an essential trace element, necessary for plants, animals and microorganisms. Zinc is found in nearly 100 specific enzymes, serving as structural ions in transcription factors and being stored and transferred in metallothioneins. It is the second most abundant transition metal in organisms after iron and it is the only metal which appears in all enzyme classes. In proteins, Zn ions are often coordinated to the amino acid side chains of aspartic acid, glutamic acid, cysteine and histidine. There are 2-4 grams of zinc distributed throughout the human body. Most zinc is in the brain, muscle, bones, kidney, and liver, with the highest concentrations in the prostate and parts of the eye. Semen is particularly rich in zinc, which is a key factor in prostate gland function and reproductive organ growth (Berdanier et al., 2007). Nevertheless, although Zinc is an essential requirement for good health, the excess of zinc can be harmful. Excessive absorption of zinc suppresses copper and iron absorption. The free zinc ion in solution is highly toxic to plants, invertebrates, and even vertebrate fish (Eisler, 1993). Manganese (Mg) is an essential trace nutrient in all forms of life. The classes of enzymes that have manganese cofactors are very broad and include oxidoreductases, transferases, hydrolases, lyases, isomerases, ligases, lectins, and integrins. The best known manganese-containing polypeptides may be arginase (Emsley, 2001). The human body contains about 10 mg of manganese, which is stored mainly in the liver and kidneys. In the human brain, manganese is bound to manganese metalloproteins most notably glutamine synthetase in astrocytes (Takeda, 2003). Trivalent chromium (Cr^{3+}), even in trace, has an influence on the metabolism of sugar and lipid in humans. In the United States the dietary guidelines for daily chromium uptake were lowered from 50-200µg for an adult to 35µg (adult male) and to 25µg (adult female). Acute oral toxicity ranges between 1500 and 3300µg/kg (Barceloux and Barceloux, 1999b).

In figure 1, the measured percentage of the atomic weight of the heavy metals with respect to the total weight of the particles collected on Saturdays, Sundays and Mondays is given. Concerning the 'highly dangerous' group, Pb weight percentage in the environment has been decreasing between Saturdays and Sundays (variation of -0.38%). Ni and Al weight percentage in the environment increased between Saturdays to Sundays (variations of 0.42% and respectively, 0.45%). Pb, Cu and Al percentage increased between Sundays and Mondays (variations of 0.62%, 0.69% and respectively, 0.26%).

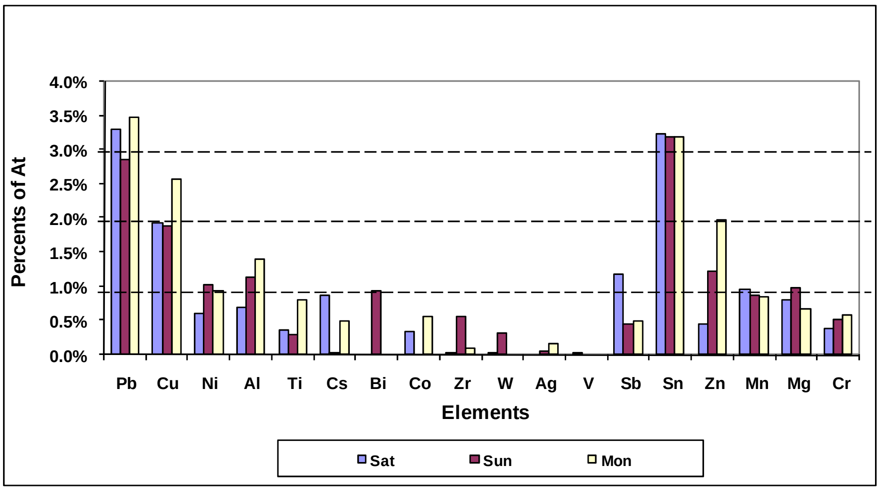

Fig. 1 The daily changes of the heavy metal elements identified in airborne particles during weekend periods in Brussels Urban Environment

As for the second 'dangerous' group: Ti, Cs, Co and Ag, concentrations increased between Sundays and Mondays (variations of 0.5%, 0.46%, 0.56% and respectively, 0.09%), while Bi, Zr and W peaked during Sundays. In the 'micro-elements' group, Zn showed high increase from Saturdays, Sundays to Mondays: the weight percentage of Zn has been 0.44%, 1.22% and respectively, 1.98%. The observed changes in the weight percentage of the heavy metals elements between the reduced working days (Saturdays), rest days (Sundays) and full working days (Mondays) might be explained by the different intensity of the industrial activities and transportation and the specific mechanism of the re-suspension of the airborne particles (Vanderstraeten et al., 2006).

'Heavy metals' is a contraversed term used to define high density metals. However, their toxicity is without any doubt and any atmospheric pollution in urban environment, and, in particular, in the region of Brussels, could lead to serious consequences on its inhabitants' health.

Henceforth, in future investigations, it would be necessary to further improve the understanding of the relations between atmospheric pollution by heavy metals, their sources and their correlated specific diseases.

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INDEX OF INDOOR AIR CHEMICAL POLLUTION IN BRUSSELS HABITAT

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Abstract

An index of indoor chemical pollution has been developed on the basis of more than 1200 surveys in dwellings conducted by the Regional Unit for Indoor Pollution Intervention (French acronym CRIPI) in the Brussels-Capital Region. This tool is intended for giving assistance in medical diagnosis. It provides a rapid evaluation of the contamination level by volatile organic compounds of a dwelling. It is also useful in cases where one of the most frequently found compound shows a particularly high concentration. The index has been developed for benzene, toluene, pinene, limonene, triclorethylene, tetrachlorethylene and formaldehyde. It allows for facing the lack of reference standard in Belgium.

Keywords: *indoor pollution, VOC, chemical index*

Rezumat

*Indicele poluării chimice a aerului din interior în habitatul din Bruxelles***.** S-a dezvoltat un indice al poluării chimice interioare pe baza a peste 1,200 de analize efectuate în locuinţe de Unitatea Regională pentru Intervenţia în caz de poluare în interior (CRIPI prescurtarea din franceză) din Bruxelles – capitala regiunii. Acest instrument poate oferi asistenţă în diagnosticarea medicală. Acesta oferă o evaluare rapidă a nivelului de contaminare a unei locuinţe cu compuşi organici volatili. De asemenea, acesta este util şi în cazurile în care unul dintre cei mai frecvenţi compuşi găsiţi indică o concentraţie relativ mare. Indicele a fost dezvoltat pentru benzen, toluen, pinen, tricloretilenă şi formaldehidă. Acesta permite înfruntarea cu lipsa de standarde de referinţă din Belgia.

Cuvinte-cheie: *poluarea aerului din interior, COV, indice chimic*

INTRODUCTION

For nine years, a service of analysis of indoor air pollution has been established in Brussels-Capital Region. This service meets the increasing demand for a monitoring of environment-related diseases.

Much of our time is spent indoor, whether at home, at work, or during leisure activities. The prevalence of allergic diseases has been increasing over recent decades in the Western world. Young children are of special concern since most of them spend the first years of their lives in kindergartens or schools. An early exposure to indoor air pollution enhances the risk of acute lower respiratory system infections in children under 5 years old.

Indoor pollution is a major problem among environmental pollution nuisances to health. Pollutants from either chemical or biological origins may have multiple and varied sources. They range from building materials to furniture through tiled floors, paints, combustion and heating devices, cleaning products, pets and more.

To address this issue, the Regional Unit for Indoor Pollution Intervention (French acronym CRIPI) provides assistance to medical diagnosis when a physician suspects that a health problem may be related to the patient's habitat. A set of chemical and biological samples is collected from the patient's home. These samples are then analyzed, identified and quantified, as well as their potential sources. This environmental diagnosis is completed by recommendations and advises to residents in order to reduce or even eliminate the nuisances [1].

Between September 2000 and December 2009, some 1,200 dwelling's surveys were conducted on medical demand. The physicians requesting the intervention of the CRIPI Unit were mostly general practitioners (64%), however, pediatricians (15%) and lung specialists (10%) also made use of this service. The health problems mentioned were mainly airway respiratory diseases (rhinitis, pharyngitis, and sinusitis) and lower airway respiratory diseases (chronic cough, asthma, bronchitis). Respiratory problems are common amongst children: indeed 30% of the enquiries made by CRIPI were for patients between the ages of 0 to 6, half of these were aged under 2 years old. In recent years, skin diseases, general symptoms such as headaches and atypical discomfort as health problems related to indoor environment have been mentioned in an increasing number of enquiries made by CRIPI. That phenomenon was recalled mainly for adults.

The objective of this work is to set up a tool to support the physician to easily understand the general information on the chemical pollution status of the dwelling. This tool is first based on analytical results of volatile organic compounds concentrations in the air. Further studies are required for analyzing the chemical composition of fine particles in suspension, as well as their micromorphology.

METHODS AND INSTRUMENTATION

The enquiries were conducted in the 19 administrative districts of the Brussels-Capital Region, both in poor and wealthy neighborhoods. The distribution of the number of investigations is shown in Figure 1. Patients were either owners or tenants of the investigated dwellings. Twenty percent of requests came from social housing.

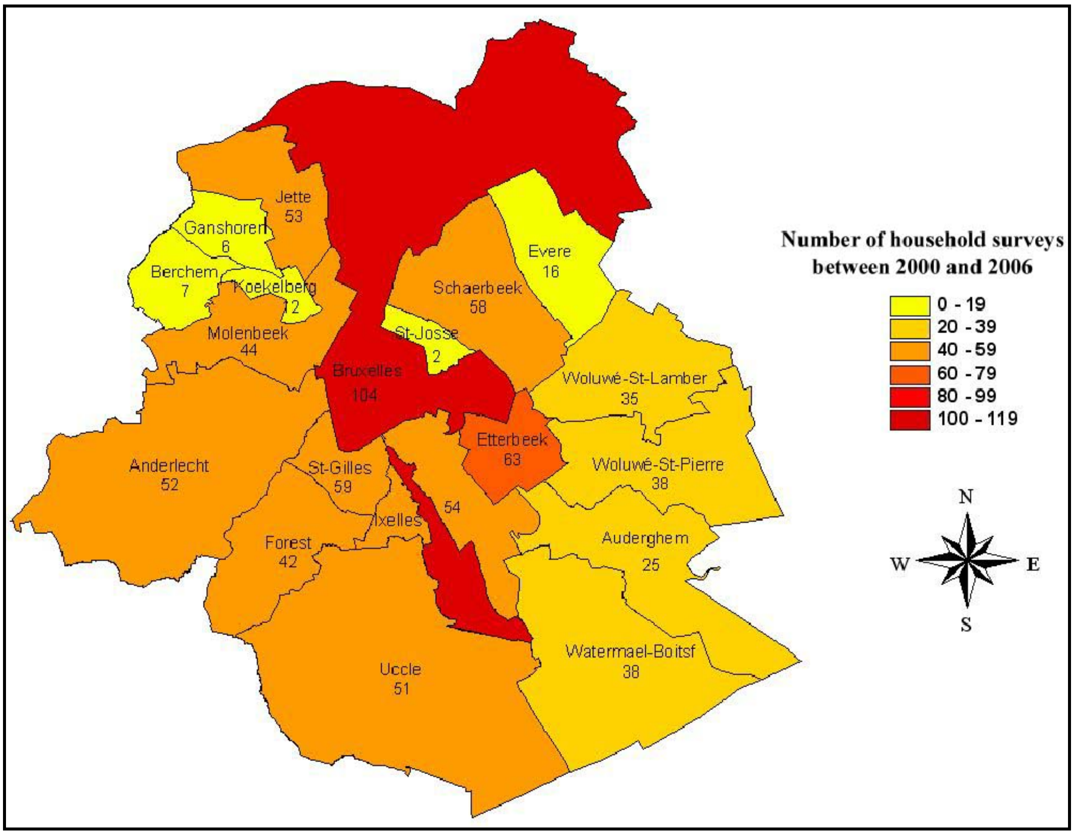

Fig. 1 Map of Brussels-Capital Region districts giving the number of surveys per district

The investigation at each home included three parts: the completion of a questionnaire by the inhabitant, if possible the patient; chemical and biological sampling of the habitat. The questionnaires are dealing with health problems, maintenance and ventilation of the home and were designed in order to obtain the best possible inventory of potential sources of indoor pollution.

Biological samples were collected following a decision-tree based on a preliminary visual examination at the air, surfaces and dust on walls, furniture and mattresses (for the determination of mite allergens and possible mold). Samples were taken from the main living rooms and from outside [2, 3].

At the chemical level, samples of air were taken using a passive radial diffusion device (Radiello's) filled with TENAX for adsorption of volatile organic compounds such as benzene, toluene, xylene, chlorinated terpenes etc. The complete sampling procedure took in average one hour. The compounds retained on the cartridges were subsequently thermally desorbed. For the determination of pesticides, dust from carpets was collected by sucking up a surface of 1m ² for 1 minute using a vacuum cleaner with a special tip (1200W). Pesticides were then extracted using a mixture of ether / hexane (5: 95).

The analysis of VOCs (Volatile Organic Compounds) and pesticides was carried out by gas chromatography coupled with mass spectrometry (GC-MS). The results were expressed in µg/m³ of air for VOCs and mg / kg of dust for pesticides.

Among the measured VOCs, limonene and α-pinene compounds were generally present at the highest concentration. These substances, considered as irritants, are mostly generated by air fresheners, household cleaners and waxes for furniture. In Austria, the guideline value for the sum of terpenes is 150 µg/m³ [4]. The concentrations of limonene and α-pinene generally were quite low (percentile 50 <10 µg/m³), however, the long-term effects of low dose are not yet known.

Note that the highest values in limonene were measured in the living room and bathroom. The highest concentrations of α-pinene were recorded in bathrooms.

Formaldehyde was directly measured via a portable analyzer INTERSCAN with electrochemical cell. The detection limit of this analyzer can be lower than 10 ppb. The results are expressed in µg/m³ (1 ppb = 1.2 µg/m³).

RESULTS

Volatile Organic Compounds

11% of investigated homes were beyond the comfort range of 200 µg/m³ applied in the United States [5] for the total concentration of volatile organic compounds. The value of the percentile 50, corresponding to 50% of surveys, reached 83 µg/m³. One can notice on the graph showing the distribution of VOCs in the different rooms investigated, that the highest values were reached in the kitchen and the child's bedroom. The values obtained for outdoor air amply confirmed that indoor air is more polluted than outdoor air.

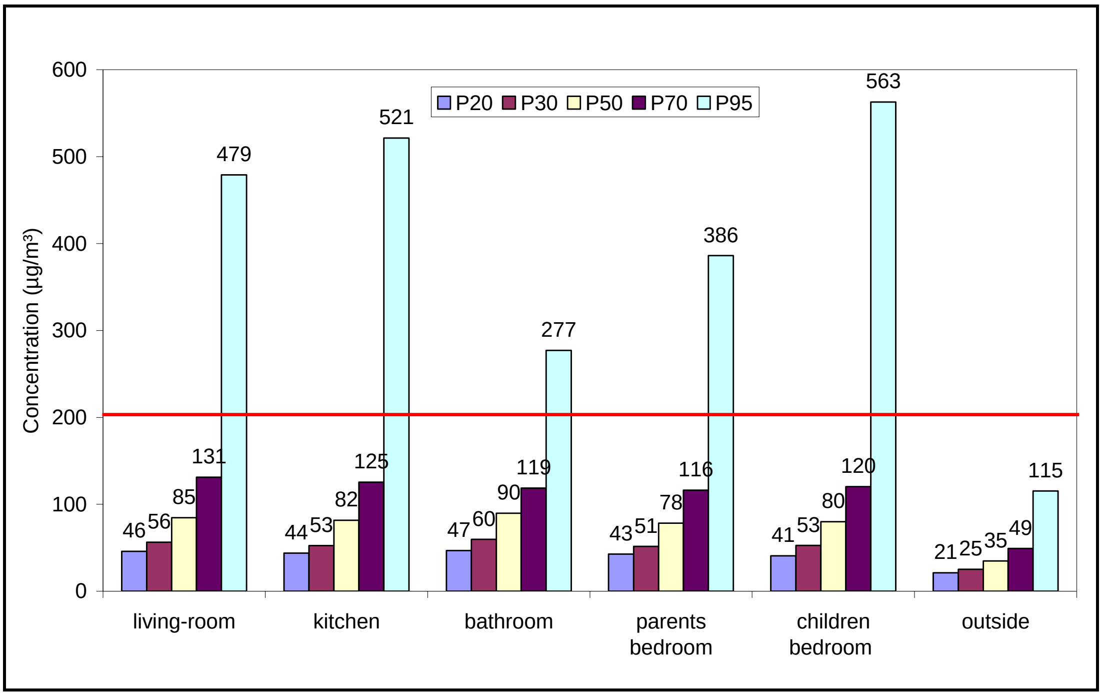

Fig. 2 Distribution of VOCs concentration in the different rooms investigated

Formaldehyde

According to the guideline values proposed by WHO for exposure to formaldehyde [6], four among the visited dwellings exceeded the value of 100 µg/m³ recommended for "normal people". In contrast, the value of 10 µg/m³ defined for "sensitive people" was exceeded in 71% of the dwellings. The maximum values obtained were in the kitchen and the children's room. The later, generally renovated and equipped with new pieces of furniture before the arrival of the new-born.

Measurements with the probe made inside the furniture, for example, showed that the furniture of bathrooms contained the highest concentrations of formaldehyde, mainly a consequence of cosmetics storage in cabinets. Some recent wardrobes and kitchen cupboards also showed high rates of formaldehyde.

DISCUSSION AND CONCLUSIONS

The lack of reference standards used in Belgium led us to use standards or guideline values established in other European countries or in the United States. The exposure standards in the workplaces are listed for information for some compounds such as toluene, trichlorethylene and tetrachlorethylene. For formaldehyde, guideline values exist for the indoor environment [6]. Similarly, recommendations are proposed for benzene in France [7]. For the other compounds, there is no standard available. It was therefore necessary to develop a tool that can assist the physician in the interpretation of the results of indoor compounds chemical analysis. Each result, either biological or chemical, is stored in a database together with information from the questionnaire.

Based on the chemical data obtained, an overall index of chemical indoor air pollution was established. It is based on the percentiles values (P20, P50, P70 and P95) calculated on the data of enquiries from the years 2000 to 2006. Those percentile values represent an average concentration of all the rooms of the dwelling (living room, kitchen, bedroom, children's room and bathroom).

The index varies from "excellent" to "execrable" through 5 categories. These values take into account the concentrations of the 7 pollutants most frequently encountered in the habitat (benzene, toluene, trichlorethylene, tetrachlorethylene, limonene, pinene and formaldehyde) and also the total amount of measured volatile organic compounds. Figure 3 illustrates an example of indoor air pollution index for total VOCs. This case corresponds to a so-called normal habitat.

The chemical pollution index per room was calculated using the same principle.

	0-44	44-83	83-122	122-239	239-445	> 445
TCOV	Excellent	Good	Normal	Bad	Very Bad	Execrable

Fig. 3. Example of global indoor pollution index of habitat

It provides a finer description of pollution than the global index. Indeed, averaging over all rooms decreases the importance of a specific contamination and dilutes the information. Moreover, the origin of the pollutant in the most contaminated room is not apparent, thereby masking the chemical pollution and leading to a possible neglect of certain situations.

This tool allows visualizing the chemical quality of both the whole housing (overall index) and each room (index per room) for different pollutants under investigation. This presentation provides a direct reading of the habitat's situation.

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INDOOR AIR QUALITY IN BUCHAREST HOUSINGS IN THE FRAMEWORK OF PRESENT ENVIRONMENTAL CHANGES

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Abstract

The indoor air quality represents one of the factors conditioning housing quality in urban residential spaces. The paper analyses the spatial and temporal distribution of parameters defining the indoor air quality from representative housings in Bucharest, correlated with their influence factors. The characterisation of *permanent*, *seasonal* and *circumstantial* influence factors was realised using the US EPA (1991) and WHO (2006) methodologies. Between November 2008 and February 2010 there were applied questionnaires for appreciating the dimension of influence factors inside and outside the housings. In the same time, for determining the values of representative indicators analysing the indoor air quality, measurements were realised in selected housings. From analysing the obtained results, it can be stated that in the indoor habitat of most residential spaces from Bucharest, the quality of air is unsatisfactory, values of human comfort recommended by international legislation being exceeded at indicators such as: volatile organic compounds, carbon dioxide or particulate matter. The building's ventilation systems are mostly dismantled or not functioning, and as a result the thermal isolation of buildings only aggravates these problems as it isn't compensated with an improvement of the ventilation systems. The significant expansion of areas affected by Sick Building Syndrome, which are economically, ecologically and/or sanitary inefficient, in the framework of recent environmental changes, it requires an integrated approach of problems concerning the air quality management in Bucharest residential spaces.

Keywords: *housings, air quality indicators, indoor air quality, environmental changes, heat island, Sick Buildings Syndrome, Bucharest, Romania*

Rezumat

Calitatea aerului interior din locuințele bucureştene în contextul schimbărilor climatice prezente. Calitatea aerului interior reprezintă unul dintre factorii ce condiționează calitatea locuirii din spațiile rezidențiale urbane. Lucrarea îşi propune să analizeze distribuția spațială şi temporală a parametrilor ce definesc calitatea aerului interior din spații de locuit reprezentative ale municipiului Bucureşti în relație cu factorii de influență. Caracterizarea factorilor de influență *permanenți*, *sezonieri* şi *conjuncturali* s-a realizat utilizând metodologiile US EPA (1991) si OMS (2006). În perioada noiembrie 2008 – februarie 2010, s-au aplicat chestionare pentru aprecierea dimensiunii factorilor de influență din interiorul şi exteriorul spațiilor de locuit. Concomitent, pentru determinarea valorilor indicatorilor reprezentativi de calitate a aerului interior au fost efectuate măsurători în spațiile de locuit selectate. Din analiza rezultatelor obținute se poate afirma că în habitatul intern al majorității spațiilor rezidențiale din municipiul Bucureşti calitatea aerului este nesatisfăcătoare, fiind depăşite valorile de confort uman recomandate prin legislația internațională, la indicatori precum: compuşi organici volatili, dioxid de carbon ori pulberi în suspensie. Sistemele de ventilare ale clădirilor sunt în cea mai mare parte dezafectate ori nu funcționează, astfel că izolarea termică a imobilelor vine să agraveze aceste probleme în cazul în care nu este combinată cu îmbunătățirea sistemelor de aerisire. Extinderea semnificativă a spațiilor rezidențiale "bolnave", ineficiente economic, ecologic şi/sau sanitar, în contextul schimbărilor actuale de mediu, impune o abordare integrată a problemelor ce țin de managementul calității aerului în spațiile rezidențiale din municipiul Bucureşti.

Cuvinte-cheie: *spații de locuit, indicatori de calitate a aerului, calitatea aerului interior, schimbări actuale de mediu, insulă de căldură, Sindromul Clădirilor Bolnave, Bucureşti, România*

INTRODUCTION

The interest for assessing the indoor air quality increased significantly at scientific, political and administrative levels, as modern population spends more and more time in the indoor environment (Koren and Bisesi, 2002; WHO, 2006).

Therefore, the indoor air quality becomes very important, especially as the pollutants exposure of population is larger in the indoors than the outdoors (US EPA, 1991).

Problems concerning the indoor air quality are found among the preoccupations of decision factors at international level, interested in the sustainable development of human settlements. The United Nations Convention for Human Settlements (Habitat II) recognises that adequate housing condition represents a human right and promotes the assurance of corresponding housings and human settlements which are safe, healthy, inhabitable, equitable, sustainable and productive (Bălteanu and Şerban, 2005). *The Declaration of Cities and Other Human Settlements in the New Millennium* draws attention upon the fact that globally there is present a tendency of accentuated degradation of habitation conditions (UN, 2001). For resolving these problems, at the Global Summit on Sustainable Development, held in Johannesburg in 2002 was launched ***The Partnership for Clean Indoor Air*** which recognises that the improvement of indoor air quality is not possible without changing the societies' consume patterns, and especially those related with the energy use (Iojă, 2008).

The preoccupations of the World Health Organization (WHO, 2006), of the European Commission and national governments in developing guides and regulations for assessing, monitoring and enacting aspects related with the indoor air quality, sustain the importance of this critical problem in human settlements, accentuated as the number of housings with thermal isolation increases (Iojă, 2008). Furthermore, the thermal isolation and the development of air-conditioning systems are closely related with the appearance of the *sick buildings syndrome (SBS)*[1], concept used in describing situations in which the buildings inhabitants present discomfort and unfavourable health state due to the fact that they spend a long time inside a building, and no specific disease or cause can be identified (US EPA, 1991; Lindvall, 1992; Bărbulescu, 2007). The causes of SBS appearance are mainly determined by the inadequate ventilation and the presence in high concentrations of chemical and biological contaminants from the indoor or outdoor environment (Marinescu, 2006; Oahn and Heng, 2005).

Furthermore, in the international scientific literature, the main problems approached in evaluating indoor air quality concern the description of the sick buildings syndrome (Lindvall, 1992; Kostiainen, 1995; Koren and Bisesi, 2002), the determination of pollutants sources and the factors influencing the quality of indoor air (Owen et al., 1992; Wolkoff and Kjaergaard, 2007), the assessment of the dynamics of specific pollutants (Kostiainen, 1995, Zhao and Wu, 2007; Gardner, 2009), the influence of indoor air quality on the population health (Kjaergaard, 1991) and establishing measures for improving the indoor air quality (Franz and Johnson, 2007).

These active preoccupations are sustained by the fact that a poor indoor air quality determines higher costs in improving the population's health state, in housing sanitation, interior endowments, and clothing items or even in the maintenance of the housing's functions.

Study area

Among the natural characteristics which influence the air quality from housings, in Bucharest the presence in the substratum of loess deposits is of significant importance (source of suspended particulate matter, especially through the numerous cracks present on the construction sites), the temperate transition climate with excessive nuances, strongly influenced by the urban environment (average multi-annual temperature of 11,2^{0}C, annual rainfall of 615 mm, absolute maximum amplitude of 71^{0}C, determining the need of a higher quality thermal isolation of buildings), an artificial catchement (the canalisation of Dâmbovita, the lakes on Colentina, the dissolution of wetlands which influenced the balance of air humidity) and the predominant presence of anthropic soils with a high concentration of contaminants (CCMESI, 1992; Lăcătuşu et al., 2007). Bucharest has a surface of 228 km^2 (of which 9 % green spaces and 4 % aquatic surfaces), a stable population of 1.9 million inhabitants, plus approximately 500,000 commuters (Rey et al., 2007). The youth (0-14 years old, 11.35 % of total population) and elder population (over 65 years, 14.45 %) present the highest exposure at factors with negative impacts in the indoor environments, as they are characterised by a reduced mobility. The high percent of built surfaces and the expansion of green fields contributes, due to the anhydrous character of different surfaces, to the generation of suspended particulate matter in the urban atmosphere (Pătroescu et al., 2003-2004).

Besides the problems of poor air quality, others have entered already in the population's collective mental, in a such called *normality*, such as the accentuation of the effects of the *urban heat island* due to the increasing number of built surfaces especially in the northern, eastern and south-western periphery (areas which bring fresh air to Bucharest), the wrong waste management, an increasing of functional incompatibilities diversity (especially the development of residential surfaces correlated with

[1] SBS is conceptually diferent from Buildings Relationed Diseases (BRD), in which the symptoms of a diagnosed disease are identified and can be linked directly with pollutants from the indoor environment.

other incompatible functions), the inefficient system of road traffic management, the uncontrolled use of dangerous chemical substance or the ageing of urban infrastructure, all of these influencing the indoor air quality (Pătroescu et al., 2003-2004).

In 2007, in Bucharest there were 785,696 housings grouped in 112,907 buildings, with a total surface of **30.4** km^2 (Iojă, 2008). According to housing typology, in Bucharest there were identified three main categories of residential spaces: *individual* (77.6% from the total buildings, 11.2% from the total housings, integrating 13.7% from the total Bucharest inhabitants), *coupled and stringed – wagon type* (10.6% from total buildings, most in an advanced state of degradation) and *collective* (11.8% of total buildings, 84.4% of total housings and 81.1% of inhabitants) (Fig.1) (Suditu, 2005).

The study has as objectives: a) identifying the characteristics of factors influencing the indoor air quality dynamics in Bucharest, b) assessing the indoor air quality in selected housings and c) estimating a development tendency of the indoor air quality indicators.

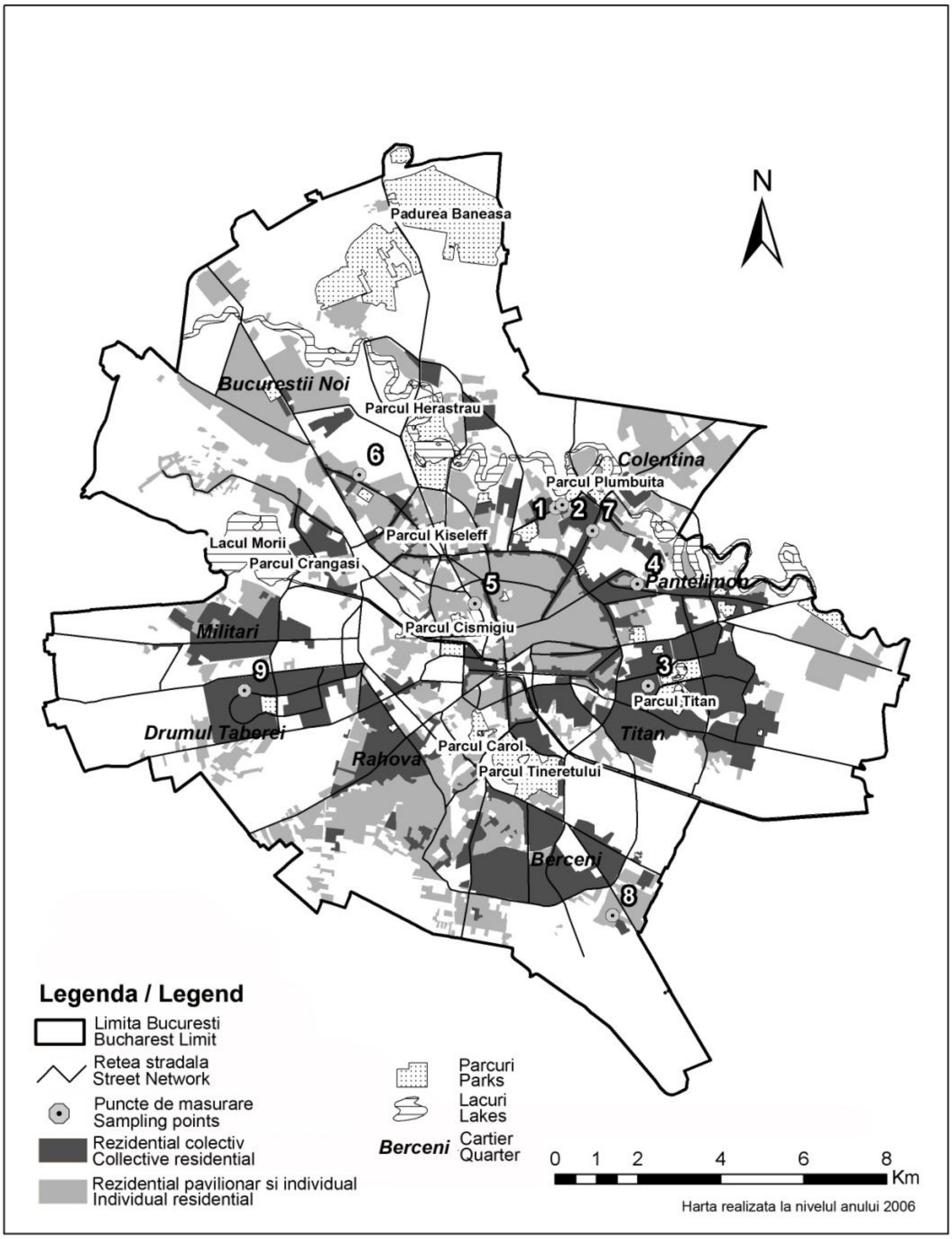

Fig. 1 The distribution of residential spaces categories in Bucharest (2006)

METHODOLOGY

The evaluation of the indoor air quality in Bucharest housings was realised based on the methodologies recommended by US EPA (1991) and the World Health Organization (WHO, 2000, 2006), the monitored indicators being adapted to the characteristics of the Romanian indoor environments and the available technologies. Between 2008 and 2010, by applying two categories of questionnaires there were assessed the *permanent factors influencing the indoor air quality* (technical characteristics, functioning of the maintenance systems, finishing works, internal endowments), the *seasonal factors* (characteristics of the outdoor environment) and *circumstantial factors* (the functioning of the existing appliances and equipments, consume patterns and adopted behaviours, the use of chemical and biological agents, specific activities). The questionnaires for evaluating the elements specific to the indoor habitat (**60** questionnaires, applied in the whole Bucharest) emphasise the features related with the residents' structure, endowments, and specific behaviours, consume and perceived problems related with the housing. The second categoryies of questionnaires (**610,** of which **528** statistically validated, applied in the Berceni, Tei, Colentina and Drumul Taberei quarters) evidenced commune characteristics of the housings (number of inhabitants, consume, endowments and external utilities, waste management). For the factors of seasonal climatic influence there were realised temperature and humidity measurements in the indoor and outdoor environment of the housings, using the DS 1923 Hygrochron sensors, with an hourly frequency of data recording and errors of $\pm 0.0625^{0}$C and 0.06 % (Dallas semiconductor TX).

The determination of different pollutants concentrations in the indoor air (particulate matter, CO_2, CO, O_3, NH_3, SO_2, H_2S, NO_2) was realised in the *November 2008 – February 2010* period, in **9** housings from Bucharest, where there were previously applied questionnaires. For evaluating the suspended particulate matter concentration, there were done measurements using the Casella CEL dust analyser. For the gases it was used the multi-gas analyser Gray Wolf Direct Sense Indoor Air Quality Kit, the average duration of a measurement being of 30 minutes. The measurements were realised in all the rooms of each housing, at the height of 1.2 meters from the floor, in conditions of lack of activities and also in conditions of normal activities.

The information was processed by using the software IBM SPSS Statistics 18, allowing the correlation of indoor air quality indicators with their influence factors.

RESULTS

Characteristics of permanent and seasonal influence factors

In Bucharest, the most important *permanent and seasonal influence factors* of the indoor air quality are the technical characteristics of the building (construction materials, size and housing spaces subdivision, the relation with the outdoor environment, finishing works), the building's maintenance systems, the number of inhabitants and the characteristics of the outdoor environment.

a. *Technical characteristics of the construction***.** The used construction materials are important in terms of their content of toxic chemical substances or with irradiation potential, but also from the point of view of their capacity of realising a healthy relationship with the outdoor environment (Spaul, 1994). In Bucharest, the buildings are built especially from concrete prefabricates (**47 %**), brick (**31 %**) and BCA (**20 %**) (Suditu, 2005), but in urban peripheries, clearly differenced structurally and functionally, the cheaper construction materials are dominant (recycled bricks, construction materials based on sand, gravel, clay and wood). In all the situations, the indoor air quality is affected especially by particles of persistent substances (heavy metals, other persistent compounds) or with radiant character (radon) (Lăcătuşu et al., 2008).

The materials used for isolation, interior joinery, finishing works or decoration are also important for the quality of indoor environments (Spaul, 1994). In Bucharest, the percent of housings which have their walls covered with washable paints is approximately of **49 %,** with a percent of **98.3 %** for housings in which capital repairs were realised in the past 10 years. In the case of the rehabilitated housings with more than 10 years ago (16.3 % of the analysed housings) is observed that the percent of finishing works with calcium, mica or clay is larger.

The housing size is an important indicator for appreciating the air quality (WHO, 2006). Thus, the air quality is better as the space is larger (as the contaminants have more dispersal space), but only if the number and activity of degradation sources are not very high. In the case of Bucharest, the average housing size is of **34.54** m^2 (**63.82** m^2 in the analyzed spaces), as the average height of the rooms is of **2.6** m. The corresponding subdivision of space is essential for avoiding the functional incompatibilities between different rooms from the housing. In Bucharest, the problems are related with the un-corresponding emplacement of catch-all (**65 %** of cases), of the sleeping space for pets (**36 %**), ateliers (**8 %**) in relation with bedrooms or other sensible spaces.

b. *The functionality of the building's maintenance systems* (ventilation systems, sanitation services, air conditioning, sewerage). The maintenance systems of buildings are those which bring inside or lead outside the chemical and biological agents (Franz and Johnson, 2007). In Bucharest they are those which significantly increase the air quality problems inside housings, especially in conditions of their imperfect functioning or their absence.

In the case of Bucharest, in **84 %** of cases, ventilation is made exclusively through the windows, with an average frequency of **2.34** openings per day per housing. Although in most situations, the ventilation through windows brings from the exterior new contaminants (especially those specific to traffic or fossil fuel burning at the P, P+1 housings), it is still preferred by most of the residents as it is the simplest and less expensive than the mechanical ventilation. Over **50 %** of those questioned sustain that the ventilation systems of the building were either destroyed, either they are recessed or closed, and **35 %** don't know about their existence, facts explaining the problems which appear in the indoor environment regarding air quality (humidity excess in air, elimination of bathroom smells, etc.).

The sewerage and spaces for the primary and secondary domestic wastes collection bring a supplementary addition of compounds from anaerobic decomposition (volatile organic compounds, hydrogen sulphide, ammonia, etc.), especially in housings situated at the inferior levels of blocks-of-flats and old buildings. Significant is the role of insalubrious and un-isolated garbage cans from the ground floor of the blocks, provisioning the air of the housings in the proximity with compounds specific to waste decomposition.

c. *The number of persons in the housings.* The intensity of problems generated by metabolic processes in the air quality is appreciated according to the number of persons in a housing (an average of **2.45** in Bucharest) and in a room (**0.98)**, the volume of apartments (average of **75.9** m^3) and the average time spent in the housing. The average time spent in the housing by its residents in Bucharest is of approximately **13.6 hours** (**17.4 hours** in the weekend), with significant variations among different professional categories and age groups.

Thus, children under 7 years old and elders above 65 years spendt **20 hours** on average inside the housing, whereas the adults spend **9-10 hours** on average**.**

d. *The characteristics of the outdoor environment.* Among the influence factors representative for the analysed area, the meteorological conditions (air pressure, wind speed, temperature and air humidity) and the outdoor air quality are detached. The relation between the dynamics of exterior and interior climatic parameters depends of the housing isolation efficiency, and of the modalities in which it is ventilated (Wolkoff and Kjærgaard, 2007). Following the measurements realised with the DS 1923 sensors in the analysed housings, it was observed that the average temperature of the indoor air was **21.5^{0}C**, with a thermic amplitude varying between **4-8^{0}C**, much lower than the outdoor environment. The air humidity recorded larger fluctuations (between **32.1** and **76.2** %), with an average of **63 %**.

These high values of, humidity and air temperature, influence significantly the reactivity of contaminants from the indoor air, increasing their aggressiveness (Koren and Bisesi, 2002).

Bucharest represents one of the cities with problems determined by the high frequency in exceeding the maximum admitted limits at the outdoor air quality indicators (ARPMB, 2009). The suspended particulate matter, the carbon monoxide, the nitric oxides and the volatile organic compounds record exceedings of the annual maximum limits at most of the air quality monitoring stations (Iojă, 2008), situation generated mainly due to human activities (the expansion of built surfaces, intensification of traffic, degradation of green spaces, development of construction works, degradation of the buildings) (Pătroescu et al., 2003-2004). The concentrations of these contaminants present a seasonal dynamics, influenced by the activity of generating sources, but also by the dispersal conditions (Iojă, 2008).

Characteristics of circumstantial influence factors

The functioning of interior installations, housing sanitation, activities taking place in the indoor environment (the use of domestic appliances, smoking, professional activities), and materials deposited inside (chemical substances, food, medicines, etc.), interior decorations (carpets, lightning installations, curtains, ornamental plants) or external risks (such as technological accidents) are a few examples of *circumstantial influence factors* (US EPA, 1991).

The domestic appliances are responsible with the charging of the indoor air with nitric oxides, particulate matter, carbon monoxide, cooling agents (ammonia, CFCs) and carbon dioxide (Gardner, 2009). They have a high diversity inside housings, being present in most of the rooms, but with a variable functioning time.

The analysed housing are endowed in a degree of **1.07** refrigerators/household, **1** cooker/household, **0.94** washing machines/household, **1.75** television sets/household, **1.6** computers/household, **0.62** microwave ovens/household and **1.03** dusters/household. In Bucharest, the highest concentration of domestic appliances is in the *kitchens* (refrigerators, cookers, microwave ovens, other appliances used for preparing food), *living-rooms* (television sets, DVD players, tape recorders, other agreement installations) and *bathrooms* (washing machines, other appliances for personal hygiene).

Among the activities with the highest influence upon the indoor air quality, we enumerate smoking (**40 %** of the analysed housings), food preparation (**93 %**), sanitation and cleaning activities (frequency of **0.7fold** per week) and pest control (**1.95fold** per year). The materials found inside the housing are also an important circumstantial influence factor in determining the indoor air quality (Spaul, 1994). They permanently supply in the air contaminants which can be removed only by periodical ventilation or trough their elimination outdoor. In Bucharest, problems regarding the indoor air quality appear also due to the inadequate *books storage* (**62 %** of situations), *medicines* (**42 %**) or *paints and solvents* (**36 %**).

Dynamics of air quality indicators

In Bucharest, the indoor air quality is, at most parameters, poorer than that of the outdoor environment (Table 1). This phenomenon is not due entirely to the existence of a large number of contaminant sources in the indoor habitat, but also to a deficient ventilation of the rooms.

Volatile organic compounds are present in housings from metabolic activities, and from a series of internal sources (such as finishing works with washable paint, other paints and varnishes, plastic materials, rubber, some decorative plant species, fuel burning, food preparation, the use of cosmetic products, etc.) or external sources (cars) (Wallace et al., 1987). The momentary concentrations of volatile organic compounds inside the analysed residential spaces (Table 1, Fig. 2) varied between **78** ppb[2] and **2 289** ppb (an average of **388** ppb, ±359), characterising, according to Kostiainen (1995), the *sick buildings)*. The highest values were recorded in storage spaces with deficient ventilation, in rooms with smoking habits or where paints, adhesives, rubber articles, plastic are deposited and in housings with problems at the domestic sewerage system (values over **500** ppb).

The smallest values, similar to those from the outdoor environment (under **150** ppb) were recorded in large rooms, with frequent ventilation, without intense activity and in which the washable paints were not used. During a day, the highest values are recorded in the morning, when the effect of pollutants accumulation is obvious. Annually, the highest values are recorded during winter (1.2-1.5 times higher than in summer) due to insufficient ventilation. The importance of ventilation in the case of volatile organic compounds is evidenced by decreases in concentrations of over 50% in most of the situations. The exceptions were present in the warm season in apartments situated at the lower floors, where the ventilation is done towards the parking space, and thus bringing important volumes of volatile organic compounds.

In the case of ***carbon dioxide***, recorded values varied between **422** and **5495** ppm[3], with an average value of **1,676** ppm (compared with 3,000 ppm, the maximum value recommended by the World Health Organization) (Table 1, Fig. 3).

Higher values are recorded during winter, when the frequency of ventilation is smaller and the heating systems are functioning. Problems are higher in housings with thermal isolation (especially with PVC), in which the source of producing thermic energy (heating stations, stove based on liquid or solid fuel, etc.) is inside the building (Gardner, 2009).

The carbon monoxide is a gas which doesn't generate problems in Bucharest, with an average concentration of **2.21** mg/m^3 (**±0.8**), with higher values (of about **5** mg/m^3) in housings with own heating systems (**11** mg/m^3 maximum value recommended by the World Health Organization).

For ***ozone***, the average recorded concentration is **29** μg/m^3, far less than the value recommended by the World Health Organization (**120** μg/m^3). The average value of this indicator contributes at increasing the aggressiveness of pollutants from the indoor air, already found in high concentrations (especially the volatile organic compounds). In the case of ***suspended particulate***

[2] ppb – parts per billion
[3] ppm – parts per million

matter, the situation is extremely variable, depending both from the outdoor environment and from a series of elements in the indoor environment (type of finishing works and decorations, surface covered by different textile products, the dynamic of housing activities, food preparation, smoking, etc.) (Koren and şi Bisesi, 2002). The average concentration in the analysed housings is **70** µg/m^3 (**50** µg/m^3 maximum recommended value), the interval of variation being extremely large (**2-675** µg/m^3). An important role in the indicators' dynamic is played by the dimension of surfaces that can receive suspended particulate matter, as well as their emplacement and characteristics (Owen et al., 1992).

Thus, parts of the surfaces retain suspended particulate matter until their removal, but most of them only retain them on limited terms until they are activated by different forces (air currents in the housing, dynamic activities, etc.). From this point of view, in Bucharest housings, the surfaces that can retain suspended particulate matter on a limited period are extremely large and varying in composition.

Table 1 Indoor air quality indicators dynamics in Bucharest housings, November 2008–February 2010

Indoor air quality indicators	Average and standard deviation	Medium	Minimum	Maximum	Recommended limit*
Volatile organic compounds– ppb	388 (±360)	286	78	2289	300
Carbon dioxide – ppm	1676 (±959)	1471	422	5495	3000
Carbon monoxide – mg/m^3	2,21(±1,11)	2,08	1,13	5	11
Ozone – µg/m^3	29,75 (±19,15)	21,9	0	63,4	120
Suspended particulate matter- µg/m^3	70 (±138)	33	2	675	50
Ammonia - µg/m^3	142 (±105)	131	0	330	100
Hydrogen sulphide - µg/m^3	6,3 (±13,6)	0	0	60	8
Nitric oxide- µg/m^3	127 (±142)	69	0	508	200
Sulphur dioxide - µg/m^3	56 (±243)	0	0	1239	250

** maximum value recommended by the World Health Organization*

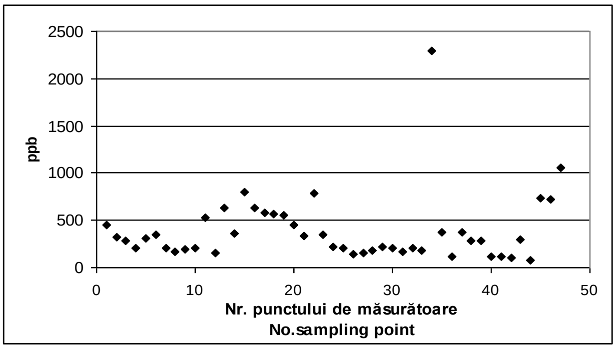

Fig. 2 Variations in the concentration of volatile organic compounds in the analysed housings in Bucharest

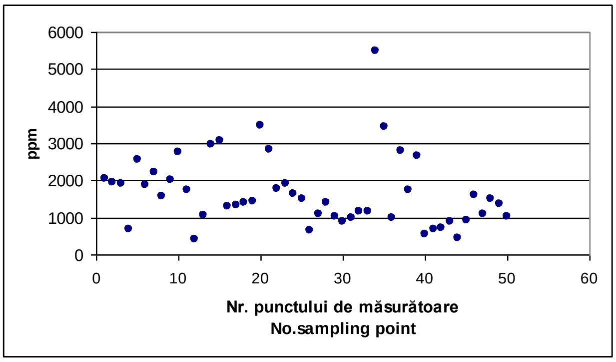

Fig. 3 Variations in the concentration of carbon dioxide in the analysed housings in Bucharest

The ammonia represents an insult related with metabolic processes which take place in the housing, but also with the presence of substances emanating ammonia (organic wastes, cosmetics, cleaning products, paints, medicines, etc.).

The values of this indicator are higher in small rooms, with poor ventilation and in bathrooms which present problems with the domestic sewerage system, recording here values over **300** µg/m^3. In the other rooms, the recorded values have rarely exceeded **150** µg/m^3. A similar situation is recorded for at the ***hydrogen sulphide***, where the average recorded values are **21** µg/m^3 in rooms with such sources (bathrooms, kitchens, and storage spaces) and **0–5** µg/m^3 in the rest.

The Nitric dioxide rises problems especially during the use of electric appliances (such as washing machines, irons, toasters, cookers, computers, etc.), the average concentration being of **127** µg/m^3 (**200** µg/m^3 the maximum value recommended by the World Health Organization). These values draws attention upon problems appearing in rooms in which electric appliances function, where values are frequently higher than those recommended, situation extremely delicate as this insult is a very stabile one (Gardner, 2009).

The Sulphuric dioxide does not represent an insult characteristic to Bucharest housings, the concentrations being generally under **20** μg/m^3. The Higher values appear especially in houses which use coal or wood for heating, where the recommended value is frequently exceeded.

DISCUSSIONS

The indoor air quality is extremely variable in time and space. Modifications in the activity of a single influence factor can generate significant transformations in the indoor air quality (Oahn and Heng, 2005). The perception manner of authorities and resident population influences decisively their reaction towards quality situations and states encountered in different housings. A certain state can be considered acceptable by some and unacceptable by others, according to their consume patterns, housing standards, education and financial levels, or circumstantial situations (Marinescu, 2006).

The factors influencing the indoor air quality are very complex (WHO, 2006). Some of these are controllable or determinable, while others are extremely variable and depend on of different circumstances. The percentage of their influence on the indoor air quality is not fixed, as in different moments but in relatively similar situations, their action can be different (US EPA, 1991). On the long term, the importance of *permanent and seasonal influence factors* determines the appearance of a certain air quality, the percent in which substances generated by them influence the air quality being estimated at **73 %** (US EPA, 1991). In Bucharest there is an equilibrated ratio between permanent and circumstantial factors, due to the high diversity of activities from housings, the strong relation between different housings from the same building (accentuated by modifications realised in the technical structure of the building) and the variability of functions outside the housings. It is estimated that permanent factors determine the quality of indoor air in Bucharest in a percent of **50-75 %**, with smaller values in the case of individual housings.

This atypical situation is determined by the current environmental changes, the ageing of urban infrastructure, the insertions realised in housing and by the un-corresponding models of behaviour.

The degradation tendency of air quality in Bucharest is a reality of the past years, determined by an increase of aggressiveness of environmental degradation sources and the significant decrease of the oxygenized surfaces (Pătroescu, 2003-2004). The projection in the indoor air quality is accentuated by the fact that degradation sources are approaching housings, examples in this direction being the gas stations, large commercial and storage spaces, the number of parking lots, etc. (Ioja, 2008).

The ageing of urban infrastructure determines a less efficient functioning of technical and urban technical networks (Lindavall, 1992). At most individual housings built before 1966, transformed trough lease in collective housings (Suditu, 2005) pollutants are brought in the indoor air also by the sewerage system which is not functioning properly. Also, in individual housings with their own system of producing heat, the ageing of building usually signifies a reduced efficiency in eliminating the contaminants resulted from the burning of fuels, generating significant increases of the burning gases concentration (ONU, 2001).

A current issue in the collective residential spaces is related with the tendency of dismantling the centralised ventilation systems through interior works. For this reason, the ventilation systems do not have the role of removing contaminants from inside to the outside, but they are relocating them from one housing to another. Therefore, the classic ventilation system using windows remains the only operational one, although it does not have a high efficiency as the quality of the indoor air is unsatisfactory (ARPMB, 2009).

A fact that is observed is that secondary toilets transformed in storage spaces (for different textile and leather products, footwear, detergents, sanitation products or electric appliance) as well as other spaces inside the housings depositing different chemical substances are confronted with an ***excessive charge*** with *volatile organic compounds, suspended particulate matter, ammonia, nitric oxides and hydrogen sulphide.* These contaminants are transferred in other rooms, but also to other housings situated at higher levels.

The thermal isolation of buildings (**72 %** of the analysed housings have thermopane window, and **21 %** have the walls out covered) improves the interior thermal regime, but in the same time accentuates the problems related with the indoor air quality, as the ventilation systems or air filtration systems have not been developed for mitigating the changes in the air circulation between the interior and exterior of the housing.

The generated problems concern pollutants accumulation, but also the improvement of conditions for them to generate synergic effects (increases of air temperature and humidity, reduction of air circulation). Besides, the obtained results emphasises that pollutants concentrations in the indoor air of thermal isolated housings are higher with **0.5 – 3** times thant the others.

The behaviour models are those contributing to a significant increase of the circumstantial factors percent in influencing the indoor air quality. Smoking, using street footwear inside the housing, the use of electric appliances during the rest periods, the frequent use of chemical substances for cleaning, the odorization of the indoor air trough aerosols or the high number of pets, represent significant circumstantial factors in the balance of indoor air quality in Bucharest housings.

Therefore, the pollutants concentrations in the indoor air of Bucharest's housings exceed frequently the recommended maximum limits for volatile organic compounds, carbon dioxide and suspended particulate matter. The obtained values place **7** of the **9** housings in the ***sick buildings*** category, in which the quality of indoor air is un-corresponding and can generate health problems to residents (Lindavall, 1992; Kostiainen, 1995; WHO, 2000).

CONCLUSION

The significant expansion of residential areas suffering from the "Sick Building Syndrome", which are economically, ecologically and/or sanitary inefficient, in the framework of current environmental changes, requires an integrated approach of problems concerning the air quality management in Bucharest residential spaces.

This is necessary as the residents' health is aggravating (the incidence of diseases characteristic to sick buildings, especially respiratory, heart and nervous diseases increases), the living costs increase (for cleaning the housing and clothing, eliminating uncomfortable odours, introducing equipments with the role of improving the conditions in the indoor environment, pests control, general repairs, for maintaining a favourable indoor microclimate, etc.) and the work productivity decreases significantly (US EPA, 1991; WHO, 2006).

The problems related with the indoor air quality are difficult to manage, as the people spending the most time in housings come from sensitive categories, represented by children, elders and ill people. Also, as most of the housings are situated in collective buildings, resolving the problems of indoor air quality requires an integrated approach. First of all, there must be increased the awareness level of the population towards behaviour which can determine increases of contaminants concentrations inside the housings, and afterwards there have to be developed technical measures for increase the efficiency of pollutants removal or fixation.

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THE RURALITY BETWEEN THE RAMNICUL SARAT AND THE BUZAU VALLEYS – DEFINITIVE COMPONENT OF THE SUBCARPATHIAN LANDSCAPES DYNAMICS

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Abstract

Rural space represents a definite element in the structural and functional transformations of Subcarpathian landscapes, analysed through their geodiversity, biodiversity, and cultural patrimony. The present analyse relieves historical and socio-economic land use changes, process, which determined a restructuring of rural landscapes, allowing a classification of environmental critical areas. Elements defining the rurality of the Subcarpathian landscapes between the Ramnicu Sarat and the Buzau valleys were evidenced and characterised in concordance with the new strategic directions of the European Council regarding rural development in 2007 – 2013 period, and with the national legislation in the field, for establishing protection, rehabilitation and valorization strategies for the Subcarpathian rural landscapes. The case study realised in the villages included in the Subcarpathian sector of the Slanic de Buzau valley relieved a spatial and temporal dynamics for the indices of human pressure through different land-uses, allowing the establishment of artificial degrees of rural Subcarpathian landscapes. The data obtained from the CORINE Land Cover model, 1990 and 2006 editions, corroborated with the data rendered in agricultural registers and statistical data from NIS (National Institute of Statistics) relieve spatial dynamics of land-uses in the analysed area, and at the same time, there were identified the areas which induce important modifications in the landscapes structure and functionality.

Keywords: *rurality, geodiversity, biodiversity, human pressure, Subcarpathian landscape, Curvature Subcarpathians, Romania*

Rezumat

Ruralitatea dintre văile Râmnicului Sărat şi Buzău- componentă definitorie a dinamicii peisajelor subcarpatice. Spațiul rural reprezintă elementul definitoriu al transformării structurale şi funcționale a peisajelor subcarpatice, analizate prin prisma geodiversității, biodiversității şi patrimoniului lor cultural. Analiza întreprinsă a evidențiat schimbările în timp istoric şi socio-economic a modului de utilizare a terenurilor, proces ce a condiționat destructurarea peisajelor rurale şi a permis ierarhizarea arealelor critice din punctul de vedere al stării mediului. Au fost evidențiate şi caracterizate elementele definitorii ale ruralității spațiului subcarpatic dintre Râmnicu Sărat şi Buzău, în concordanță cu noile orientări strategice ale Consiliului Europei pentru dezvoltare rurală, specifice perioadei 2007-2013, şi legislației naționale în domeniu, în scopul stabilirii politicilor şi strategiilor de protejare, reabilitare şi valorificare a peisajelor rurale subcarpatice. Studiul de caz realizat în arealul comunelor circumscrise sectorului subcarpatic al văii Slănicului de Buzău a evidențiat dinamica spațio-temporală a indicilor de presiune umană asupra mediului prin diferite moduri de utilizare a terenurilor şi a permis stabilirea gradului de artificializare a peisajului rural subcarpatic. Datele obținute din prelucrarea modelului CORINE Land Cover ediția 1990 şi 2006, coroborate cu datele existente în registrele agricole şi datele statistice furnizate de către INS, evidențiază dinamica spațială a utilizării terenurilor în arealul subcarpatic analizat, permițând în acelaşi timp spațializarea arealelor care induc modificări importante în structura şi funcționalitatea peisajului rural subcarpatic.

Cuvinte-cheie: *ruralitate, geodiversitate, biodiversitate, presiune antropică, peisaj subcarpatic, Subcarpații de Curbură, România*

INTRODUCTION

The landscape, seen as a materialization of temporal and spatial interactions between natural components and human activities, is considered a projection of geodiversity, biodiversity, and cultural diversity interactions (*Patroescu et al., 2000, Toma, 2008)*, with geodiversity functioning as a support for the other components. The synergic integration of these components determines the complexity of rural landscapes.

Rural landscape, as an integrated part of the natural material patrimony (*CEMAT, 2000*) is considered a *complex of interacting factors and whose internalities and externalities offer a special dynamics*, a life frame for the rural population *(Patroescu et al., 2000*).

Analysing characteristic elements from the rural Subcarpathian landscapes were identified and prioritized three main components, with a major influence on the structure and functionally of landscapes: *the rural settlement, rural population,* and *the predominant agricultural land use.* The materialization of the landscapes functions and structure in the three components progressively determined characteristics of the rural space, analysed regarding the externalities and internalities of environmental factors.

From a socio-demographical perspective, rural spaces are defined as areas with reduced population and low density values (*Fuguitt, 2005*), the predominance of inhabitants considering themselves ***"peasants"*** with a rural mode of life, in the villages (*Wolfe and Fischer, 2003*), in spaces with predominant agricultural production (*Madu, 2009*) being strongly connected with urban environments situated in the proximity, and with a strong influence upon the values of rural-urban and urban-rural migratory flows, according to socio-economic and political conditions.

Rural spaces were characterised according the cultural and traditional perspectives, *Madu (2009)* identifying a series of defining aspects: predominant landscapes are open ones, most of the population being associated with the agricultural and forestry sectors, a traditional lifestyle, excessive land-uses, with distinct socio-cultural characteristics and low densities of constructed spaces, etc.

These factors were identified and classified in the rural Subcarpathian space between the Ramnicu Sarat and the Buzau, the analyses allowing the establishment of politics and strategies for the development and management of relationships between rural communities, both at local and regional level, as well as classifying optimal measure for protecting and preserving rural Subcarpathian landscape, therefore maintaining an equilibrium between environmental factors.

Study area

The study area is located in the Curvature Subcarpathians (in Vrancei and Buzaului subdivision) (*Posea and Badea, 1974*), overlapping a relief dominated by the alternance of depressions and hills, from the folded Miocene formations, Pliocene and Villafranchian (in the case of Vrancea Subcarpathians) and Miocene – Pliocene formations of crease fissures in the Buzau Subcarpathians (*Geological map 1:200 000, Ploiesti and Covasna sheets).*

Administratively, it is situated mostly in the Buzau County and Vrancea County, including the surfaces of 35 villages, and a part from the city of Patarlagele and the village of Sibiciul de Sus (Fig. 1).

The absence of urban poles in the Subcarpathian area between the Ramnicu Sarat and the Buzau, relieves the rural character of the analysed spaces, the nearest urban centre being Patarlagele, established as a city in 2004.

For identifying rurality characteristics in the Subcarpathians between the Ramnicu Sarat and the Buzau, it was realised a study case in the Subcarpathian sector of the Slanic from the Buzau valley, including the villages of Lopătari, Mânzăleşti, Vintila Vodă, Beceni, and Cernăteşti, and representing approximately 26% of the total study area.

METHODS AND MATERIALS

A series of indices were selected and analysed function of the rural space characteristics, classified on several domains: *demographical, economic,* and *social*, with the purpose of evidencing the rural character of the analysed space, a dominant factor in the dynamics or rural Subcarpathian landscape.

In the analyse we used statistical data extracted from *the localities cards*, for the years 1992, 2001, and 2008, obtained from the *National Institute of Statistics, Buzau* and *Vrancea* county divisions.

The main indicators calculated and evaluated are: *the value of population density*, calculated as a ratio between the total population and the surface of each village (square km); *age groups structure of rural population*, with an analyse on three main categories (under 14 years, 15-59 years, over 60 years); *agricultural density* – a relationship between the rural population and the agricultural surfaces from the analysed territory; *the proportion of agricultural surface from the total surface of the village*, expressed in percents; *proportion of different land uses from the total agricultural surface*, expressed also in percents.

The spatial and temporal dynamic of the rural Subcarpathian landscape was assessed also by evaluating the impact of human pressure upon environmental components and its projection in the artificialization of the landscapes.

A series of *human pressure indices* through different land uses (*agricultural, arable, pastures, grasslands, vineyards, and orchards)* were prioritized and calculated for each territorial administrative unit. The obtained results where then compared with the limits established by *FAO* in maintaining an environmental equilibrium. The values of human pressure indices were obtained by relating the surfaces with different land uses (expressed in hectares) with the total number of rural population for each territorial administrative unit.

Another method used for analysing the rurality of the space, was the spatial and temporal dynamic of land use and cover (*Turner and Mayer, 1994*) and its role upon the structure and functions of the rural landscape.

The spatial database realised by the European Environmental Agency in the *Corine Land Cover* project for the years *1990* and *2006* (*CLC 1990* and *CLC 2006*, data available at *http:/www.eea.europa.eu/data-and-maps/ data/ corine -land- cover - 1990 - raster* and *http:/www.eea.europa.eu/ data-and-maps/data/corine-land-cover-2006-raster),* resolution of 100 m, version 13 was used. These were conditioned with the ArcGIS 9.3 software.

In the analyse was used the classification from the CORINE Land Cover model, land use and cover types being grouped into 5 major classes and 15 subclasses (*EEA, 1994*).

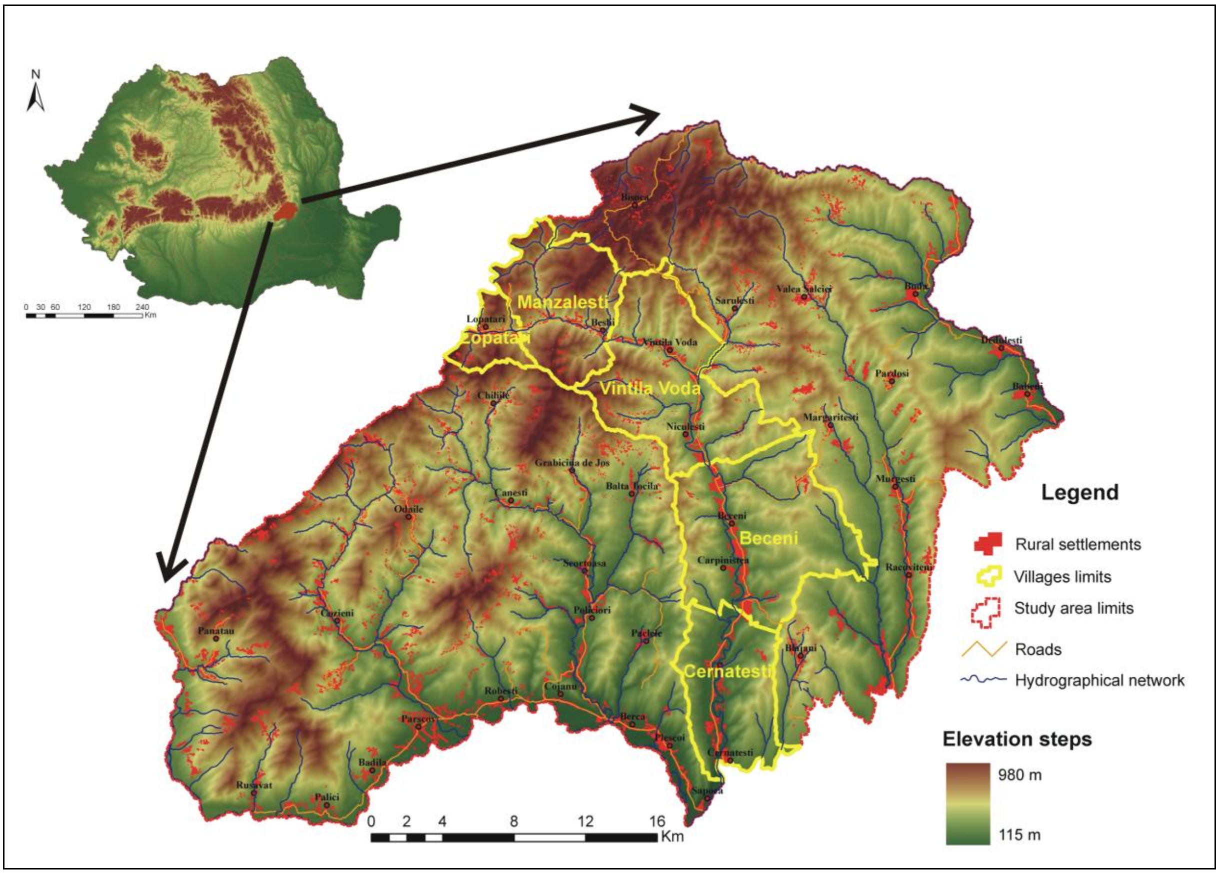


Fig. 1 Location of the study area

For the graphical and cartographical material, land uses were regrouped into 10 classes for 1990 and respectively 9 classes for 2006, adapted to particularities of the analysed space, according to the manifestation of environmental externalities and internalities.

The difference recorded between the two legends of the *Land use and cover maps*, for the year 1990 and 2006, can be explained by the vegetation covering of sand fields, or those affected by erosion, these types being absent in the CLC 2006 database.

RESULTS AND DISCUSSIONS

Values of the population density calculated for the analysed villages record a negative dynamics (Fig. 2), being situated under the value of 150 inhabitants per square kilometre, value considered by OECD (1996) as the limit for rural settlements in the European Union, the main cause being the low social level, but also the dynamics of the main demographical phenomena: natural balance and migratory flows. An analyse of the demographical potential and the dynamics of rural population is necessary in evidencing their influence upon the agricultural work force.

The decrease of the inhabitants' number from rural environments had a major effect upon the age and sex structure of population. Following analyses for the 5 villages, a high percent was occupied by the population situated in the 15-59 year old group, occupied in the agriculture, and by the population in the over 60 year old group, with a major effect in the ageing process (Fig. 3).

The third indicator, *agricultural density* demonstrates the rurality of the analysed space, and the artificialization of the Subcarpathian rural landscape. The calculation of this index revealed decreases in values in 2008 compared with 1992 for the villages of Lopătari, Mânzăleşti, and Vintilă Vodă, as a result of the population reduction and agricultural surface increases, while in the case of Beceni and Cernăteşti the index recorded an insignificantly increase in the year 2008 compared with 1992 (Fig. 4).

The rurality was relieved also by analysing the balance of agricultural surface from the total surface, but also by the balance of different agricultural land-uses from the total agricultural surface.

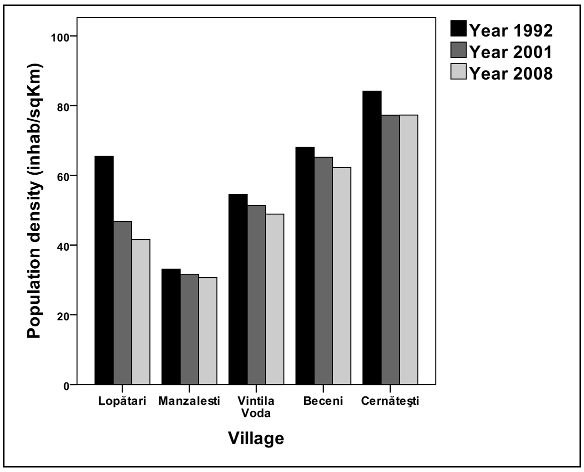


Fig. 2 Population density values in the analysed villages

Evaluating the percent of agricultural surface from the total surface of the villages, a decrease can be observed in 2008, when compared with 1992, with the exception of Vintila Voda, which recorded an increase from 63.9 % in 1992 to 66.5 % in 2008. The main cause is the increase of agricultural surface in 2008 with 176 hectares (Table 1).

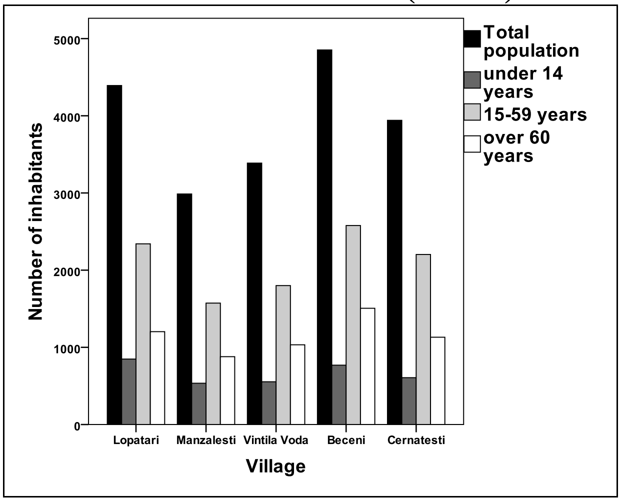


Fig. 3 Population structure by age groups in the analysed villages

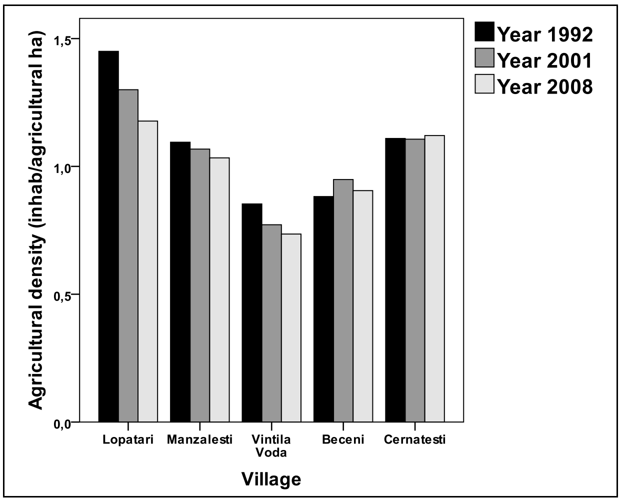


Fig. 4 Agricultural density for the analysed villages

Table 1. Percents of agricultural surfaces from the total surfaces of analysed villages

Territorial administrative units	Lopatari		Manzalesti		Vintila Voda		Beceni		Cernăteşti	
Years	1992	2008	1992	2008	1992	2008	1992	2008	1992	2008
Percent agricultural / Total surface (%)	45.1	35.3	30.2	29.7	63.9	66.5	77.1	68.7	75.8	69

Source: Values obtained based on statistical data supplied by NIS

Among the categories of agricultural uses, in 2008, the largest percent was occupied by pastures and grasslands for the villages Lopătari, Mânzăleşti, and Vintilă Vodă, situated in the uooer hydrographical watershed of the Slanic, and with geomorphologic conditions improper for crops, the emphasis being on animal growth and wood conditioning.

In the case of Beceni and Cernăteşti, situated on the lower course of the Slanic, the highest percent of the agricultural fields is occupied by arable fields and pastures. Here, it can be observed increases in the percents occupied by vineyards (Table 2).

Human pressure through different land uses represents a synthetic indicator of environmental quality and the artificialization of rural landscapes *(Dumitrascu, 2006)* recording differentiating values in the five villages from the analysed space.

Values of the human pressure indices through different land uses are expressed in Table 3.

Table 2. Percents of different agricultural land uses in the analysed villages

Territorial administrative unit	Lopatari		Manzalesti		Vintila Voda		Beceni		Cernăteşti	
Index / year	1992	2008	1992	2008	1992	2008	1992	2008	1992	2008
Arable from agricultural (%)	4.8	0.1	4.5	10.1	18.7	17	**27.8**	**33.5**	**30.8**	**38.6**
Pastures from agricultural (%)	**34.6**	**34.8**	**38.5**	**31.3**	**48.9**	**47**	**50**	**38.5**	**52.4**	**44.8**
Grasslands from agricultural (%)	**50.6**	**57.1**	**54.5**	**52**	**27.8**	**31.9**	14.7	19.1	4.3	4.1
Vineyards from agricultural (%)	0	0	0.1	0	0.8	0.5	2.4	2.7	9.1	8.7
Orchards from agricultural (%)	9.9	7.9	2.4	6.6	3.9	3.4	5.1	6.2	3.4	3.8

Source: Values obtained based on statistical data supplied by NIS

By comparing the values of human pressure through arable with the *0.4 ha/inhabitant* value considered by FAO as a maximum limit *(Geografia României, vol.I, Geografie fizică, 1983)* for maintaining an equilibrium between environmental components, it can be observed that arable land use is reduced in Lopatari, situated mostly in a mountainous area, with a strongly fragmented surfaces (Fig. 5).

Table 3. Dynamics of human pressure through different land uses indices

Territorial administrative units	Year	Inhabitants' number	Agricultural	Arable	Pastures	Grasslands	Vineyards	Orchards
Lopătari	**1992**	5,174	0.6896	0.0334	0.2387	0.3492	0	0.0682
	2001	4,836	0.7692	0.0010	0.2616	0.4456	0.0010	0.0600
	2008	4,193	0.8702	0.0012	0.3034	0.4968	0	0.0689
Manzalesti	**1992**	3,135	0.9136	0.0411	0.3518	0.4976	0.0006	0.0223
	2001	2,997	0.9366	0.0944	0.2906	0.4885	0.0007	0.0624
	2008	2,881	0.9770	0.0982	0.3054	0.5085	0	0.0649
Vintila Voda	**1992**	3,651	1.1720	0.2191	0.5730	0.3254	0.0090	0.0455
	2001	3,439	1.2957	0.2207	0.6098	0.4138	0.0070	0.0445
	2008	3,203	1.3908	0.2363	0.6544	0.4449	0.0074	0.0478
Beceni	**1992**	5,213	1.1337	0.3148	0.5670	0.1671	0.0267	0.0581
	2001	4,999	1.0542	0.3397	0.3997	0.2026	0.0336	0.0786
	2008	4,652	1.1322	0.3792	0.4364	0.2160	0.0307	0.0698
Cernăteşti	**1992**	4,252	0.9015	0.2778	0.4727	0.0383	0.0823	0.0303
	2001	3,905	0.9037	0.3467	0.3997	0.0369	0.0860	0.0343
	2008	3,890	0.8964	0.3465	0.4013	0.0370	0.0776	0.0339

Source: Values obtained based on statistical data supplied by NIS

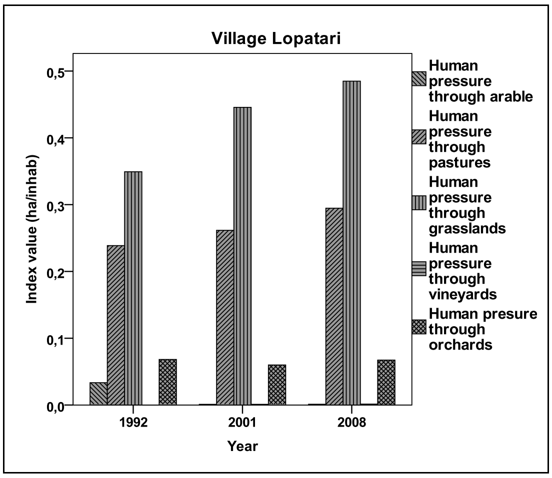
Values near the limit imposed by FAO are recorded for Vintilă Vodă, Beceni, and Cernăteşti, where arable fields occupy a large percent from the total agricultural surface.

In the case of Mânzăleşti, values of the human pressure through arable index record an increase in 2008, when compared with the other years, from 0.0411 ha/inhab. to 0.0982, it followed an increase of arable surfaces in the disadvantage of other land uses.

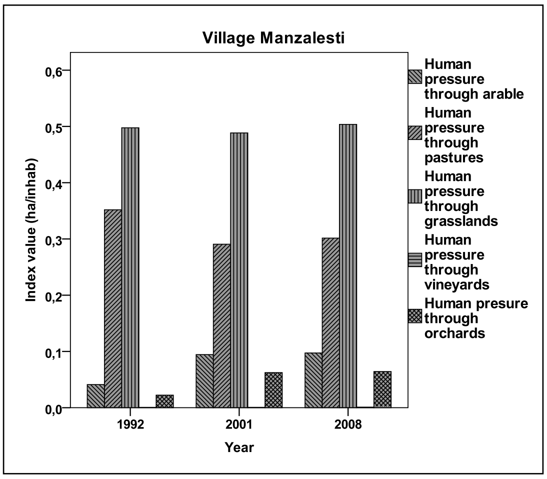
Human pressure through pastures records high values in Vintilă Vodă, Beceni, and Cernăteşti, with increases in 2008 compared with 1992 in the case of Vintilă Vodă, and decreases in values for Beceni and Cernăteşti.

Analysing *human pressure through grasslands*, there are recorded increases in 2008 compared with 1992 in all the villages except Cernăteşti where the values record a slight decrease, evidencing the specific of agricultural use with valances resembling rural spaces from the contact with plain units.

Human pressure through vineyards relieves the contrast of agricultural use in the five villages in relation with the specific of surrounding relief units. The highest values for this index are recorded in Cernăteşti.



a.



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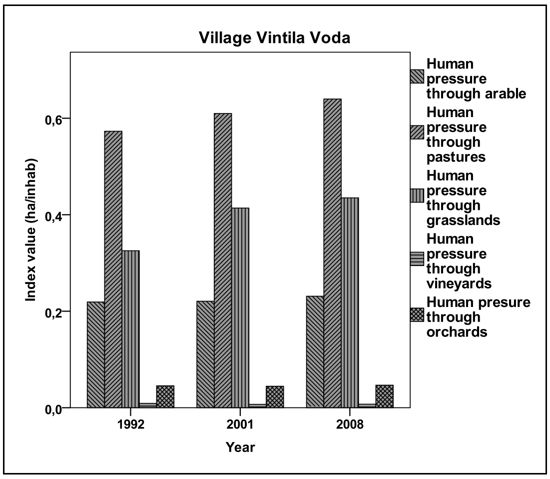

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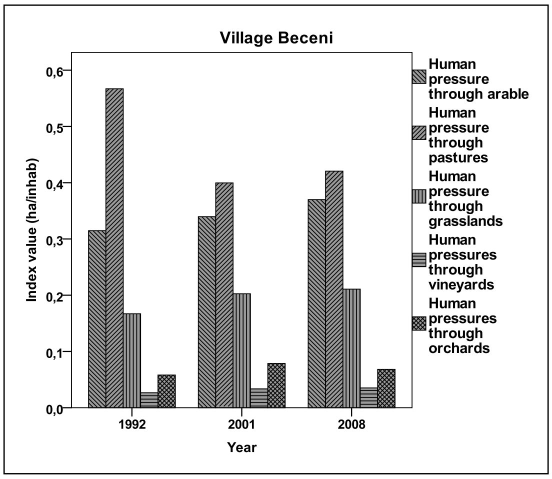

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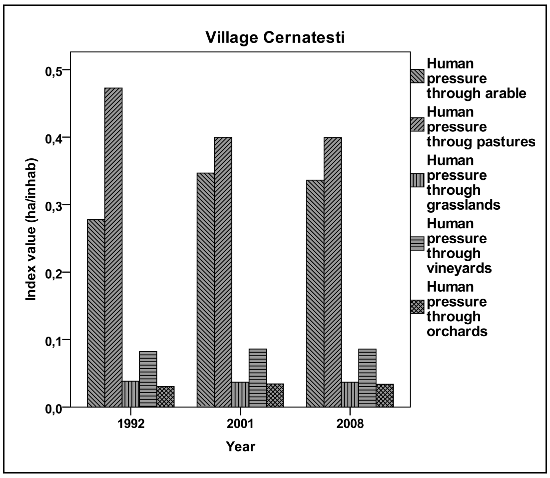

e.

Fig. 5 Human pressure through different land uses (a, b, c, d, e)

Values of the *human pressure through orchards index* record an ascendant trend in 2008 compared with 1992 for all villages, thus existing preoccupations for the expansion and revitalisation of orchards.

Analysing and representing graphically data resulted from CLC 1990 and 2006 models, there were evidenced changes in the structure of the land use for each analysed village, in a comparison between 2006 and 1990 (Fig. 6), under the pressure of rural

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population, and the necessity of satisfying their human needs.

Between the two maps, there are recorded increases in 2006 compared with 1990 for *arable fields, surfaces occupied by orchards and tree nurseries, pastures and un-productive agricultural fields.*

These increases are realised in the disadvantage of the other land uses and coverings, specific to the analysed area, which suffered obvious decreases: *vineyards, forestry surfaces, bushes and grass associations, constructed surfaces.*

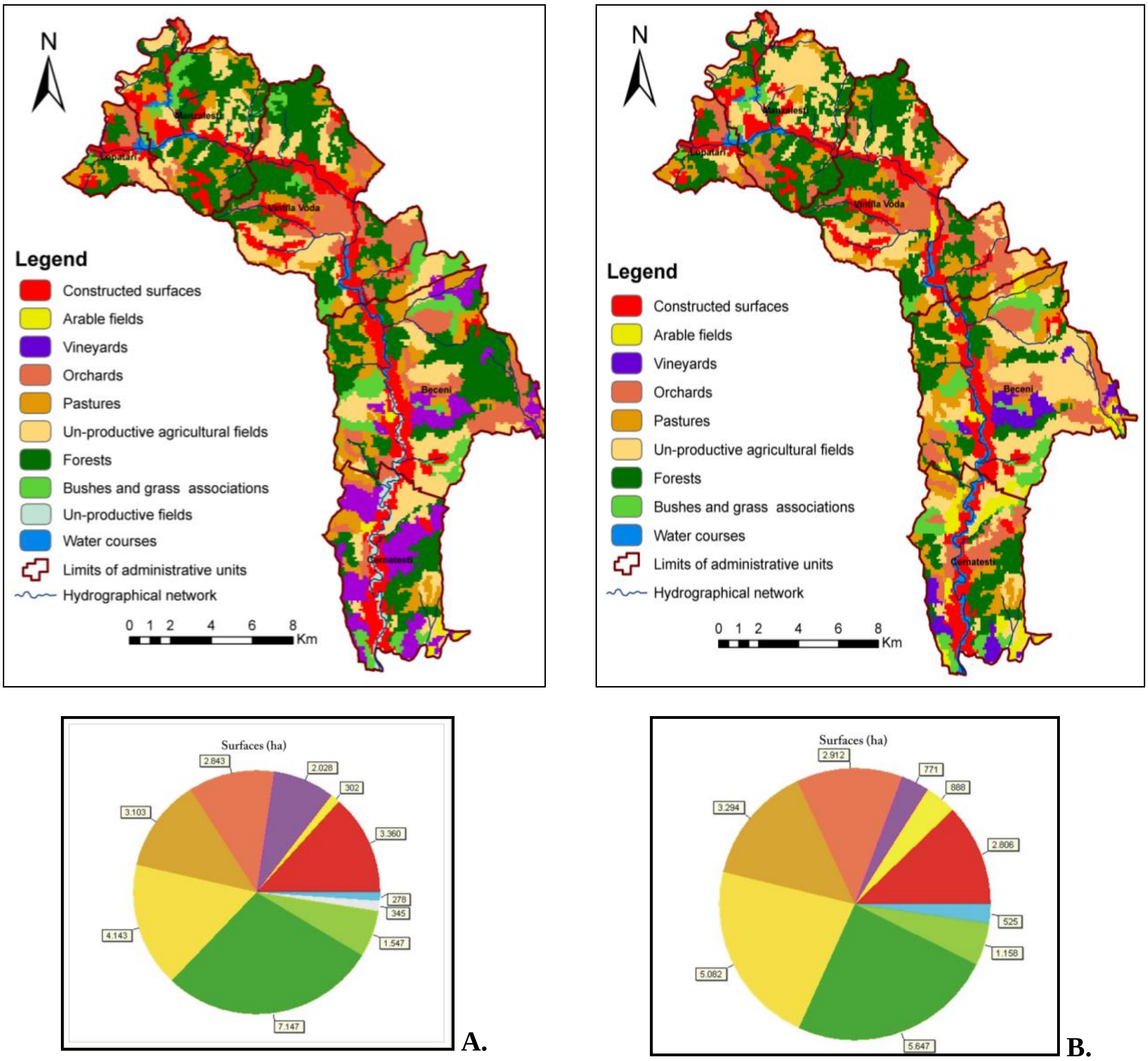

Fig 6 Land use and cover in 1990 (A) and 2006 (B), in the analysed villages

CONCLUSIONS

On the surfaces of the 5 villages, there are encountered particularities of the rural Subcarpathian space, characterised through a dominance of settlements with rural functions, structure and aesthetics, a predominant agricultural land-use and dominant agricultural population.

The spatial and temporal dynamics of the values for human pressure indices upon the biotic components reveals changes from the socio-historical times upon land uses, conditioning in the same time the restructuring of rural landscapes from the Subcarpathian area.

From the calculated values for the five villages, it can be observed a clear differentiation regarding human pressure on the environment, related with geodiversity, major relief type, the dynamics of inhabitants numbers – in a continuous decrease, but also according to climatic changes recorded at local, regional and global level.

Regarding the arable land use, factors influencing the temporal dynamic of the human pressure through arable index are especially the decrease of rural population, but also increases and decreases of arable surfaces, corroborated with particularities of the lithological substratum, relief fragmentation degree and soil erosion.

The analysis realised based on the data extracted from the CORINE Land Cover model, for the years 1990 and 2006, evidenced a real expansion of arable surfaces and pastures, in the disadvantage of forest and vineyards, the main cause being the need of expanding pasture fields and the arable use of fields, increasing the functional heterogeneity degree of the rural Subcarpathian landscape and its fragmentation.

Values obtained from the statistical data regarding the proportion of different land uses from total agricultural surface, corroborated with values of human pressure through different land uses indices, calculated for each territorial administrative unit are verifiable by the CORINE Land Cover model. The differences are determined only by the interpretation and classification methodology of different land uses and covers developed by the European Environmental Agency.

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THE ANALYSIS OF FOREST DYNAMICS WITHIN THE CONTACT AREA BETWEEN THE CARPATHIANS AND SUBCARPATHIANS BY USING HISTORICAL CARTOGRAPHY APPROACH AND OPEN SOURCE GIS SOFTWARE. CASE STUDY: THE LIMPEDEA CATCHMENT (ROMANIA)

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Abstract

The paper is an original contribution based on the diachronic comparison of historical maps from different periods, with the purpose of capturing and mapping the landscape history of the Limpedea catchment (tributary of the Argeş), which stretches almost equally into the strongly man-altered space of the Subcarpathians, as well as into the mountain area. The study highlights the changes undergone by the Arefu - Corbeni Subcarpathian depression and the neighbouring mountain area, paying particular attention to the Carpathian - Subcarpathian interface zone. In order to achieve its goal, the study relied on large scale maps from the 1790-1980 period, which were processed in Open Source GIS (Quantum GIS, GRASS, gvSIG Sextante, MapAnalyst). The interpretation of cartographic information using GIS techniques showed a continuous recession of the forests in the Subcarpathian part of the catchment and their replacement by agricultural lands, which led to a gradual decrease of the naturality degree. In the 1864-1904 period, the extension of pastures and hay fields to the detriment of the forests was prevalent, whereas in the second half of the 20th century larger and larger areas of pastures and hay fields were turned into orchards or built-up areas.

Keywords: *historical cartography, Open Source GIS, Quantum GIS, GRASS, forest, landscape, land use*

Rezumat

Analiza dinamicii pădurii în zona de contact Carpați - Subcarpați prin cartografie istorică în mediu SIG open source. Cazul Bazinului Limpedea (România). Lucrarea constituie o contribuție originală, bazată pe compararea diacronică a hărților istorice din diferite perioade, cu scopul surprinderii şi cartografierii istoriei peisajului în bazinul hidrografic al pârâului Limpedea (afluent al Argeşului), bazin extins în părți aproximativ egale în spațiul puternic antropizat al Subcarpaților şi în zona montană. Studiul surprinde atât modificările din depresiunea subcarpatică Arefu - Corbeni, cât şi din zona montană şi mai ales din zona de interferență carpatico-subcarpatică. Pentru atingerea scopului propus s-au folosit hărți la scară mare din perioada 1790-1980, care au fost exploatate în mediu GIS Open Source (Quantum GIS, GRASS, gvSIG, Sextante, MapAnalyst). Interpretarea datelor conținute în hărți cu ajutorul tehnicilor GIS a evidențiat o reducere continuă a pădurilor din spațiul subcarpatic al bazinului şi înlocuirea acestora cu terenuri agricole, fapt ce a determinat reducerea treptată a gradului de naturalitate. În perioada 1864-1904 a predominat extinderea păşunilor şi fânețelor în detrimentul pădurilor, iar în partea a doua a secolului XX, suprafețe tot mai mari de păşuni şi fânețe au fost transformate în livezi sau areale construite.

Cuvinte-cheie: *cartografie istorică, SIG Open Source, Quantum SIG, GRASS, pădure, peisaj, utilizarea terenurilor.*

INTRODUCTION

Investigations have proved that over the time, several cultures and economies overlapped on this territory and the result was a real "layering" in time of the landscapes, each of them being in essence a cultural landscape that reflected the identity of the territory. Thus, the landscapes depend on "man's will and his concrete actions", which means they are not "a fabrication or a subjective interpretation" (Lorenzi, 2007). In order to capture the landscape history one should turn to historical cartography, because it reveals the landscape features, their dynamics in various stages and especially their location. This is the reason why the cartographic approach has been tackled widely in the literature (Corna Pellegrini, 2004; Lago, 2004; Longhi, 2004; Robinson, 2004; Rosseli, Paulmier, 2006; Campiani, Garberi, 2008; Osaci-Costache, 2004, 2008, 2009a, 2009b etc.). Therefore, the originality of our contribution consists in the analysis and diachronic comparison of large-scale maps with the purpose of highlighting some aspects concerning the landscape dynamics based on the employment of Open Source GIS software (Quantum GIS, GRASS, gvSIG, Sextante, MapAnalyst).

The study has sought to investigate from a cartographic point of view the changes that occurred in the contact area between the Subcarpathians and the Carpathians, i.e. in the space ”invaded” more and more by man in his quest for new resources and new agricultural lands. As study area, we have chosen the catchment of the Limpedea stream (35.58 sq km), a left-side tributary of the Argeş, which stretches almost equally in the Subcarpathian (18.08 sq km) and Carpathian (17.5 sq km) spaces. In the north, the catchment overlaps the mountain area (maximum elevation of 1621.9 m in the Ghițu peak), whereas in the south it overlaps the Arefu - Corbeni Subcarpathian depression (with minimum elevation of 592 m at the confluence of the Limpedea with the Argeş). In the extreme southeast there lies the Chiciura peak (1217.9 m), which is the highest summit in the Romanian Subcarpathians (Fig. 1).

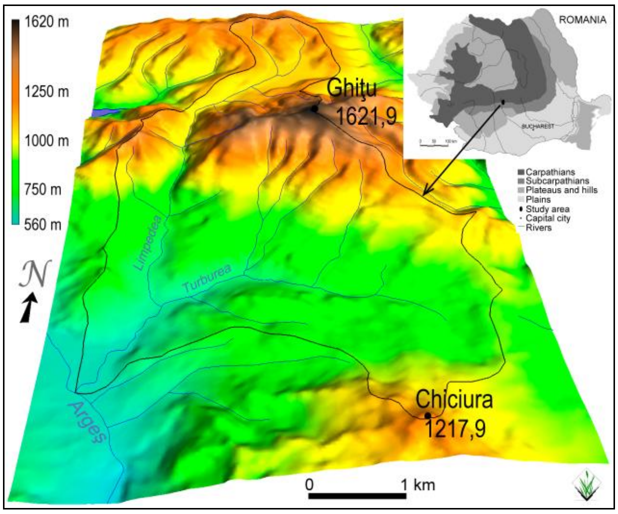

Fig. 1 The study area (3D model obtained in GRASS software by using the “NVIZ” module)

From the administrative point of view, the investigated area belongs to Corbeni Commune, consisting of several villages. One of these is Berindeşti, firstly shown at the beginning of the 18th century on the map drawn by Anton Maria del Chiaro (1718); it appears on the Russian Map of 1835 with 30 families and on the Russian Map of 1853 with 40 families (Osaci-Costache, 2004). The other two are Turburea and Poienari, the latter being shown on the Szathmary Map of 1864. The Subcarpathian catchment of the Limpedea stream occupies a part of the Arefu - Corbeni subsequent tectonic-erosive depression, lying at the contact between the Subcarpathian and the Carpathian areas. The depression is made up of Paleogene and Miocene sedimentary formations (sandstones, marls, clays and sands), on which landslides, torrentiality and sheetwash are extremely active (Nedelea, Dorca, 2001). These processes have been encouraged by human actions, which have been responsible not only for the shrinking of forest vegetation, but also for overgrazing and plowing up and down the slopes.

At present, forests are found especially in the mountain area of the catchment (beech forests and mixed beech-coniferous forests, with different features depending on elevation, slope aspect and declivity), as well as on the high Subcarpathian hills (the northern side of the Chiciura Hill).

At the contact between the Subcarpathians and the Carpathians, on the southern slopes of the Ghițu Massif, on the relatively gently inclined slopes and on the rather flat surfaces of the Gornovița erosion level, human settlements and agricultural lands (characteristic for the depression) have gradually climbed to the highest elevations of the mountain area, to the detriment of the forests. Consequently, they have come to occupy the rather steep slopes lying above 800 m of altitude. For the Făgăraş - Iezer Mountains, the mean inner limit of permanent settlements ranges from 600 to 800 m (Mihăilescu, 1936), whereas that of the temporary ones lies above 1300 m (*Geografia României*, III, 1987). Agricultural lands are common in the lower part of the Limpedea catchment.

A specific feature that has influenced the man-environment relationships within the contact area between the Argeş Subcarpathian Hills (Muşcelele Argeşului) and the Carpathian area is the development of the settlements’ estates farther into the mountain area (the Arefu and Nucşoara communes etc.). This feature, together with the favourable pedoclimatic conditions and the high percentage of low declivity surfaces, has encouraged the gradual rising of the temporary settlements’ line, north of the investigated area, as high as 2,035 m (at Bâlea Lake).

SOURCES AND METHODS

In order to reach the settled objective, we have proceeded to the overlapping and diachronic comparison of several large-scale historical maps, which cover a period of 190 years. These are the Specht Map (1790-1791, scale 1:57,600), “Charta României Meridionale” or the Szathmary Map (1864, scale 1:57,600), the Lambert’s projection topographic plan (1904, scale 1:20,000) and the Gauss-Krüger topographic map (1980, scale 1:25,000). All these cartographic documents have been processed using the GIS Free and Open Source softwares under Windows Vista: Quantum GIS (http://qgis.org/), known as QGIS, (versions 1.0.2. – Kore, and 1.3.0. – Mimas), as well as “gvGIS”, version 1.1.2. (www.gvsig.gva.es).

The research has been conducted in several stages: (a) map scanning; (b) map georeferencing to a common reference system, which was done in Quantum GIS; (c) producing of vector layers in ESRI *Shapefile* format and creation of a database in Quantum GIS; (d) quantitative and qualitative analysis of geographical data using GRASS (integrated in QGIS; http://grass.osgeo.org/) and Sextante (integrated in gvSIG; http://www.//sextantegis.org) softwares; (e) elaboration of synthesis maps in QGIS. Some final processing was accomplished with the Open Source “GIMP” (http://www.gimp.org/) and “Inkscape” (http://www.inkscape.org/) softwares.

Because of their significant distortions, the maps dating back to the 18th and 19th centuries have been georeferenced on the basis of the control points corresponding to those also existing on the map of 1980. These have been chosen by the “MapAnalyst” free software, so that the standard deviation values be minimum (Fig. 2).

The employment of a common reference system (WGS84/UTM Zone 5N) and the good overlapping of the chosen maps have allowed us to compare the land use between 1864 and 1980, both from a quantitative and a qualitative point of view.

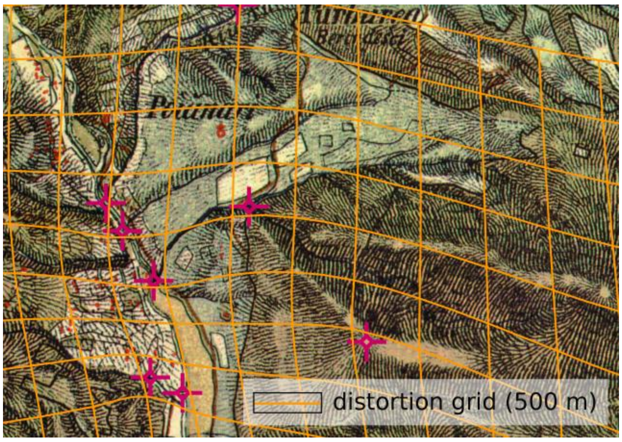

Fig. 2 Distortion analysis of the Szathmary map (1864) through Helmert transformation by using MapAnalyst software

MAIN RESULTS AND DISCUSSIONS

The present analysis has started from the situation mirrored by the Specht Map for the end of the 18th century (1790-1791), when the study catchment was highly forested, even though it was lying in the immediate vicinity of an important road connecting Wallachia and Transylvania. The road followed the Argeş valley, passing through Curtea de Argeş, Corbeni, Arefu and Sălătruc, finally reaching Câineni (Năstase, 1972; Osaci-Costache, 2004, 2010). The map verifies the existence of Berindesk (Berindeşti) village, surrounded at that time by forests. Because of the large distortions, the Specht Map has only been used for a reconstruction of the areas covered by forest at the end of the 18th century (Fig. 3), but not at all for other kind of investigations.

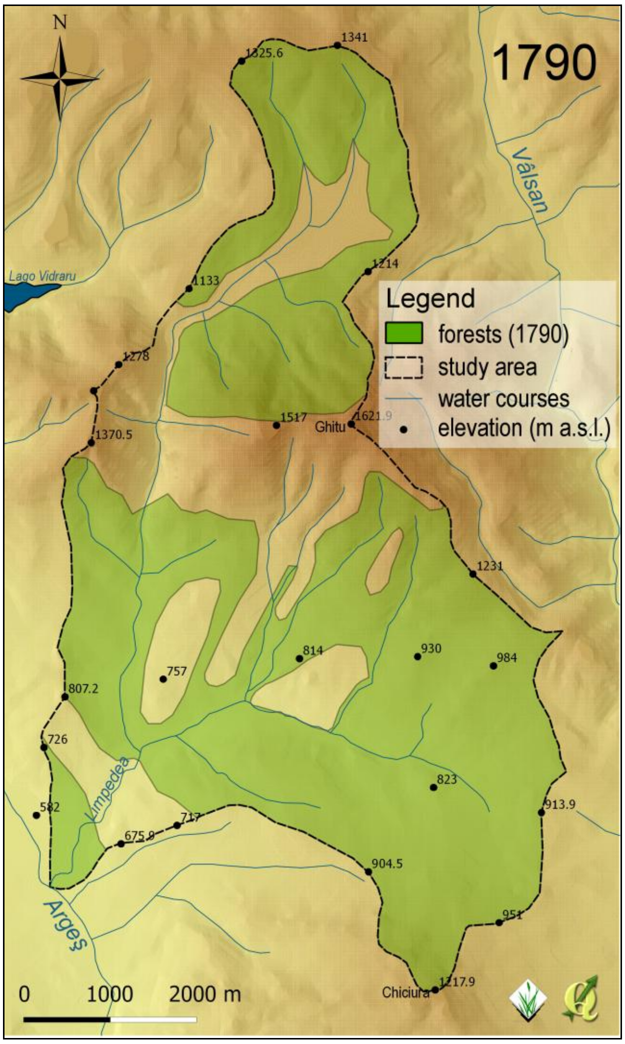

Fig. 3 Reconstitution of the forest extent on Specht Map (1790-1791) in Quantum GIS

Starting from the second half of the 19th century, diachronic comparison of maps has revealed a recession of wooded areas (3,158 ha in 1864, 2,682 ha in 1904 and 2,092 ha in 1980). At the same time, it has highlighted the fact that between 1864 and 1904 deforestations were mainly done on the Limpedea-Argeş interfluve, whereas later (1904-1980) they affected also the hearth of the depression, the strip of land situated along the Tulburea stream and the mountain area. The diminution of the forest areas was accompanied by a rising of the lower tree line (from 594 m in 1864 to 635 m in 1904 and 680 m in 1980), whereas the upper tree line continued to remain at about 1,620 m (Fig. 4). Thus, between 1864 and 1904, the lower tree line rose 41 m and between 1904 and 1980 it rose again by 45 m, which means a total of 86 m in 116 years (1864-1980). The phenomenon can be explained by anthropogenic interventions, which were stronger on the bottom of the depression (on lower and gently inclined surfaces), where wooded areas were turned into agricultural lands.

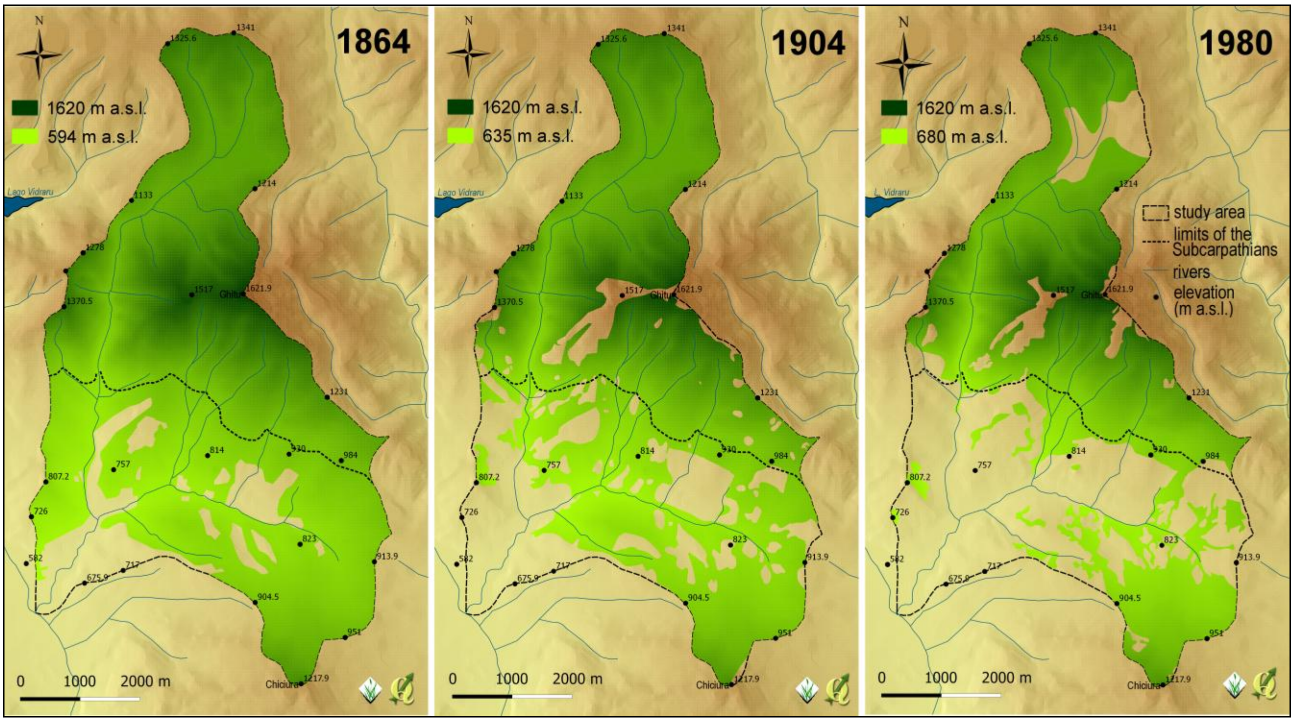

Fig. 4 Forest distribution in relation to altitude. Reconstitution in Quantum GIS – GRASS based on cartographic information

The general view of the deforestations that affected the Limpedea catchment highlights a marked recession of the wooded area in the Subcarpathian space in comparison with the mountain region. At the same time, the analysis of historical maps reveals several stages of anthropogenic intervention and points out the fact that the human pressure was very strong during the 20th century (Fig. 5). The deforestations affected the wooded areas owned by the state, especially at the beginning of the period, as it has resulted from the overlapping of a cartographic document issued in 1900 by the State Forest Service (the *Forest map on categories of ownership*, scale 1:200,000).

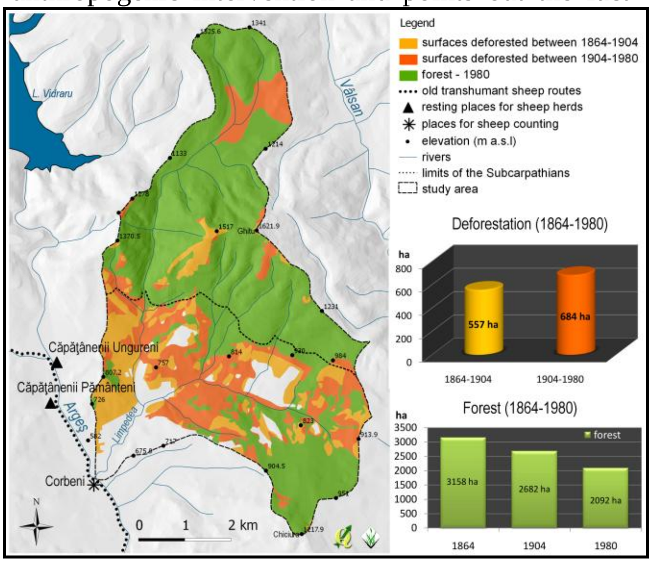

Fig. 5 Reconstitution in Open Source GIS of the deforested areas during the 1864-1980 period

The diminishing of wooded lands determined a continuous lowering of the naturality degree, expressed as percentage of the forest in the total area (Ionescu et al., 1989). It must be mentioned, however, that we have computed the index relying on the information provided by historical maps (Fig. 6), while being aware of the fact that man was not entirely responsible for the recession of wooded areas. Although, on the whole, the values slightly decreased (88.76 percent in 1864, 75.38 percent in 1904 and 58.80 percent in 1980), thus allowing us to include the Limpedea catchment into the category of intensely forested lands, a detailed analysis conducted separately for the Carpathian and the Subcarpathian areas has shown a different situation. Thus, because deforestation affected primarily the Subcarpathian space, the naturality degree of this area dropped, reaching a value of 32.4 percent in 1980 (according to the specialists, a value of less than 50 percent leads to negative ecological interactions; Ionescu et al., 1989). The differences are big: most of the mountain sector has currently values higher than 60 percent (often 100 percent), while in the Subcarpathian region there are large areas with values of the naturality degree below 11 percent (with a minimum value of 0 percent at the confluence with the Argeş).

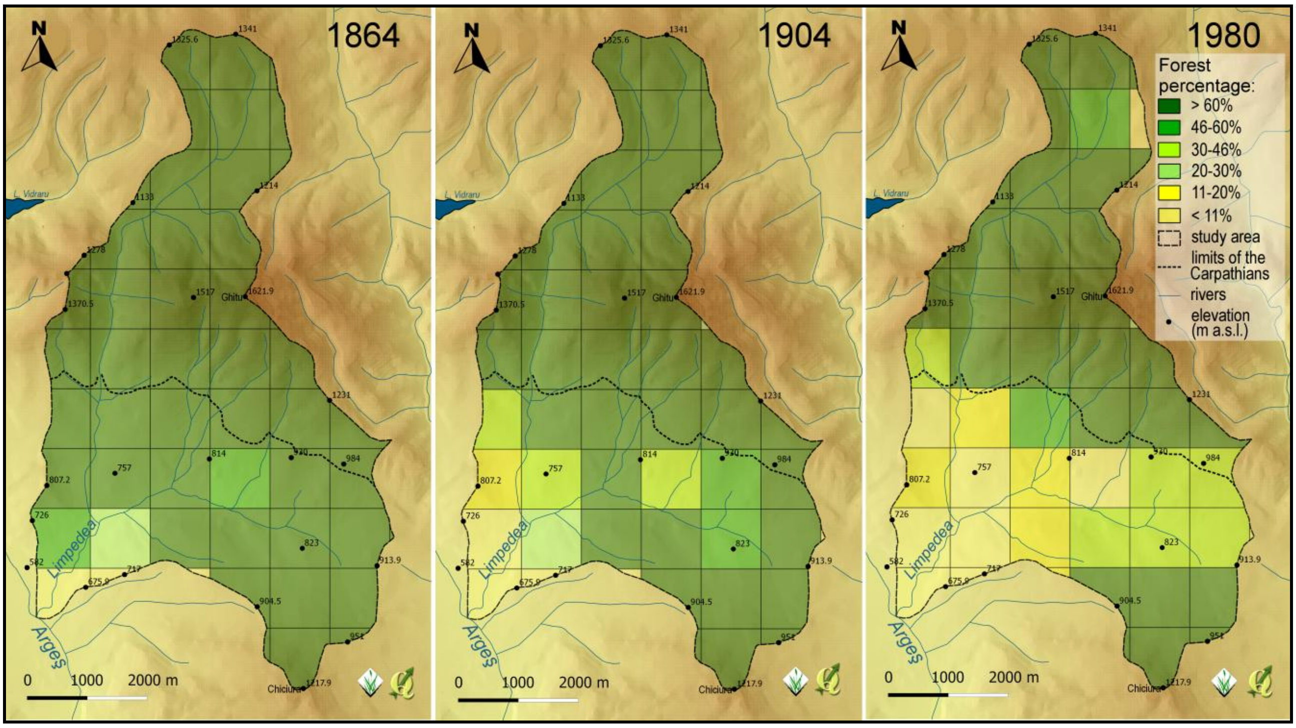

Fig. 6 The evolution of naturality degree computed based on the information provided by historical maps

Deforestation, the most conspicuous anthropogenic intervention on the landscape did not remain without response in the toponymy of the area. Under these circumstances, the old and present maps turn to be important sources for getting in touch with the toponyms, especially with those belonging to the past centuries. Most of the toponyms extracted from the maps we used for this investigation are connected to the deforestation: Secături (roughly Cleared lands), Poiana Vişinului (The Cherry Tree Glade) etc. Other remind of the pastures and hay fields specific for the 19th century: Izlazul Berindeşti (The Berindeşti Common), Izlazul Brădetului (The Brădetului Common). Likewise, there are many toponyms referring to specific tree species (La Sălcioara – At the Dwarf Willow), or to the existence of fruit bearing trees (La Vişini – At the Cherry Trees).

The deforestations were triggered by the new demands of the inhabitants (agricultural lands, building sites etc.) and they were followed by an alteration of the initial land use. Therefore, the land use has been another investigated aspect. Comparing the maps, one can notice not only the deforestation of large areas, but also the fact that over the time the lands had various uses (Fig. 7).

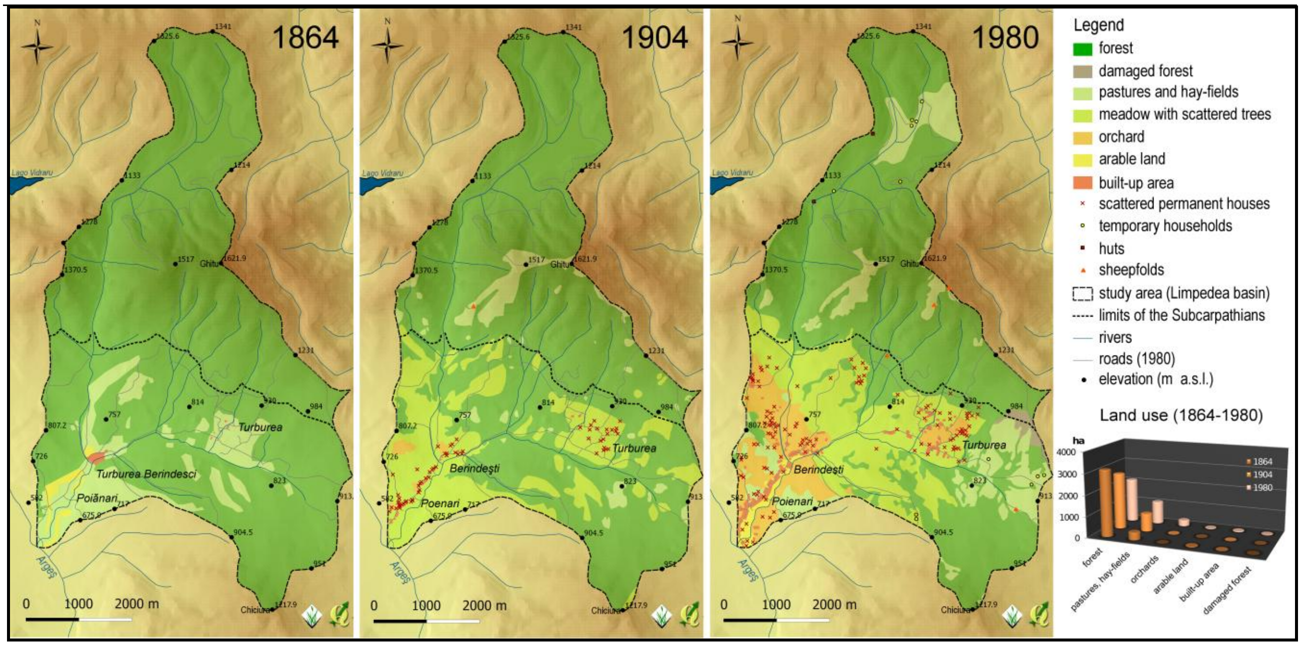

Fig. 7 Land use reconstitution based on historical maps in Open Source GIS (Quantum GIS, GRASS)

A comparison between the Specht Map and the Szathmary Map shows that the dominant phenomenon for the 1790-1864 period was the turning of forests into pastures and hay fields. Cartographic documents (the Szathmary Map) and written sources suggest the main occupation of the inhabitants was stockbreeding, often under the form of transhumance (Osaci-Costache, 2009b). Thus, the spatial extension of pastures was dictated by the necessity to provide food both for the local herds and for those belonging to the Transylvanian shepherds, as the study area was lying near a passing track of transhumant herds. This sheep itinerary was climbing upstream the Argeş River, passing through Corbeni, then reaching Căpăţânenii Ungureni (Fig. 5), from where it headed to Arefu and farther away to the Frunţi Mountains and the Făgăraş Massif (Popp, 1933). Along this way, Arefu and Corbeni used to be the villages where sheep counting was done (Constantinescu-Mirceşti, 1976), while Arefu, Căpăţânenii Ungureni and Căpăţânenii Pământeni were resting places for the tired herds (Popp, 1933; Fig. 5).

At the beginning of the 20th century, large areas of pastures and hay fields developed on the site of the former forests. One can also notice an extension of built-up areas and orchards, the latter reaching a large development at the end of the last century (1980). The extension of the orchards after 1960 was encouraged by the socialist legislation, which turned the pastures and the hay fields into socialist plantations (Bold et al., 1960).

The gradual extension of built-up areas within the permanent settlements (29 ha in 1904 and 39 ha in 1980) was accompanied by an increase in their absolute elevation (Fig. 8). Unlike the forests, which continuously withdrew to higher elevations, the built-up areas stretched both up and down (Fig. 8). Consequently, the amplitude of built-up areas grew from 171 m (1864) to 289 m (1980). Most of the isolated households shown on the topographic plan of 1904 (67.21%) were included in the 20th century in the compact built-up area. At the same time, 32.79 percent of the isolated households kept their position, remaining far away from the compact built-up area, but preserving their potential to become future nuclei for its further expansion, as it happened between 1904 and 1980.

The increasing human pressure was accompanied by the rising of the upper line of temporary settlements. The altitudinal spreading of isolated buildings (chambers, dwellings, huts, isolated houses with or without courtyards) meant both a lowering of the absolute minimum elevation and an increase of the absolute maximum altitude. Looking strictly at the vertical location of sheepfolds one can also ascertain an increase in their absolute altitude (from 1,130 m in 1904 to 1,490 m in 1980), determined by the quest for new pastures, inasmuch as stockbreeding has been a traditional occupation in this area. This also explains the vast lands covered by pastures and hay fields during the former centuries.

Another consequence of the agricultural land expansion to the detriment of the forest was the tillage of highly inclined surfaces (Fig. 9). For instance, if at the beginning of the 20th century the buildings occupied the lands lying at gradients between 0 and 18°, at the end of the same century they came to seize the slopes with declivities as high as 34° (the highest frequency, however, being specific for the 8-15° interval). With respect to the pastures and hay fields, which represent the dominant land use in the Subcarpathian area of the Limpedea catchment, one can notice that if in 1980 they recorded a maximum gradient of 37°, in 1980 this value reached 40°. However, in 1980 most of the Subcarpathian pastures and hay fields were found on slopes lying at gradients between 7 and 15°. The same phenomenon is also obvious for the orchards: an increase of the land gradient from a maximum of 15° in 1900 to 37° in 1980. In the mountain area of the catchment, gradients often exceed 50° and, consequently, the slopes are covered by woods (Fig. 9).

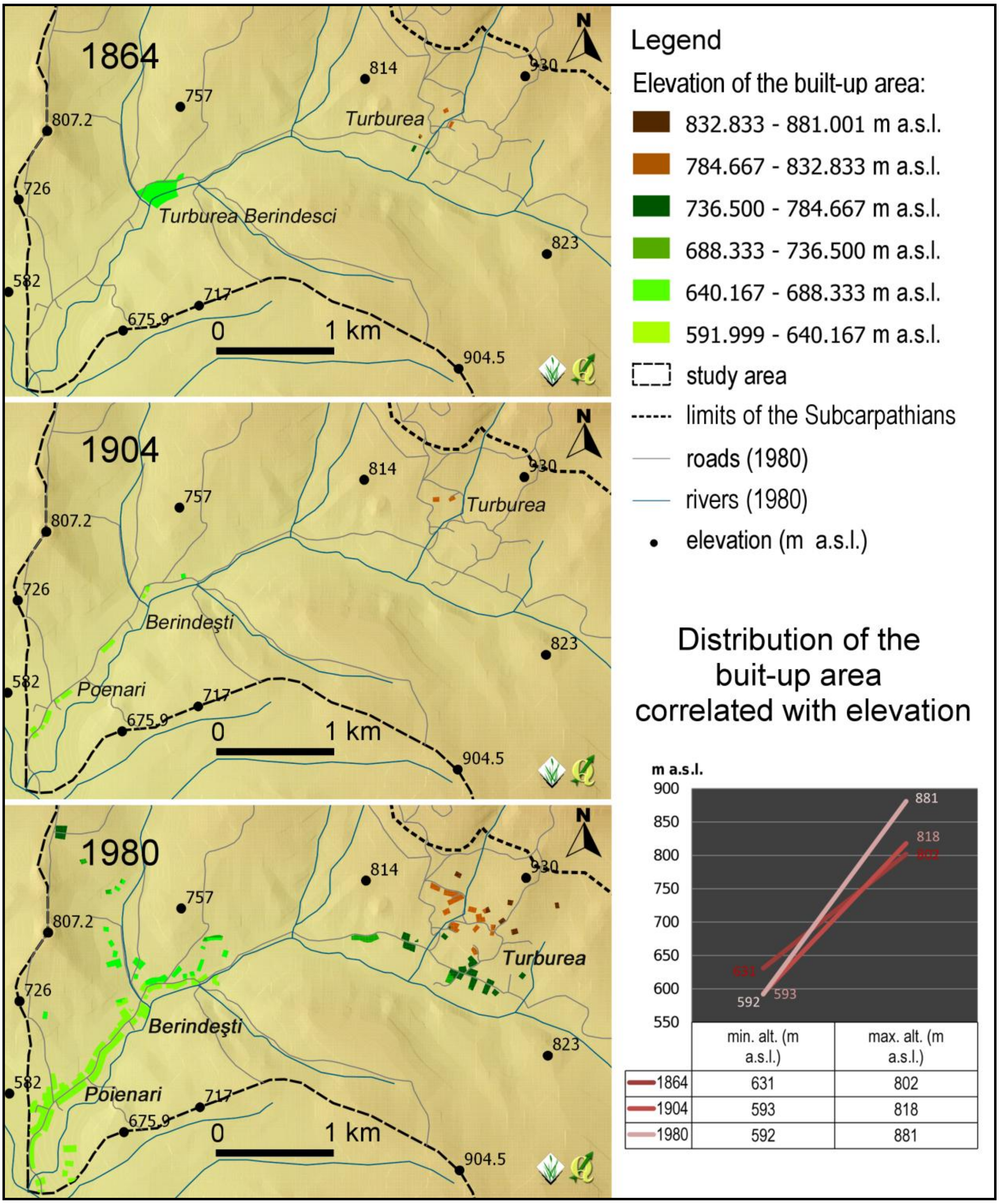

Fig. 8 Correlation between the built-up area and the relief elevation on the basis of cartographic information, in the years 1864, 1904 and 1980

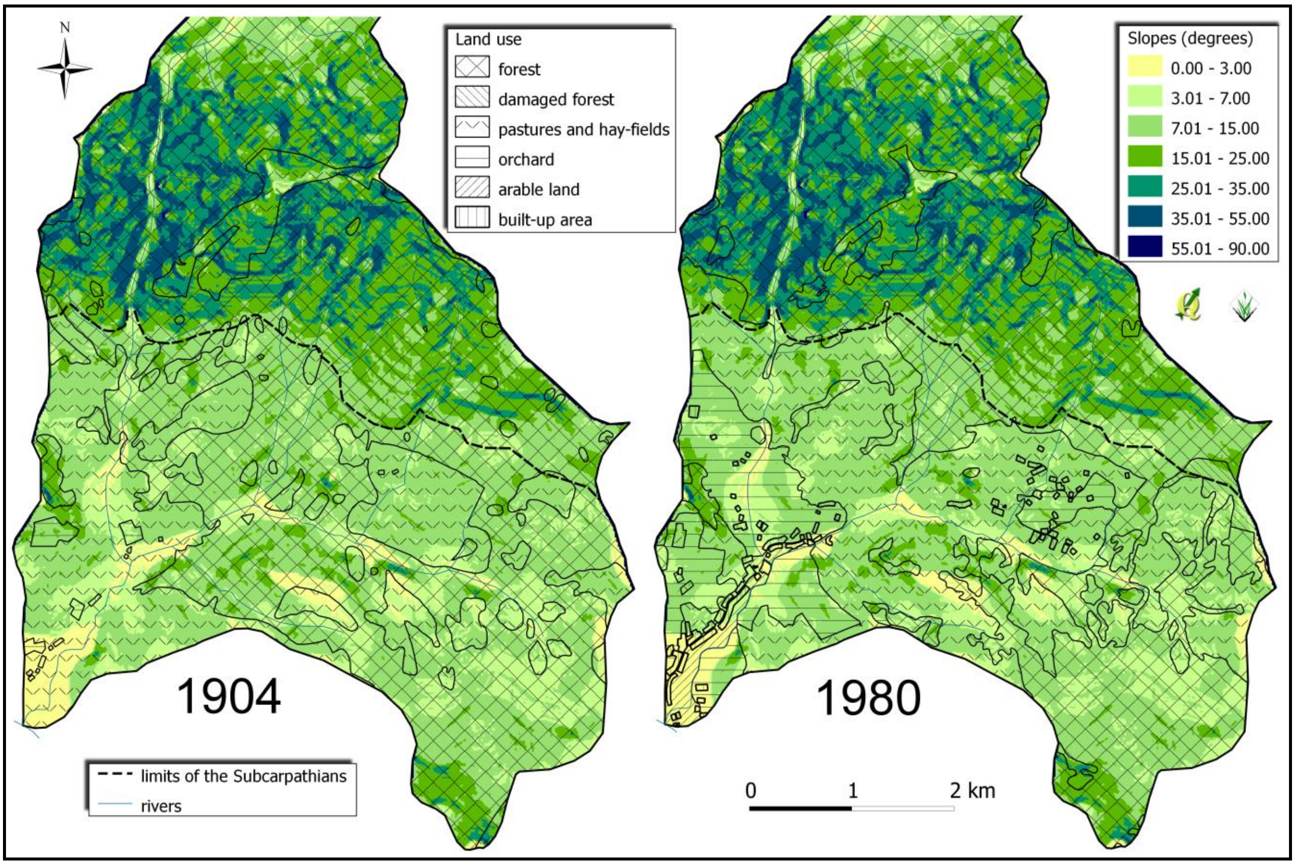

Fig. 9 Correlation based on cartographic data between land use and declivity at the beginning and the end of the 20th century (fragment)

CONCLUSIONS

The large-scale historical maps made in the last 190 years have proved to be the best witnesses of the landscape features. Their analysis and comparison have highlighted a landscape profoundly altered by man. Over the time, the human intervention has had various intensities, but it has particularly influenced the Subcarpathian area and the contact strip between the Subcarpathians and the Carpathians. As far as the mountain space is concerned, it has been affected to a lesser extent. At the end of the 18th century, a big part of the investigated catchment was covered by forests, but the wooded area declined significantly in the following centuries, as a result of their turning into pastures, hay fields, orchards and built-up areas. This phenomenon entailed an increase in human pressure, concomitantly with a lowering of the naturality index. The dwellings and sheepfolds, which are specific for the local traditional economy, grew numerically and spread to higher elevations in the mountain area.

The use of Open Source GIS software (Quantum GIS, GRASS, gvGIS, Sextante and MapAnalyst) has proved to be very productive for the quantitative and qualitative analysis of historical maps, as well as for their diachronic comparison, obviously improving the results obtained through classical methods. The overlapping of maps (based on the same reference system) in GIS environment has highlighted the landscape dynamics under the influence of human activities and allowed for its reconstitution in various stages. At the same time, this technique has also allowed for the correlation between the present features of the landscapes and their genesis.

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THE INTENSIFICATION OF ANTROPIC PRESSURE THROUGH THE EXPANSION OF THE CONSTRUCTED AREA IN THE SUBCARPATHIAN SECTOR OF THE PRAHOVA VALLEY/ROMANIA (1800-2008)

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Abstract

The present research focuses on the evolution of anthropic pressure on the environment through the continuous development of the constructed space, in a diachronic comparative analysis of urban-rural environment, detailed on the basis of two characteristic examples: Breaza town and Cornu town. The information resulted from the historical maps was completed by mapping from the ortophotoplans and GPS land surveys. The data base went through statistic differential processes and correlational analysis with the conditions of the physical support, highly important limitations and favorabilities in the assessment of the vulnerability of the Subcarpathian space being revealed.

Keywords: *antropic pressure, constructed area, Prahova Valley, GPS survey*

Rezumat

Intensificarea presiunii antropice prin expansiunea spațiului construit în sectorul subcarpatic al văii Prahovei/ Romania (1800-2008). Prezentul studiu se focusează pe evoluția presiunii antropice asupra mediului prin extinderea spațiului construit, printr-o analiză comparativă diacronică a mediului urban şi a mediului rural, detaliată în principal prin două exemple caracteristice: oraşul Breaza şi comuna Cornu. Informațiile rezultate din hărțile istorice au fost completate prin cartările de pe ortofotoplanuri şi prin expediții de teren realizate cu GPS-ul. Bazele de date obținute au fost procesate prin metode statistice şi prin analize corelative, ținându-se cont de suportul fizico-geografic şi factorii constituenți cu cea mai mare importanță în limitarea sau favorizarea vulnerabilității spațiului subcarpatic analizat.

Cuvinte-cheie: *presiune antropică, spațiu construit, valea Prahovei, monitorizare GPS*

INTRODUCTION

General data

Ut The Prahova Valley emerges from the mountain sector through the Posada gorge and forms a succession of tectonic-erosive depressions with an accentuated development of the fluvial terraces on 20 kilometres in the Subcarpathian sector, until it reaches the plain sector, near the Câmpina town (Fig. 1 - Right).

The extension of the residential space is mainly favoured in this area by:

-the moderate Subcarpathian climate, with an annual average temperature of 10^{o}C and a degree of insolation similar to the one in the plain area;

-the medium heights of approximate 500 m and the moderate slopes with a North-South direction. Also, the top of the second terrace is 2 kilometres wide in the depression sectors.

These elements are the basis for the development of the constructed space after 1990, a specific phenomenon being the holiday houses that appeared as a consequence to the degree of accessibility and the proximity to the country capital (about 100 km north of Bucharest).

Objective

The present research focuses on the evolution of anthropic pressure on the environment through the continuous extension of the constructed space, in a diachronic comparative analysis of urban-rural environment, detailed mainly on the basis of two characteristic examples: Breaza town and Cornu town.

STUDY AREA

The two settlements under study are located in the Subcarpathian sector of the Prahova catchment area (Fig. 1 - Left).

The studied perimeter represents the western part of the Mio-Pliocene subzone of the Eastern Carpathian Foreland, developed on a subzone of diapire folds. The geological evolution of the area is similar to that of the Dacian Basin, with an initial connection with the Tethys Sea, when there were accumulated the gypsum and salt deposits during the Lower Miocene (Badenian) age. Beginning with the Lower Pontian, the communication between the eastern and western part of Paratethys, through the Dacian Basin, is narrowed down to closing, leading to a stage of rhythmic deposits of fine-coarse materials (Armaş et al. 2002).

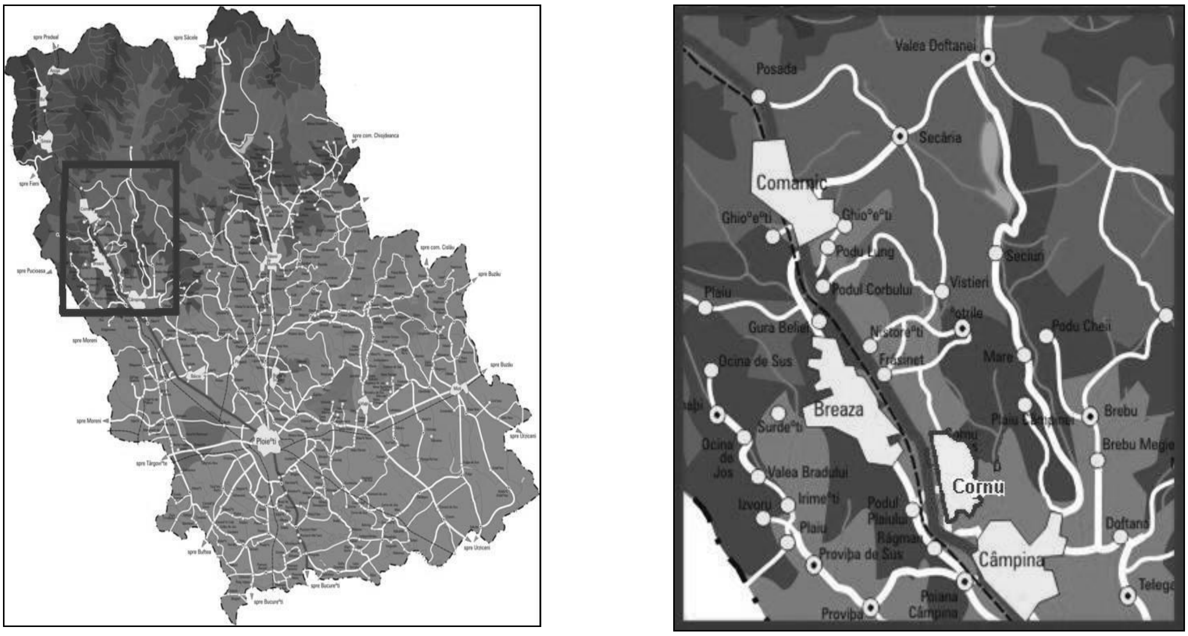

Fig. 1 Left/ right - Study area located in the Prahova county/ Geographical position of Breaza and Cornu settlements in the Subcarpathian sector of Prahova basin

Cornu town had 4,475 inhabitants in 2002, from which 2,152 are males and 2,323 females and 1,659 buildings in total. In all this buildings, according to the census in 2002, there were 1,860 permanent residences (including 5 spaces used for trading purposes), which includes 5,876 rooms in total (Yearbook, 2003) (Fig. 2 - Left).

Breaza town had 18,199 inhabitants in 2002, from which 8,964 are males and 9,235 females. There were 6,078 buildings in total. In all these buildings, according to the census in 2002, there were 7,368 permanent residences (including 46 spaces used for trading purposes), which includes a total of 22,697 rooms (Yearbook, 2003) (Fig. 2 - Right).

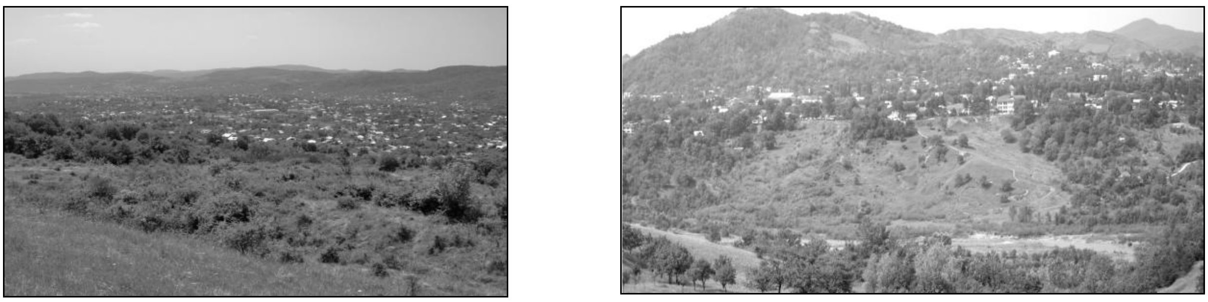

Fig. 2 Left - Terrace plain of Lower Cornu seen from the Plaiu Cornului ridge; Right - General overview over Breaza settlement

METHOD

One of aspects concerning the anthropogenic impact lies in the continuous expansion in time and space of built domain. To analyze the impact of the process we use the GPS device for the inventory, positioning and mapping of the buildings built in Breaza locality, in July 2008 (continuing the mapping action started in 2007) and also in Cornu settlement.

Measurements were made with the GPS equipment, using an Garmin76 device type.

During this field investigation we sought to update the database referring to the evolution of the built space in the southern part of the city, and then from the northern extension and from isolated neighborhoods of the city east of DN 1 (Nistoreşti, Frăsinet).

It was found that in this area there are 3 main categories of buildings, similar to those from the previous mapping stage:

Category 1 - new buildings;

Category 2 - old buildings with ground floor, but renovated;

Category 3 - old buildings with ground floor and one or even two new added levels.

The third category includes the old buildings with new added levels that also have the ground floor of the building renovated. The transposition of measurements in the GIS environment has been achieved by the vector type themes layer of information, differentiated on stages of building construction, having as cartographic support for guidance the ortophotoplan in Stereo 70 projection.

Layer type themes of information created in GIS are: "*the area built until 1970", "the area built until 2003*", "*the construction after 2003"*. The projection used for these themes is Stereo 70.

All the points raised in the field using the GPS in geographical coordinates represent the position of each construction, to which we made a series of observations regarding the components that create a pressure on the substrate. We noted the information relating to the height of the building, the structure of the materials used, the type of property, utilities and considerations on the degree of compaction for the area where the building is located (Tab. 1).

All this information has been linked with the reality from the field by exact note of the address (street and no.), and using GIS environment by automate assignment of an unique serial number made by the GPS for each point marked in the field and accompanied by a set of geographical coordinates. The database was updated based on the points with the tables of attributes raised with the GPS, to each point marked being added a description according to an unique table of attributes.

Table 1

Settlement	**TOTAL**	type of property		material used for construction			high regime				utilities			degree of tightness	
		public	private	wood+glass	brick	mixt*	1 level	2 levels	3 levels	other	water supply	gas	sewage	yes	no
BREAZA	488	7	481	10	160	318	270	201	11	6	316	401	180	417	71
CORNU	307	3	304	25	222	60	204	96	4	3	251	264	85	294	13

**Mixt= CAC+Brick, CAC+Wood or Brick+Wood*

ANALYSIS

The new buildings are located especially in the hilly area of the city, with a higher density in Breaza de Jos and in the northern extremity. In this area the Breaza town has a diffuse structure regarding the distribution of the newly constructed buildings (Fig. 4). The streets are very irregular and have a pavement of concrete slabs placed transversally on the road axis, with a big influence on the drainage direction of the rain water and washed alluvia.

The representative streets mapped for this type of construction are Poenița Street, Putna Street, Coștila Street, Răsărit Street, Oituz Street, Sunătoarea Street, Tineretului Street (Fig. 5).

The buildings from the 2nd and 3rd category are most common in the northern extremity of the town, on the terrace scarp (in this area the town has a linear structure) as most of the buildings in Cornu. The buildings, because the material they are made of have a high potential to trigger the phenomena with a geomorphologic risk, but their difficult location (difficult access, etc.) determine a small number of buildings of this type (Fig. 3). The representative streets mapped for this type of constructions are: Piatra Arsă Street, Sulfinelor Street, Dunărea Street, Colin Street, Rugului Street, Panselelor Street, Porumbari Street, Micşunele Street, Fagului Street, Cerbului Street (Fig. 6).

Fig. 3 New buildings in Cornu settlement

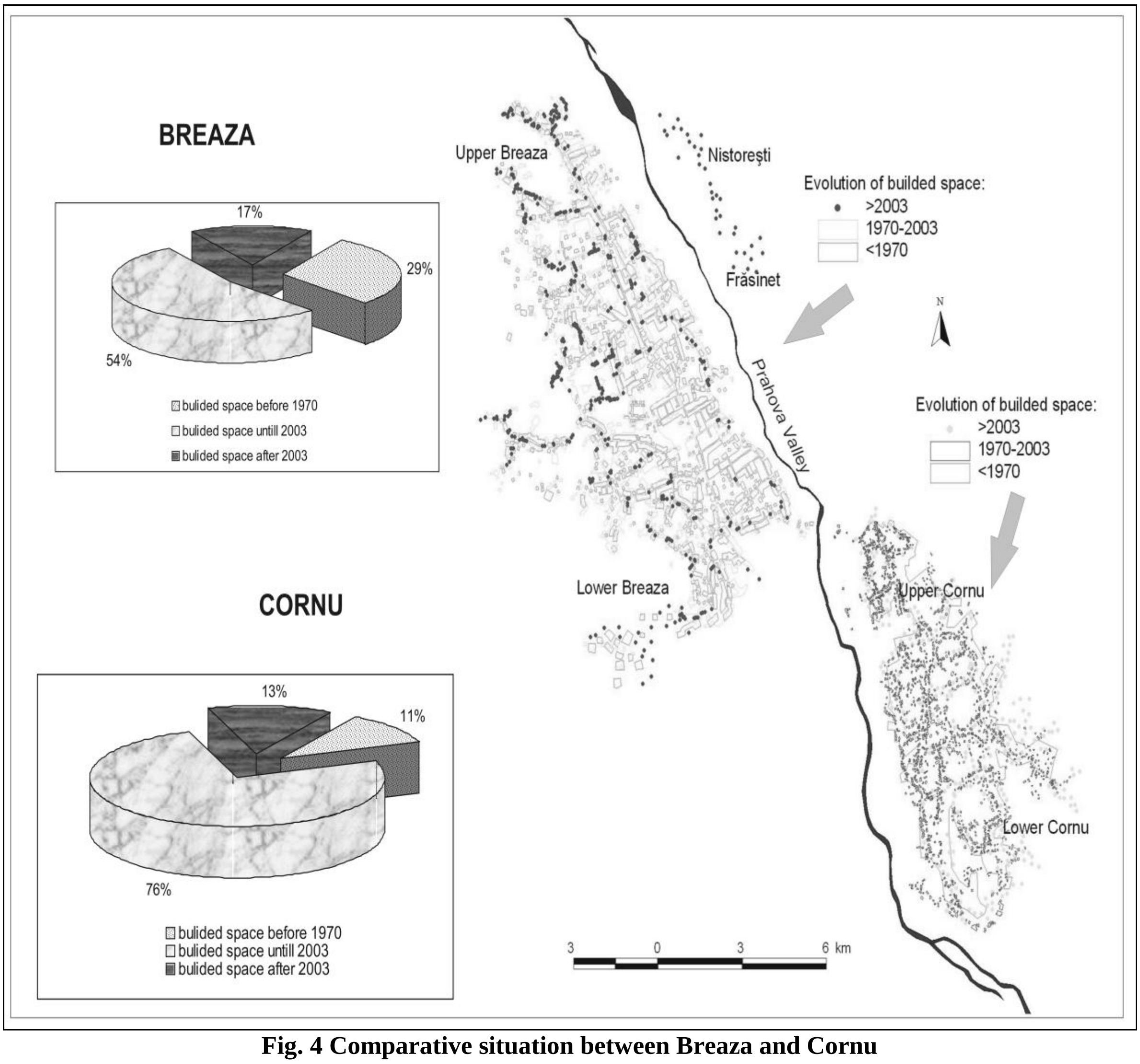

Fig. 4 Comparative situation between Breaza and Cornu

The buildings in 3rd category are widespread in particular on the top of the terrace, in the middle part of the town, along Liberty Street, where we note the rectangular type structure. The streets having a great number of this type of buildings are Saturn Street, Aurora Street, Moldavia Street, Wallachia Street, Banat Street, Sunătorii Street and the streets in the neighborhoods of Nistoreşti and Frăsinet.

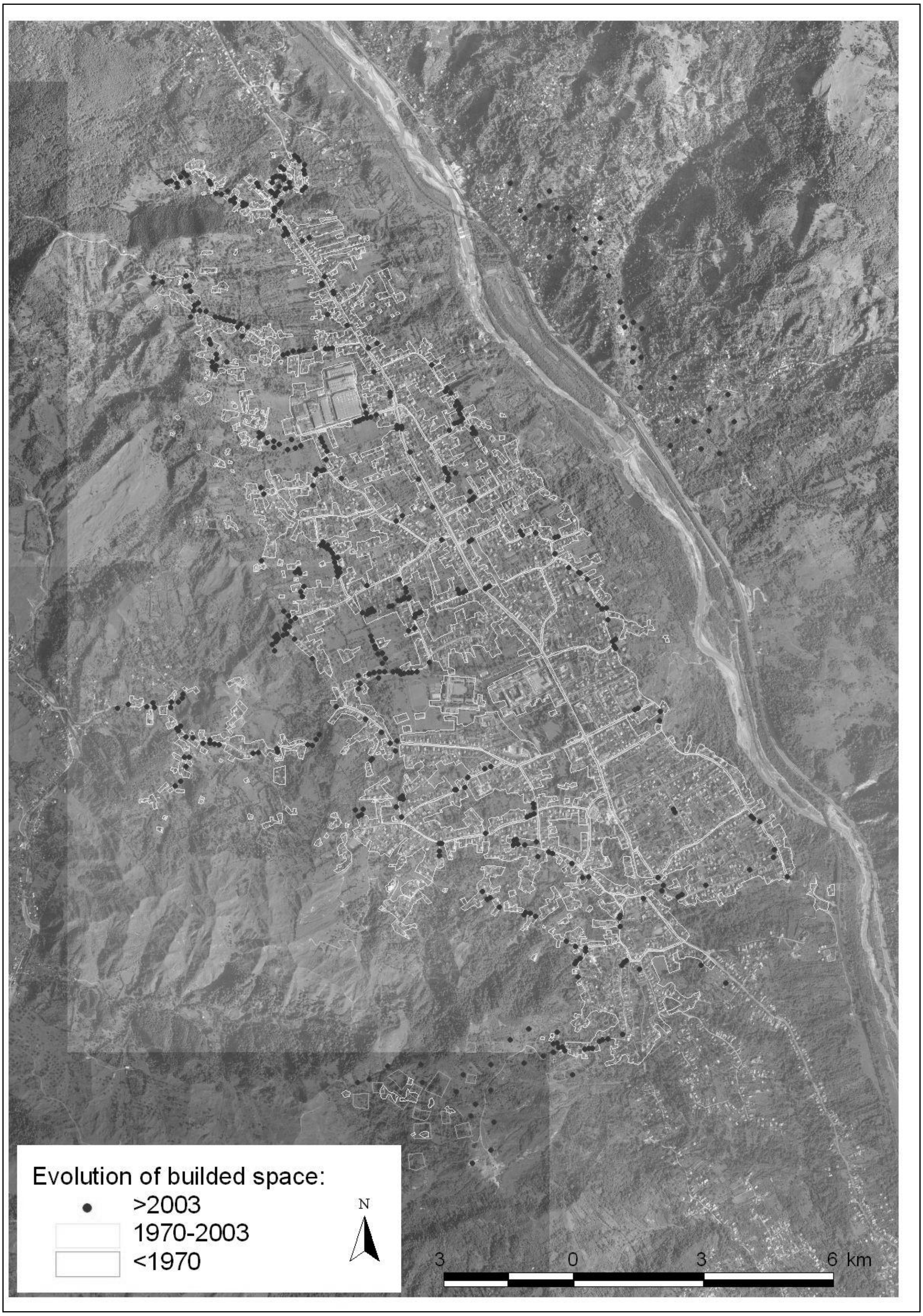

Fig. 5 The evolution of the space built in BREAZA town (processed orthophotoplan image)

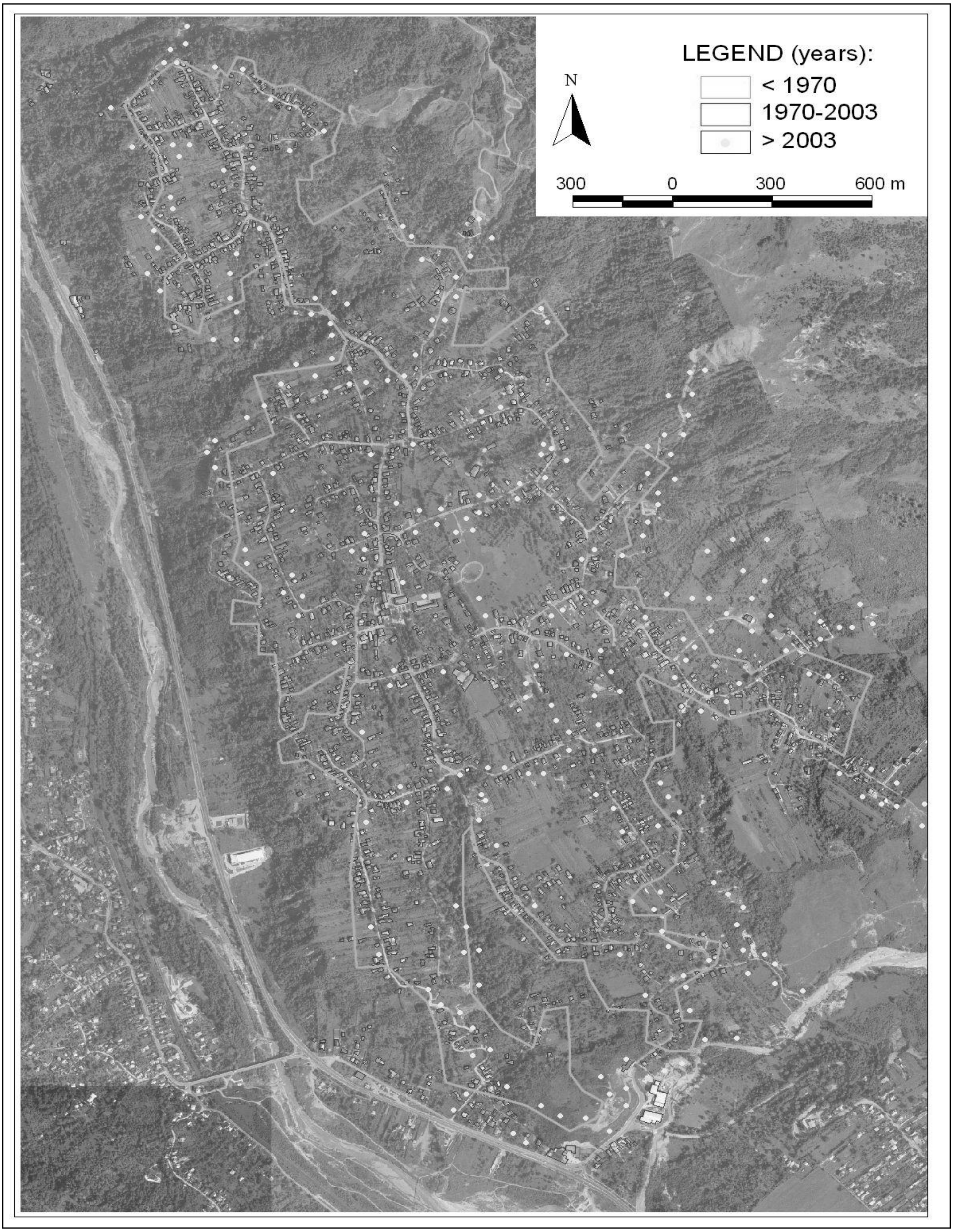

Fig. 6 The evolution of the space built in CORNU settlement (processed orthophotoplan image)

MORPHODYNAMIC AND ANTHROPOGENIC IMPACT

In the perimeter of Breaza town, field observations made during a period of more than five years have shown specific morphodynamics aspects. Bodies of rocks are marked by creep processes on the active slopes, and in the slide mass by the appearance of transversal cracks, parallel to the ravines (Mihai Parichi et al. 2008).

Landslides have a specific operation in the neighborhood of constructed areas. In the southern sector, under the Cross from Breaza town, the landslides are more profound on the face of the layers. In the northern sector (the north flank of the syncline, where the Brebu conglomerates appear), on the slope towards the Prahova river the landslides are superficial, stabilized, drained, the predominant specific process is surface wash. A single landslide is mapped in this area, being man induced by opening a quarry (Armaş et al. 2003).

The slope of the 2nd terrace is fragmented into a sequence of small sliding basins arranged in the shape of an amphitheater, with steps and waves corresponding to different generations of landslides.

The studies and researchers in the field led to the conclusion that landslides generally have small and medium depths, with damage to the soil and to a superficial part of the base rock. The trigger factor is represented by the infiltration of rain water into the terrace material and lithological interfaces, a phenomenon correctly perceived by the locals living in the sectors with landslides (Arrnas, 2006). Rain waters infiltrate into the deposits of gravels and outburst above the ground as springs in the slope of the 2nd terrace. Because of this landslide occur at the limit of the bridge, continuously undermining the edge. In the case of colluvial-proluvial glacis located at the base of the upper terraces (3rd and 4th), is maintained an excessive humidity, favouring the dynamic of the slope. The geomorphologycal analyses are sustained by the observations and soil mapping carried out in the summer of 2006.

The risk to landslides is important, as people constructed a lot on the slope during the past 15-25 years, as a result of new financial opportunities and land and cadastral availability. There appeared numerous large "holiday houses", with one-two levels, some of them having the ground floor partially buried into the slope.

For new constructions, the issue regarding the foundation was not properly approached, there had not been performed any studies regarding the loading of the slope with the respective constructions, with waste materials, as well as studies concerning the taking over and drainage of rain and sewerage waters (improper sewage networks, septic tank etc.). Constructing these buildings - located on the edge of the terrace and/or "cut" into the slope, as well as all trenches performed for foundations/ walls and underground laying of cables and pipes – represented the cause induced by the human action that favoured the landslides occurred in 1992, 1997 and those from the autumn of 2005 and the summer of 2008 in Cornu settlement (figure 7).

Fig. 7 Recent landslides in Cornu settlement (stage in 2008 - left; stage in 2009 - right)

The increased interest in creating residential spaces has not been in direct relationship with the road systematization, problems caused by the type and intensity of traffic and vehicle weight. In this respect, an example is Căproiu Miron Street, a non-standard sized road, without infrastructure and drainage systems, which follows the edge of the slope toward the Prahova river and which is unrestricted exploited. There are some limitations after the occurrence of the landslides in September 2005 (Armaş et al., 2004).

CONCLUSIONS

The data bases processed using statistic methods and correlative analyses, taking into account the physical and geographical support and the component factors having a high importance in the limitation or favour of the vulnerability of the analysed Subcarpathian space.

In this study area, represented by Breaza and Cornu settlements, there had been identified three main categories of buildings: category 1 - new buildings; category 2 - old buildings with ground floor, but renovated; and category 3 - old buildings with ground floor and one two levels newly added.

Analysing these three categories of buildings we noticed the influence of the landscape, alongside with the economic factor, in the spatial distribution. So, buildings from the 3rd category are particularly spread on the top of the 2nd terrace of the Prahova river, in both cases (Breaza and Cornu). That indicates the oldest space occupied by these settlements.

Buildings from the 1st category are spread, in both cases, in the peripheral area, in the hilly area and rarely in the terraces area. These buildings represent only 17% from all the buildings in Breaza and 13% in Cornu, this area being constructed after 2003.

As a consequence, in both cases, the risk to landslides is highly important, being in the same time a result of new financial opportunities and cadastral changes in the land administration.

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MATHEMATICAL MODELS USED FOR VISUAL ASSESSMENT OF THE LANDSCAPE *IN SITU* – CASE STUDY SINAIA TOWN

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Abstract

The aim of this study is to modify, to adapt, and to apply to the Romanian urban landscape a quantitative method proposed and applied in Spain by Cañas Guerrero (1995). Several specific parameters and variables of a given landscape are analyzed and assessed. Then, using mathematical formulae, one gets a score which indicates the quality of the studied landscape.

Keywords: *landscape, visual evaluation, landscape mapping*

Rezumat

Modele matematice utilizate pentru evaluarea vizuală in situ a peisajului – studiu de caz oraşul Sinaia. Scopul acestui studiu este să modifice, să adapteze și să aplice peisajului urban românesc o metodă cantitativă propusă și aplicată în Spania de către Cañas Guerrero (1995). Sunt analizate și evaluate câțiva parametrii specifici și variabilele unui peisaj dat. Apoi, folosind formulele matematice, se obține un rezultat care indică calitatea peisajului studiat.

Cuvinte-cheie: *peisaj, evaluare vizuală, releveu peisagistic*

INTRODUCTION

During the last decade, in order to analyze and assess landscapes, there had been issued various quantitative methods based on *non-visual mathematical models* – landscape metrics (Botequilha Leitão et al., 2006) or on grilles for *visual evaluation of the landscape in situ* (Kane, 1981; Cañas Guerrero, 1995). The scope of applying these methods was to eliminate the subjectivism and to create the possibility to characterize, to exemplify, and to compare various areas of landscape. The results summed up from these quantitative models are used to rehabilitate and revive the landscape (Pătroescu, 2000) from certain spaces, as well as in adjacent domains (territorial organization, agronomy, ecology, environmental geography, architecture, etc.).

The visual method of landscape *in situ* evaluation is based on a qualitative assessment, as well as on a quantitative one, realized by the addition and mathematical processing of the scores given in the field. As for any method, there can be evidenced both advantages, as well as disadvantages. *The advantages* are, that by using this method, there can be gathered all attributes that we must take into account when we associate the value of a landscape to an area. Thus, we obtain more information regarding the degree of detail of the landscape in the field. *The disadvantages* are linked to the difficulties occurred being connected with the person's capacity of perception during the assessment (experience), with the degree of subjectivism, with the degree of the landscape to open or to close (it is considered a ray of 1,200 meter starting from an observation point), with the moment when the assessment is made (depending on the season, weather conditions).

The scope of our study is to continue to apply *the sheet of landscape surveying type* (Pătru, 2006) also in the case of an urban space. In order to develop the application, we chose the Sinaia town located in the north of Prahova county (geographical coordinates: 45º21'00" latitude N, 25º33'05" longitude E), in the mountainous sector of the Prahova Valley, which is documented as a spa and tourism resort and a town of the third rank. Thus, in this urban area the variety of landscape elements is high (natural objectives, tourism objectives from the patrimony, architectural and cultural objectives, etc.).

DATA AND METHODS

Lorem The visual assessment in the field (*in situ*) is, first of all, based on a rigorous inventory of the landscape elements, called *parameters*. These elements of the landscape have a variety of the landscape from one areal to another, from one parameter to the other, which is expresses by the notion of *variable*. On the other hand, the parameters can be grouped in three classes, called *attributes*. Actually, we can talk about *physical,* *aesthetical* and *psychological* attributes. This methodology was proposed and developed by Cañas Guerrero (1995), being applied in visual assessment for certain regions from Spain (see also Cañas Guerrero & Sanchez Ruiz 2000). For Romania, the inventory method for the elements in the field, as well as the mathematical formulae had been adapted by Pătru (2006), respectively Stupariu & Pătru-Stupariu (2007), aiming at quantifying the landscape characteristics within a rural space. In order to make the application of the landscape surveying sheet type possible in an *urban* area, we inventoried the attributes, parameters and variables specific to an urban landscape:

I. **Physical attributes.** We take into consideration the following 12 parameters: *types of residences, green areas, the orientation of the streets, transport infrastructure, industrial spaces, cultural endowments, educational equipment, trading spaces, sanitary equipment, sounds* (noise), *smells* (air pollution), *elements that alter the landscape* (waste, deserted buildings, etc.).

II. **Aesthetical attributes.** There are analyzed two parameters: *the shape* (by evaluating this parameter we understand the aspect of the distinct elements which occupy an extension determined in the landscape higher than 5%) and *the color* (the descriptor which has the highest capacity to draw the observer's attention, it must be mentioned that it depends on the variability degree of atmospheric conditions).

III. **Psychological attributes.** There are included two parameters: *the unit* (defined by the structural lines of the landscape) and *the expression* (the landscapes that get a high scope at this parameter are considered as exceptional).

In the present paper, the explicit formulae for calculating the value of the landscape (Cañas Guerrero, 1995) is adapted and improved: to each considered parameter it is given a maximum score of 100 points and the final value is given by the weighted average of the values obtained for each parameter. For example, P is a parameter and X an associate variable. If we have a type one variable (see, for example, table 1), the corresponding value V_{PX} is equal to the arithmetic mean of the variable values scores registered in the assessment point. If, we have a type two variable, the following formulae is being used:

$$V_{PX}=f_{PX}\cdot\Sigma_{Y\text{ de tip 1}} V_{PY},$$

where f_{PX} is the *multiplicative factor* of the X variable for the P parameter (see, for example, table 1). For P parameter, the value V_P is obtained by totalizing the values corresponding to the associate variables:

$$V_P = \Sigma_X V_{PX}.$$

Let's suppose that we took into consideration N parameters. In order to emphasize only some of these parameters, as to have a higher flexibility in establishing the value of the landscape, we will consider that for each parameter it is associated a *share*. So, being $\mu_1, \ldots, \mu_N$ the shares for the N parameters that we considered. The value of the *landscape* V in the working point is the weighted average of the landscape values for the considered parameters, with the system of shares indicated, being given the formulae:

$$V = (\Sigma_P\, \mu_P \cdot V_P)/\, \Sigma_P\, \mu_P.$$

In case that all shares are equal to 1, we obtain the simplified formulae:

$$V = (\Sigma_P\, V_P)/N.$$

The obtained value mentions the category where the analyzed landscape is included, established according to the following classification:

$V < 21$	degraded landscape
$V = 21 \ldots 35$	mediocre landscape
$V = 36 \ldots 50$	ordinary landscape
$V = 51 \ldots 65$	landscape in good keep
$V = 66 \ldots 80$	landscape in a very good keep
$V = 81\ldots$	remarkable landscape.

We must mention that, in the method presented above, the evaluator has the role to establish the scores for the variable values of type one, the multiplicative factors associated to type two variables and the shares for the considered parameters.

DISCUSSIONS

Using, on one hand, the values established by the evaluator and mentioned before and, on the other hand, the actual observations within the field and the given scores, there had been filled in the landscape survey sheets in several working points chosen in all ten districts of Sinaia town.

Forwards, we give the detailed sheet for one parameter and namely the one for *Type of residences*, and its variables (Tab. 1), as they were filled in the working points in Furnica district. By applying the formulae mentioned before, we obtain the score V_1 =39.1. We mention that when calculating the final score, to this parameter is given a higher share compared to the shares given to other parameters.

Table 1 Landscape surveying sheet – Furnica district, Sinaia

Parameter	Total score of the variable	Variable *X*	Value (a_1, b_1,...)	Score	f_{PX}	Type
***P*=1: Type of residences V_1 = 39,1**						
	$A\ V_{1a1} = 9$	**Category (*A*)**	individual households	9		**1**
	$A\ V_{1a2} = 10$		villas	10		
	$A\ V_{1a3} = 10$		new residential complex	10		
	$A\ V_{1a4} = 7$		collective block of flats	7		
	$B\ V_{1b1} = b_1 \times a_1 + b_1 \times a_2 = 9.5$	**Construction material (*B*)**	wood, stone		1	**2**
	$B\ V_{1b2} = b_2 \times a_1 + b_2 \times a_2 + b_2 \times a_3 = 4.85$		brick		0.5	
	$B\ V_{1b3} = b_3 \times a_4 = 0$		BCA		0	
	$C\ V_{1c1} = c_1 \times a_4 = -7$	**Degree of degradation (*C*)**	high		-1	**2**
	$C\ V_{1c2} = c_2 \times a_1 + c_2 \times a_2 = 4.75$		medium		0.5	
	$C\ V_{1c3} = c_3 \times a_3 = 0$		low		0	
	$D\ V_{1d1} = d_1 \times a_1 = 9$	**Visibility (*D*)**	reduced		0.5	**2**
	$D\ V_{1d2} = d_2 \times a_2 + d_2 \times a_3 + d_2 \times a_4 = 9$		normal		1	

By applying this sheet and by calculating the value of the landscape we obtained a differentiation for the visual assessment of the landscape (Fig. 1) at the district level in Sinaia town which classifies the landscape from this town in different categories of landscape. Thus, the maximum value of 81.43 obtained in Furnica district is explained by the accumulation of the score resulted from the high values obtained for green areas, sounds, smells, historical and architectural monuments (the Peleş Castle, the Pelişor, the Turret, the Hunting House). Also, the Center, the Oppler and Tir cu Porumbei districts obtained high values due to the existence of historical and architectural monuments, green spaces or to the type of residential spaces (villas, new residential complexes).

At the opposite pole are the districts appeared during the communist period in the south of the town (Platoul Izvor, Izvorul Rece), where the given score was diminished by the presence of industrial spaces, pollution (phonic, olfactory) associated to them, as well as because of the type of existing residences (collective block of flats).

This landscape typology is used by local actors. In this respect, in Sinaia town, pursuant the assessments of the landscape had been issued proposals for the organization of the limestone quarry, the Serb's Tavern in the touristic village.

In the present, the landscape of the quarry is deeply affected by the presence of waste and industrial deposits and by the present processes which make the quarry slope to be instable.

With the project proposed by the House of Architects in Sinaia (Fig. 2), is intended to realize a pleasure and sport touristic area on this side of the quarry, which should respond to the high requests needed for the organization on the European Youth Olympic Festival of 2013.

The proposal for ecological construction of the quarry by the organization of a touristic village is based on: the reconstruction of the landscape; the use of ecological materials (wood, stone, grass); the consolidation and exploitation of the excavation as a background; the insurance of a step-up constructive system with a maximum height regime of G+3+A; PTO maximum = 50%

and CTU = 1.5; the provision of insolation and visibility; the use of a waste recycling system and waste water treatment plants.

CONCLUSION

The performed study shows the fact that between the assessment of the urban and rural landscape there are significant differences in inventorying the elements of the landscape (parameters, variables) which compose the landscape survey sheet, and that the share method is an adequate one, as it also allows to analyze mixed landscapes, those with a high degree of complexity, as well as to adapt the set of parameters depending on the actual characteristics of the landscape faced *in situ*.

In addition, the values of the shares can be chosen by the evaluator depending on the nature of the studied problem and the type of performed analysis. In other words, taking into consideration the high degrees of the landscape dynamics in the area in question, it is highly requested to mention two facts. First of all, it is desired that the new urban organizations to take also into account the assessments of the landscape in order to avoid the excessive degradation of this resource.

Besides, it is necessary to update the survey landscape sheets periodically, in order to monitor the evolution of various parameters, variables and the landscape as a whole.

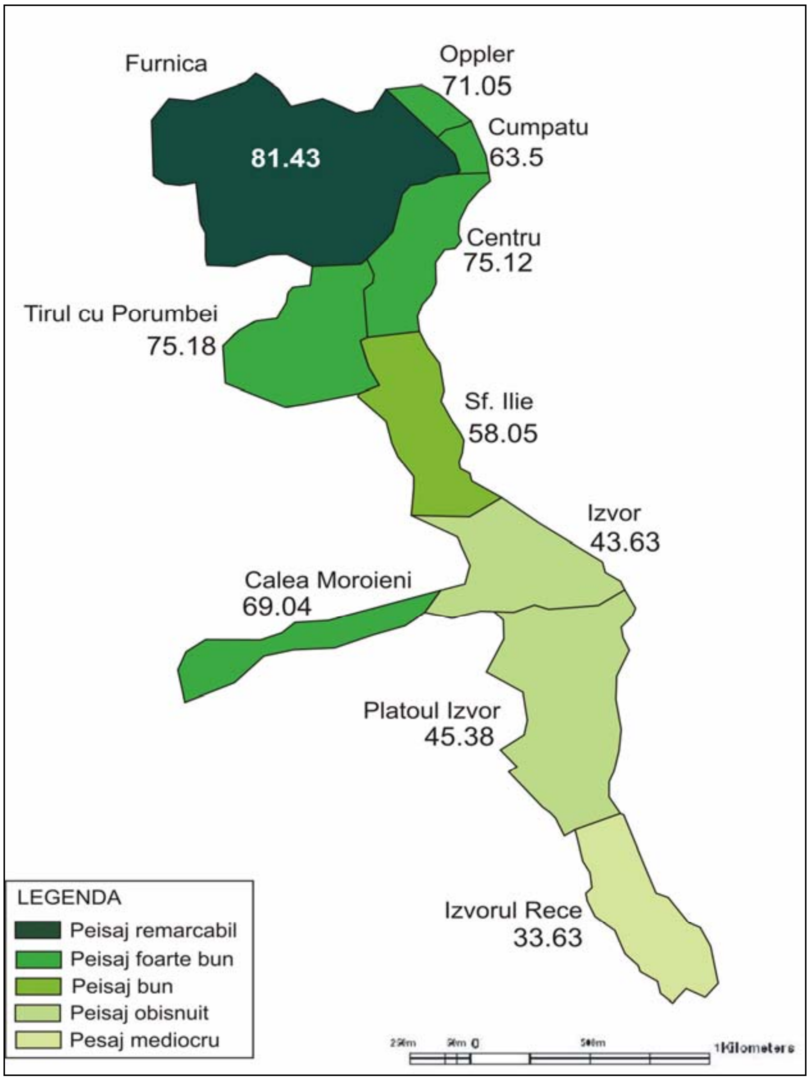

Fig. 1 The map of landscape value – Sinaia town

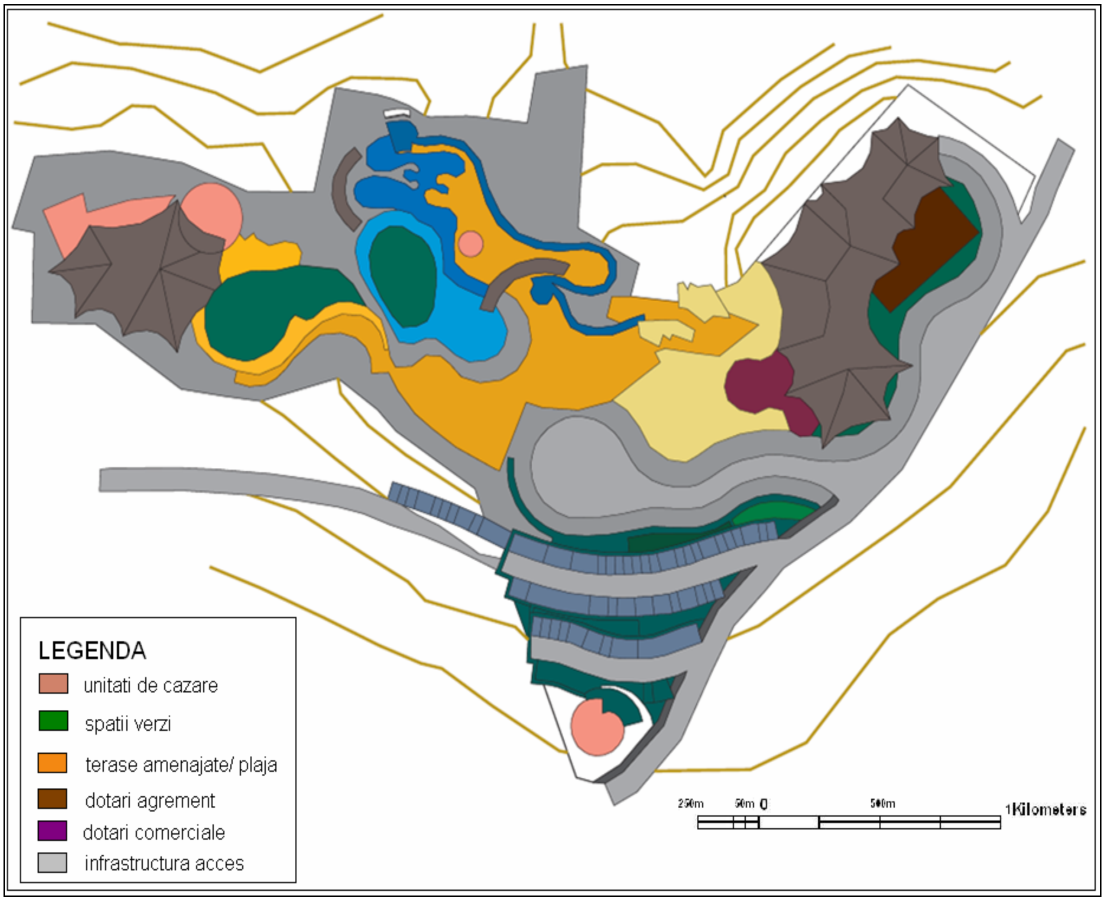

Fig. 2 The ecological reconstruction of limestone exploitation quarries from the Serb's Tavern. Source: The House of Architects in Sinaia

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THE LANDSCAPE DIFFERENTIATIONS IN THE PRAHOVA SECTOR OF THE BUCEGI MOUNTAINS

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Abstract

The physiognomic complexity as the main characteristics of the Bucegi Mountains landscape is the result of lithology, structure, tectonics and high altitude, which led to the vertical zoning of modelling conditions. There can be separated: the landscape of erosion outliers and the structural plateaus from the alpine area, the landscape of Prahova scarp and that of the plains at the Bucegi mountain feet. Up to about 2200 m, the landscape of erosion outliers and structural plateaus was mostly affected by human activities, mainly the tourism and uncontrolled grazing. The landscape of the Prahova scarp of the Bucegi is notable by high touristic anthropization on the slopes of the Vârful cu Dor - Furnica - Piatra Arsă mountains, neighbouring Sinaia, where there are frequent degradations of the roads and paths improperly located and maintained. The Bucegi slope northwards of Piciorul Pietrei Arse still preserves the natural landscapes in dynamic equilibrium (which possess a great tourist and alpinist potential). At the scarp foot, following the modelling of the Cretaceous flysch and sedimentation of large talus material, there resulted a relief with smooth field - plai (Plaiul Fânului,Plaiul Coştila, Munticelu, Plaiul Stânei, Plaiul Peleşului, Plaiul Furnica) - rounded interfluves with a slope below 30^0, compared to those over 30^0 (often over 50^0 within the scarp.

Keywords: *landscape differentiations, Prahova sector of the Bucegi Mountains*

Rezumat

Diferențieri peisagistice în sectorul prahovean al MunțilorBucegi. Complexitatea fizionomică, caracteristică principală a peisajului Munților Bucegi, este impusă de litologie, structură, tectonică şi de marea desfăşurare altitudinală, care a determinat etajarea condițiilor de modelare. Pot fi separate: peisajul martorilor de eroziune şi al platourilor structurale din golul alpin, al abruptului prahovean şi cel al plaiurilor, de la poalele Bucegilor. Până la aproximativ 2200 m peisajul martorilor de eroziune şi al platourilor structurale a fost în cea mai mare parte afectat de influența antropică prin turism şi păstorit necontrolat. Peisajul abruptului prahovean al Bucegilor se remarcă prin intensa antropizare turistică pe versanții munților Vârful cu Dor- Furnica-Piatra Arsă de deasupra Sinaiei, unde apar şi degradări pe drumuri, poteci şi pârtii necorespunzător amplasate şi neîntreținute. Versantul Bucegilor de la nord de Piciorul Pietrei Arse, conservă încă peisaje naturale în echilibru dinamic (care au un mare potențial turistic-alpinistic). La baza abruptului, modelarea, desfăşurată pe flişul cretacic şi prin depunerea unor mari trene de grohotişuri, a generat un relief de plaiuri domoale (Plaiul Fânului, Plaiul Coştila, Plaiul Munticelu, Plaiul Stânei, Plaiul Peleşului, Plaiul Furnica etc.) - interfluvii rotunjite, cu o pantă sub 30^0, față de cele de peste 30^0 (frecvent peste 50^0) din cadrul abruptului.

Cuvinte-cheie: *diferențieri peisagistice, sectorul prahovean al Munților Bucegi*

INTRODUCTION

This paper is based on several specialty works, which have been included in the Reference section. In addition, the interpretation of topographic maps of scales 1:25,000 and 1:50,000, satellite images, geological maps of scales 1:50,000 and 1:200,000 and soil maps at scale 1:200,000 has provided useful information. In order to reach the objectives, an important volume of data has been processed and interpreted in a correlative manner: the National Administration of Meteorology, the Forest Research and Management Institute, which has supplied data regarding the coppice of the Azuga and Sinaia Forest Services, the Directorate of Statistics and Ploiesti Environmental Protection Agency. During the field trips, observations have been made, as well as soil and geomorphic mapping (especially concerning the present processes) has been undertaken, focusing on the upper forest limit, areas covered by juniper tree associations. Access roads and touristic paths have also been mapped and their actual state has been assessed. Likewise, sheepfolds and chalets have been taken into account for their impact on the surrounding areas.

We consider that there are various ways for conceiving the landscape and to analyse it. Many definitions bring a lot of subjectivity to the geographical landscape. According to these, the geographical landscape would represent the visual projection of some rather psychological relationships between man and the territory in which he lives (Drăguț, 2000). However, most definitions refer to the objective landscape, consisting of concrete elements strongly linked by a set of relations. This type of approach assimilates the geographical landscape to other concepts used in geography, such as the geographical environment and the geosystem.

Between environment, landscape and geosystem there is a mutual interaction. Therefore, no landscape or geosystem can exist without exhibiting a certain type of environment, as there is no type of geographical environment to possess life conditions outside the landscape or its geosystemic functionality (Roşu, 1987). Consequently, the environment represents the entire terrestrial organism, while the geosystem stands for its functional part, whereas the landscape offers the most specific stable material expression that every environment type and geosystem put on (Posea, 1978).

The western limit of the analysed area follows the watershed between the Prahova and Ialomita rivers up to Omu peak (2505 m). From here, the northwestern, northern and northeastern limits separate the Prahova's mountain basin from the Ghimbav, the Timis and the Garcin basins. As far as the eastern boundary is concerned, this is embodied by the Prahova Valley.

RESULTS AND DISCUSSIONS

The main feature of the Bucegi Mountains is given by the complex physiognomy of the landscape. This is primarily imposed by lithology, structure, tectonics and the great altitudinal development, which explain the zoning of physical-geographical characteristics. Therefore, several types of landscapes can be distinguished in this area, namely the landscape of the outliers and structural plateaus of the alpine area, the landscape of the Bucegi escarpment to the Prahova Valley and the landscape of the flat ridges at the foot of the Bucegi Mountains.

The landscape of the outliers and structural plateaus of the alpine area. In the upper part of the Bucegi Mts., the headward erosion carried out from the Prahova level towards the highest altitudes in the Bucegi and the evolution between the Prahova – the Ghimbav in the north-eastern part of the Bucegi, led to the appearance of the following peaks: Bucsoiu, Omu, Bucura Dumbrava, Gavanele, Coltii Obarsiei, Costila, Caraiman, Jepii Mici, Jepii Mari, Piatra Arsa, Furnica, Varful cu Dor, Vanturis, etc.

Westwards from the above-mentioned peaks, there is an area with smooth and moderate slopes (almost all of them having less than 15º) known as the Bucegi plateau (Vâlsan, 1939), which is drained almost entirely by the upper reaches of the Jepilor and Izvorul Dorului streams. It streaches to the sequence of Baba Mare 2292 m, Cocora 2191 m, Laptici 1877 m, Blana 1877 m, Nucet 1860 m peaks and several saddles that form the present watershed (separating the Prahova basin from that of the Ialomita).

This plateau preserves an upper erosion level, which can be seen on the eastern edge of the Bucegi Mts., at elevations of 1800 – 2500 m (Omu, Costila, Caraiman, Jepii Mici, Ciocarlia, Jepii Mari, Piatra Arsa, Furnica, Varful cu Dor, Vanturisul peaks etc.), as well as on the western watershed of the Izvorul Dorului (Nucet – Cocora), where it is represented by structural outliers, most of them with asymmetrical appearance (cuestas), which tower over structural surfaces.

The age of this erosion level is disputable, being generally considered equivalent to the Borascu level (Orghidan 1931, Valsan 1939, Valeria Michalevich Velcea 1961, Posea 1998). The microforms developing on the Bucegi plateau are the rock pedestals, mushroom rocks and sphinx-like rocks (Babele, Baba din Vanturis, Sfinxul), the genesis of which is linked to cryoclastism, gullying and corrasion, which operate differently on sandstones and conglomerates.

Up to approximately 2200 m (in the upper basin of the Izvorul Dorului), the landscape of the outliers and structural plateaus with subalpine elements has been almost entirely affected by anthropogenic influence (Fig. 1), consisting of touristic activities (a dense and chaotic network of paths) and uncontrolled shepherding. Where juniper trees have been cleared and where the debris from the existing buildings has been thrown away, one can notice serious ecological disequilibria. Beside the destruction of natural vegetation and its replacement by *Nardus stricta* and other ruderal species, anthropogenic actions have also led to soil cover removal on large areas and to the formation of a gully network along the numerous roads and paths.

The landscape of structural plateaus has been affected for the most part by anthropogenic influence consisting in touristic activities and overgrazing. Serious problems arise where juniper trees that once covered the entire plateau of the Bucegi Mts., at least as high as 2200 m altitude, have been cleared and in the areas where various constructions have been accomplished. Beside vegetation destruction, human actions have also contributed in a negative manner to the removing of soil cover from the oversized network of roads and paths.

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Fig. 1 The landscape of structural plateaus Bucegi Mts

Up to approximately 2200 m (in the upper basin of the Izvorul Dorului), the landscape of the outliers and structural plateaus with subalpine elements has been almost entirely affected by anthropogenic influence (Fig. 1), consisting of touristic activities (a dense and chaotic network of paths) and uncontrolled shepherding. Where juniper trees have been cleared and where the debris from the existing buildings has been thrown away, one can notice serious ecological disequilibria. Beside the destruction of natural vegetation and its replacement by *Nardus stricta* and other ruderal species, anthropogenic actions have also led to soil cover removal on large areas and to the formation of a gully network along the numerous roads and paths.

The boundary between the alpine and subalpine zones is easy to establish on the Bucegi plateau, because *Nardus stricta* disappearance is obviously preceded by its nestling on the bottom of microdepressions. Above 2200 – 2300 m, the landscape of the outliers and structural plateaus with alpine elements (low grass and plant associations that form small cushions) is better preserved than the previous one, even though here can be noticed several ecological disequilibria around the Costila relay and the Omu Peak chalet and weather station.

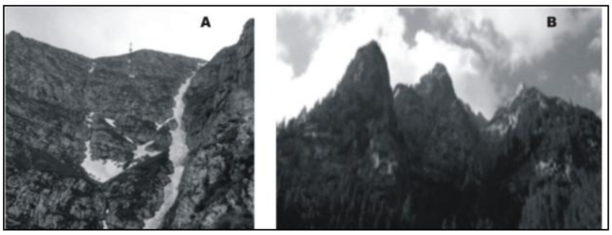

Fig. 2 Escarpment valleys with temporary flow, which also act as rock streams and avalanche chutes (A). Haystack-shaped outliers in the Jepii Mts (B).

The landscape of the Bucegi escarpment to the Prahova Valley. The Bucegi plateau has an impressive cuesta front, 15 km in a straight line, but very winding in the field, which towers over the Prahova Valley. The appearance of the Bucegi escarpment to the Prahova Valley, where the maximum declivities are generally specific for the slopes developing between 1550 – 1600 m and 1950 – 2000 m, is very diverse. The lithology, consisting of conglomerates, sandstones and limestones in the upper part of the Bucegi Mts. and Cretaceous flysch at the base, as well as monoclinal structure and tectonics (horsts and grabbens) have produced a great variety of microforms and mesoforms.

Headward erosion of the Prahova's tributaries (triggered by the neotectonic uplift of the mountains) and periglacial processes led to the formation of intersection crests (residual periglacial relief) from the general line of escarpment and large screes at the base of the slopes, where there can be seen 2 – 3 generations of talus cones (the oldest are stabilized by soil and woods, while the newest are still exerting their pressure on the forest).

The undercutting of the Bucegi conglomerates and the transportation of materials along the steep incipient thalwegs, frequently conditioned by tectonics, have produced impressive escarpment valleys (Fig. 2 A) separated by ridges, which show a temporary flowing regime. Many of these are mere rock streams or avalanche chutes. Avalanche chutes are fed with snow coming from the cirques and nival niches that are found on the escarpment edge of the Costila Mt.: Blidul Uriasilor (on the southern slope), which supplies a steep thalweg stream developing under Costila relay, and the nival cirques lying at the headwaters of the Costila, Malin and Pripon valleys. If Costila valley develops on the eastern slope, the last two are found on the northern one. The ridges have different physiognomies. The most spread are the indented ones (Creasta Morarului and Balaurul within Bucsoiu Mic), but there are also ridges made up of haystack-like outliers (Fig. 2 B), as it is the case of the Jepii Mici – Claia Mare (1863 m) and Claita (1853 m), separated by the Valea Seaca a Clailor.

Fig. 3 Brâna Mare a Coştilei – a bench lying on the northern slope of the Coştila Mt.

The escarpment microrelief is very complex. The sandstones (especially quartzitic ones, which are harder and less permeable) and conglomerate intercalations favouring the development of structural benches (Fig. 3), overhanging rocks and lithological levels that look like big steps (Valeria Michalevich Velcea, 1961). The microtectonics has further led to rock-walls fragmentation by horns, fissures (the most impressive being the Fisura Albastra from the southern wall of the Costila Mt.), hollows under overhanging rocks, wind potholes and escarpment valleys.

The Pleistocene induced some changes in the landscape of the northeastern scarp through the appearance of small glaciers at the headwaters of the Cerbul (Fig. 4) and Morarul valleys. These two valleys are now separated by the Morarul Ridge, with triangular profile, which once acted as an arête. Before the glacial period, the catchment areas of the valleys stretched as far as the foot of the Omu peak, while the thalwegs had been very steep in the long profile.

Fig. 4 Glacial-nival cirques on the Valea Cerbului headwaters. The influence of structure is obvious

The amount of ice being rather low, glacial erosion was restricted to the catchment areas lying at the valley headwaters, between 2100 m and 2450 m altitude, where cirques with diameters ranging from 1 to 1.5 km came into existence. The troughs may owe their U – shaped profile to the present geomorphologic processes as well, of which the most important is the accumulation of avalanche snow on some structural steps. At the base of the cirques, the debris covers the rocks that look like they have been polished by glaciers. As far as the moraines are concerned, these have been moved to lower sites by waters and avalanches. The valleys make up a dense and intricate network. Some have a V – shaped cross-section profile in the escarpment area, which certifies their younger age. Others (as the Caraiman and the Peles) widen out at the headwaters or exhibit a more rounded profile, sometimes resembling a trough (the Cerbul, Morarul and Malinul valleys), a feature that is often the result of nival cirques development. The long profile of obsequent valleys (the Costila, Jepi, Urlatoarele, Babei, Peles and Zgarbura valleys etc.) is steep until approximately 1400 – 1600 m and becomes less inclined at lower altitudes, in the flysch domain.

The breaks of slopes that can be seen in the thalwegs owe their existence to the geological structure and rock hardness. Sometimes they are highlighted by the presence of waterfalls, as it is the case with those developing on the Caraiman, Valcelul Inspumat, Urlatoarele, Peles and Zgarbura valleys. The headward erosion exerted on the plateau area has led to stream piracy phenomena. Thus, the Valea Jepilor has captured the upper stretch of the Valea Izvorul Dorului, whereas the stream developing in the escarpment area, at present the obsequent stretch of the Izvorul Dorului valley has captured the subsequent reach of the aforementioned river, which drained the plateau.

The Cerbul and Morarul valleys, with headwaters in the glacial or glacial – nival level, show complex long profiles, with important knick-points at the contact with the periglacial zone (2100 – 2200 m altitude), and present accumulations of big rocks. Further down, in the flysch domain, the profile becomes less inclined. Likewise, the Izvorul Dorului Valley dips gently on the plateau, then, down the escarpment, it has the same features as the other obsequent valleys in the area (high breaks of slopes, waterfalls and blocks), getting in the end a less inclined profile when crossing the flysch domain. Seen from the Baiul Mts., the Bucegi escarpment to the Prahova Valley appears higher to the north and lower to the south. The sector between Bucsoiu and Piciorul Pietrei Arse is the most impressive and the most fragmented (Fig. 5 A, B), due to the recent uplifts (Neogene and Quaternary), which have led to a significant deepening of the Prahova and the Ghimbav base levels.

From the general scarp line, the erosion has detached trapezoidal sides (the Costila Mts., Caraiman, Jepii Mici, Jepii Mari, Piatra Arsa etc.), triangular facets (the Morarului Mts. and the Bucsoiu Mic), as well as ridges, either indented or made up of haystack-like peaks. South of the Piciorul Pietrei Arse, the scarp looks more compact, due to the higher base level and the presence of calcareous rocks (represented by klippes). The landscape of the Bucegi escarpment to the Prahova Valley has suffered an intense touristic anthropization, especially on the slopes of Varful cu Dor, Furnica and Piatra Arsa summits, which rise above Sinaia town. These areas are full of degradation phenomena that affect roads, paths, as well as the bad located and ill-maintained tracks.

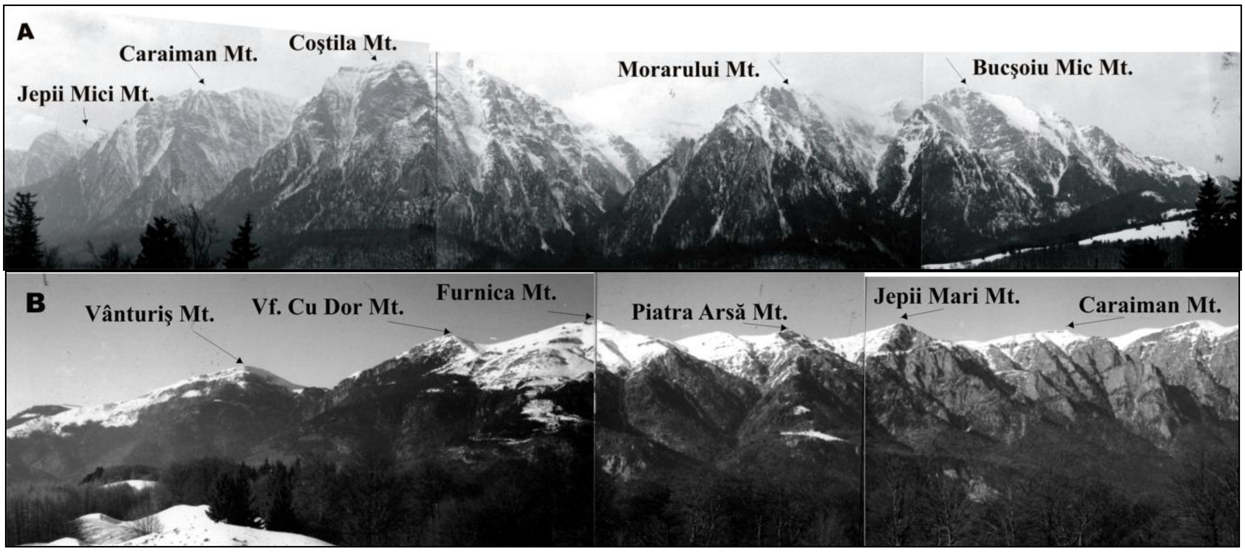

Fig. 5 The landscape of the Bucegi escarpment to the Prahova Valley can be divided into two sectors: the sector lying north of the Piciorul Pietrei Arse, more impressive and more fragmented (A) and the sector lying south of the above-mentioned ridge, which is more compact (B).

The Bucegi slope lying north of the Piciorul Pietrei Arse still preserves natural landscapes found in a dynamic equilibrium, which have a great potential for tourism and climbing. The rare forests (spruce fir, larch tree and occasionally Swiss pine), which develop near the upper tree line, are another representative feature of the eastern escarpment of the Bucegi Mts. They account for 3 per cent of the total forested area of the Prahova mountain catchment and are found either on the steep slopes, where they advance as high as 1800 m altitude or even more, or on the scree fields lying beneath. These forests are fragmented and their consistency is low. Likewise, the trees are rather short, showing specific physiognomies (flag or crawling creatures) and low vitality.

The landscape of the flat ridges at the foot of the Bucegi Mts. At the base of the scarp, the shaping processes that affected the Cretaceous flysch and contributed to the accumulation of scree have generated a relief made up of flat ridges and rounded interfluves (Fig. 6). Here, the gradients are lower than 30^0, unlike the scarp area, where slopes frequently exceed 30^0 or even 50^0. From north to south, the main flat ridges are Plaiul Fanului, Plaiul Costila, Plaiul Munticelu, Plaiul Vaii Seci, Plaiul Bolovanului, Plaiul Stanei, Plaiul Stana Veche, Plaiul Paltinului, Plaiul Secului, Plaiul Piatra Arsa, Plaiul Pelesului, Plaiul Furnica, Plaiul Zgarburei and Plaiul Coltii lui Barbes. Here and there, ridge profiles show flat sectors that preserve erosion levels, such as those found at ± 1500 m and ± 1100 m (possibly being the same age as the Clabucetele and Predealul levels).

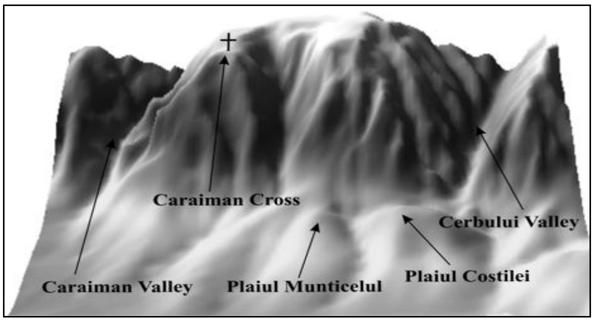

Fig. 6 At the base of the Bucegi escarpment to the Prahova Valley, the shaping of Cretaceous flysch rocks and the accumulation of scree have generated a relief of flat ridges.

Their presence is put on the account of harder rock formations, as it happens with the Sfanta Ana calcareous rocks, or with those found at Poiana Stanei or in the Piatra Arsa area, etc. In comparison with the escarpment sector, the lower reach of the valleys develops on flysch. Consequently, the valleys are larger and deeper, showing less inclined long profiles and narrow floodplains bordered by small glacises. For the most part, the flat ridges are covered with coppices that preserve their natural state, which is also the case of those growing on the Bucegi escarpment to the Prahova Valley. However, there are certain areas where the land is covered by secondary meadows. Here and there, the intense human pressure has contributed to the degradation of this landscape type, the best example in this respect being the Plaiul Furnicii with its complex touristic improvements.

CONCLUSION

Where anthropogenic activity is intense (road construction, forest harvesting, clearings, overgrazing, development of touristic infrastructure, especially for winter sports etc.), the relationships between the systems' elements are disturbed, generating to a greater or lesser extent other geodynamic and ecologic relationships that are mirrored by the system. The anthropogenic factor influences all the elements of the landscape, leading to their artificialization in various proportions. At present, one can hardly spot purely natural landscapes. This is why anthropogenic activities have turned into a criterion for separating the various landscape categories, based on their anthropization degree. According to the classification proposed by Cristina Muica (Geografia Romaniei, vol I, 1983), in the study area, there can be distinguished slightly and moderately anthropized landscapes. The slightly anthropized landscapes show a high degree of naturality. For this type of landscape, the natural elements prevail, while the human intervention is almost absent. This means the changes of structure and the alterations of natural floristic composition are minor, whereas human habitats are poorly developed. In this category we can include the sector of the eastern escarpment of the Bucegi Mts. lying north of the Piciorul Pietrei Arse; the alpine meadows; the forests the natural character of which has not been altered dramatically by plantations of resinous species; the subalpine meadows, both primary and secondary ones, which have a low degree of degradation; and, partly, the secondary meadows from the spruce fir zone, which in their turn are less degraded. The moderately anthropized landscapes are characterized by a strong fragmentation of the forest area, alterations of structure and floristic composition, and the presence of degraded meadows. We include here the sector of the eastern escarpment of the Bucegi Mts. lying north of the Piciorul Pietrei Arse (clearings, degraded secondary meadows, touristic improvements) and the primary and secondary meadows of the subalpine zone degraded through the spreading of invasive species (most often *Nardus stricta).*

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ISSUES OF TERRITORIALITY AND TERRITORIAL COHESION IN THE REVISION OF THE TSP AND THE TERRITORIAL AGENDA – A SORT OF CONNECTION BETWEEN GEOGRAPHY AND REGIONAL POLICY

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Abstract

After Hungary was asked according to the Territorial Agenda (TA), agreed in the informal ministerial meeting under the German Presidency in May 2007, it undertook the responsibility to evaluate and review the TA and update the closely related Territorial States and Perspectives of the European Union (TSP). The TA has a key importance due to the fact that it had been the first document which identified joint action oriented framework of spatial (territorial) policy on the EU level. The TSP (as basic evidence of the TA) in its more synthetic chapters attempted to identify more integrated territorial structures of the European territory including main geographic dimensions such as north-south and east-west dichotomies, polycentricity and urban-rural patterns. Due to the changes in the driving forces and the new conditions of an enlarged EU, the content and also the function should be revised. The paper is aiming to introduce some of the main findings of the TSP/ TA revision process with special reference to the new aspects and trends related to the territorial structures of the Union and the spatial structure of Europe. Finally, some solutions will be introduced which could help to enhance the currently not enough strong territorial approach within TSP and TA.

Keywords: *TSP, TA, territorial cohesion, EU, macroregions*

Rezumat

Aspecte legate de teritorialitate şi coeziune teritorială în revizuirea PTS şi a Agendei teritoriale – o legătură între geografie şi politică regională. După ce Ungariei i s-a cerut conform Planului Teritorial (PT) şi s-a aprobat la şedinţa ministerială neoficială sub conducerea Germaniei din mai 2007, aceasta şi-a asumat responsabilitatea de a evalua şi de a revizui PT-ul şi să actualizeze Perspectivele Teritoriale asociate ale Statelor Uniunii Europene (PTS). PT-ul are o importanţă deosebită, deoarece a fost primul document care a identificat acţiunile comune ale politicii spaţiale (teritoriale) orientate în funcţie de context la nivelul UE. PTS-ul (ca dovadă de bază a PT-ului) în capitolele sale cele mai sintetizate încearcă să identifice structurile teritoriale integrate ale teritoriului european, inclusiv dimensiunile geografice principale precum dicotomiile nord-sud sau est-vest, policentricitatea şi modelele urban-rural. Datorită modificărilor din forţele de acţionare şi a noilor condiţii date de o UE lărgită, atât conţinutul, cât şi funcţia trebuie revizuite. Lucrarea are ca scop introducerea principalelor rezultate ale procesului de revizuire a PT/ PTS-ului cu referire specială la aspectele şi tendinţele legate de structurile teritoriale ale Uniunii şi la structura spaţială a Europei. În cele din urmă, vor fi introduse unele soluţii care pot ajuta la intensificarea abordări teritoriale care în prezent nu este suficient de puternică în PTS şi PT.

Cuvinte-cheie: *PTS, PT, coeziune teritorială, UE, macroregiuni*

INTRODUCTION

After Hungary was asked according to the Territorial Agenda (TA), agreed in the informal ministerial meeting under the German Presidency in May 2007; it undertook the responsibility to evaluate and review the TA and update the closely related Territorial States and Perspectives of the European Union (TSP). The TA has a key importance due to the fact that it had been the first document which identified joint action oriented framework of spatial (territorial) policy on the EU level, defining the challenges and the priorities related to the territorial state and structures of the EU. So, the TA can be assessed as the first step of a common European territorial policy addressed to territorial dimensions of several thematic issues such as climate change, growth and innovation, culture, environment, etc. Together with the TSP – which serves as a basic evidence for the analysis of the TA – both documents are basic elements of the European regional (spatial) development and planning scene.

Our article, after a general introductory part about the importance of territoriality in planning activity and the connecting role of the notion "Territorial

Cohesion", deals with the first results and conclusions of the aforementioned update and revision processes. The main focus is on the relatively weak territorial dimension of TSP 2007 and TA 2007 and on the attempts of the international drafting team (led by VÁTI Hungarian Public Limited Company for Regional development and Town Planning) to improve the territorial contents of the documents. Among these attempts the article introduces in so many words the new intended chapter of the TSP2011 draft dealing with the main geographical zones of Europe; a kind of territorially synthetic part of TSP2011 and the delimitation of the units which the subchapter describes.

The importance and the issues of territoriality in planning

One of the first main results of the revision processes has been the relatively weak territorial approach of the two documents – although both of them are (at least in their names) territorial planning documents. Of course, readers could ask why do we emphasize the importance of territoriality in the planning activity? In our opinion territorial sensitiveness or territorial consciousness has to be inevitable a component of the strategic thinking. The appropriate planning activity (not only the actual territorial planning, but also the sectorial (thematic) planning activity) should deal with the territorial differences/ disparities, the regional characteristics due to the fact that every sector exists in the space. Development paths cannot be identified independently from the space/ territory in which the subject of the planning operates. Furthermore, nowadays, when within the European (regional) development policy the notion of the place based approach or the main message of the "Green Paper on Territorial Cohesion –Turning diversity into strength" gains their momentum the focus on the territorial differences within the planning activity becomes more and more important. In the same time the special endowments of regions, territorial units come to the fore to use their territorial capital through development actions.

An effective tool that can contribute to achieve territorial cohesion is the new policy concept called "new paradigm of regional policy" by OECD and the place-based approach by the Barca report, which means the practical implementation of the subsidiarity principle and multilevel governance in territorial development and policy. The objective of the place-based concept is to reduce persistent inefficiency (underuse of resources resulting in the income below the potential in both short and long-run) and persistent social exclusion (primarily, an excessive number of people below a given standard in terms of income and other features of well-being) in specific places. Places are defined through the policy process from a functional perspective as regions in which a set of conditions conducive to development apply more than they do in larger or smaller areas. This is, in the Report's view, the appropriate and modern way to interpret the task set by the EU Treaty to promote "harmonious development" and to tackle the "disparities" of the regions and "regional backwardness" by means of cohesion." (Barca F., 2009, pp. xi). Basically, the concept attracts our attention to the special endowments of different territories and the different ways of development based on these features (TA Outline. Draft version, 2010).

It is worth clarifying what do we understand exactly about territoriality, territorial approach? According to us territoriality means first of all an approach focusing on territories instead of sectors or thematic issues like environment, economy, social problems etc. This territorial approach puts special emphasis on the territorial structures and territorial types of the analysed territorial unit (continent/ region/ country). In planning documents most of the time the situation analysis parts might contain this kind of analyses, evaluations; or the strategic parts in the objective structure could comprise territorial-like special objectives/ priorities.

The role of Territorial Cohesion

Another crucial moment in the European spatial policy is the increasing importance of the notion of Territorial Cohesion. The Treaty of Lisbon signed in December 2007 entered into force in December 2009. With the changes made by this treaty territorial cohesion was entered into the text. It defines that the Union "shall promote economic, social and territorial cohesion, solidarity among Member States." (Art. 3 TEU); territorial cohesion however needs to be further clarified.

According to the "Green Paper on Territorial Cohesion – Turning territorial diversity into strength" the main function of territorial cohesion (TC) is to ensure the harmonious development of all types of places and make sure that the citizens of these places are able to make the most inherent features of these territories. As a matter of fact TC is a means of transforming diversity into an asset contributing to sustainable development of the entire EU. Consequently TC aims at better territorial state of the EU with efficient, sustainable territorial structures and harmonious territorial patterns. It is very important to secure the multilevel understanding of TC – not only at the European level, but also on global, macro-regional, national, regional and sub-regional/ local scale. The main justification of TC is its integrative character. TC is a tool to build networks of functional areas.

Territorial cohesion is a crucial issue also for TA 2020 (the revised TA document) on the one hand through the contribution of the regions, local levels and other territories to common priorities (e.g. competitiveness, climate change, etc.). On the other hand it plays a key role to secure a "territorial optimum" both through the support of (long term) efficiency of the sector policy interventions and through the contribution to increase the living quality of citizens experienced at local level. Territorial approach is a key moment within the TC approach as a tool for harmonizing different development paradigms such as sustainability, convergence (solidarity between regions) and regional competitiveness.

In the implementation there is a shared competence between the Member States and the Union in the field of economic, social and territorial cohesion (Art. 5c TFEU). Member States shall exercise their competence to the extent in which the Union does not exercise it. This gives a stronger base for joint action in pursuing territorial cohesion, however the subsidiarity principle has to be respected and the Union shall act only if and in so far as the objectives cannot be sufficiently achieved by the Member States at the central, regional or local level, but can be better achieved on European level (Art. 5 TEU). Policies of the Union have to pursue the goal of territorial cohesion, and Member States shall conduct and coordinate their economic policies to attain territorial cohesion (Art. 175 TFEU).

If we would like to summarize the double understanding of territorial cohesion we can say there are two sides of the coin. On one hand the understanding of the mechanisms – in other words territoriality should be taken into account in every situation to prove horizontality of the notion. It means that all kind of territories should be inspired and supported to utilize their territorial capital and secure territorial co-ordination of different development intentions of different sectors on a given territorial unit. On the other hand the space-related understanding of territorial cohesion aims at the identification and formation of territorial structures even of given sectors/ themes to secure proper territorial consciousness in every sector related development activity.

Another interesting issue is that how we can use territories in planning and programming. In quantitative term which is the most traditional use of territorial structures/ types in planning; certain territories get priority and more resources to support them (usually their catching up process). In this case the key question is: "Who gets the support (=money)" and "How much"? In qualitative term – which approach gathers ground recently – the focus is on the idea that different spaces with different characteristics need specific solutions. In this case every place (territorial unit) could be part of one or more territorial types and there are no more and less important types of territories. The key question is: "How and what to do in a certain spaces"? In our opinion this latter approach is more suitable regarding territorial planning and territorial cohesion to correlate with the theory that territorial cohesion is not about the financial support (that is the function of regional policy), but about the ways and methods, the coordination and planning mechanisms.

TSP update and TA revision – the mission: enhancing territorial approach in TSP and TA

With regard to the decision of the Ministers responsible for the spatial planning and development of the Territorial Agenda at their informal ministerial meeting under the German EU Presidency in 2007, the Hungarian Presidency evaluates and reviews the Territorial Agenda in the first half of 2011. Hungary through VÁTI plays a leading role in these processes as lead partner of the working group and the drafting team of the revision since the autumn of 2009.

In order to introduce the two documents shortly the TSP serves as a situation analysis of the current European sectorial and territorial trends and territorial impacts of common EU policies. The Territorial Agenda based on the results of TSP has a mission as a policy paper to develop and specify the territorial perspective/ vision wider than what it is indicated in main EU-policy papers, to underline and specify the most important territorial implications of different EU-policies, to indicate important territorial structures which should be taken in consideration at EU level and as well as at the national level and to identify some of the most important principles, instruments and mechanisms and priorities for the promotion of better territorial cohesion in Europe.

The first versions of both documents were prepared/ adopted in 2007. Since then significant changes have happened in the European and global trends, and in the European policy context; the interpretation of the concept of territorial cohesion has further developed and new challenges of territorial development have emerged. The changes in the circumstances underline the need to rethink the trends and the challenges introduced in the TSP 2007 and further develop the territorial priorities of the EU, strengthening the territoriality of the objectives/ priorities to serve better as a territorial compass for EU and for the national sector policies as well as to point out messages for the regional, subregional and cross-border territories. The framework of implementation has also changed once they adopted the changes within the Treaty and the implementation mechanisms shall be improved based on the experiences with the actions taken in order to achieve the goals of the Territorial Agenda.

The TSP and the Territorial Agenda are evaluated and reviewed in cooperation of the Member States and the Commission to increase the validity of the objectives and to ensure that the objectives are in line with other policy developments and that will be implemented based on the consensus of the parties participating at the revision and the implementation of the Territorial Agenda.

Summarizing our experiences during the revision process so far, territorial content seemed to be weak in both documents. Due to the fact that both document are (or should be) territorial oriented; the weak appearance of territorial approach was a quite displeasing surprise. Steady opinion of the drafting was that in the updated TSP and the revised TA territorial aspects should get significantly greater emphasis to enable the 2 materials to act as the part of the basic documents of territorial idea and the notion of territorial cohesion.

TSP – need to enhance the territorial content of sectorial chapters' and the propagation of a new, synthetic territorial chapter

Regarding TSP the improvement of territoriality could be fed from 4 main sources. (1) Currently the thematic subchapters of the Trends chapter that deal with the sectorial trends miss the identification of the special territorial structures/ types of the given sectors. In the updated TSP these thematic (economy, social issues, climate change, environment, culture, transport, etc.) subchapters have to be completed with relevant territorial content, e.g. regarding climate change with the main zones of Europe facing different challenges connecting the topic (e.g. south - desertification, north - increasing precipitation etc.). (2) The urban-rural dimension of the material, which is quite strong even in the old TSP, has to be enhanced further due to the fact that the importance of the topic has come into the fore recently (ESPON Project 1.1.2.; Urban-rural seminars in Brussels in 2008-09; formation of an international working group on the Implementation of Action 1.1a of the urban-rural Issues within the Context of the Territorial Agenda of the European Union etc.). (3) The group of „regions with geographic specialties" has to be completed in the updated TSP with some new elements which on the one hand try to react to the special characteristics of the new member states, on the other hand counterweight the unbalanced structure of the current types (only mountainous, coastal, remote and island regions are mentioned). A question comes up, if we talk about mountain regions why do not we talk about plain regions? If we talk about coastal regions why do not we talk about landlocked regions? This issue of unbalances should be solved during the planning process. The 4th tool that enhances the territorial content of the TSP is the most important and synthetic one. It is introduced on a more detailed way hereinafter.

Currently, there is one subchapter within the TSP that deals directly with territorial issues (called "Territorial structures and challenges") and additionally a general preamble of the "Trends Chapter" mentions some structural dimension, and the fact that "Northern and southern Europe have different territorial potential which shape their way into the future…". This kind of contents is worth extending. To strengthen the territorial integrative role of the whole material a potential solution could be the creation of a self sufficient territorial chapter (comprising the aforementioned preamble and the current "Territorial structures and challenges" subchapter) that can be completed by a new macro regional (or territorial synthesis) part.

This new part has been elaborated as a result of comprehensive examinations to identify and shortly describe bigger geographical zones within Europe. The aim of this macro regional subchapter is giving a short presentation of the Europe's main parts synthesizing the messages of the other thematic (sectorial) chapters to the given geographical unit. So the key function is systemization of the territorial content, features and problems and not a new regionalization of Europe. These zones can be assessed as proper tools for the identification of territorial challenges and special problems/ strengths of given territories of Europe. With this method we have access to territorially relevant answers to the main challenges of Europe (such as climate change, ageing and migratory flows etc.). The list of these challenges is geared to the structure of the trends chapter's thematic subchapters. The use of these categories can be assessed as a representation of the place based approach at higher territorial level.

The question comes up: how many main zones (macroregions) are there? What will be the background of the delimitation? In the followings we try to answer to these questions. TSP, as a European-wide situation analysis can be based on the descriptions of different sectors of society, economy and environment in various chapters, but the different elements, processes are often closely interlinked, affecting one another in the geographical areas, thus a territorial approach is needed, and the summary of the features in the context of territorial types is expedient.

One way of assessing the state is based on the comparisons of statistical data of different territories (countries, regions), like in the Cohesion Reports or Progress Reports of the EU regional policy. It needs concrete territorial divisions and exact borders, because in this way we can process statistical data. The other way is to write general establishments, like in the current TSP-document. This description is typical at macro-regional level, because usually these territories can be characterized without exact borders, and with similar and different features. The macro-regional summary calls the attention on the (hidden or evident) relations of the territorial processes of the different features in the concrete area, and the uncovered identical problems start collective actions and collaborations between the countries, the regions concerned, and in this way strengthen the learning from each other (best practice).

In the geographical, historical, political studies there are many divisions of Europe, because "European diversity can be discussed at many different geographical levels reaching from general appreciation (…) to more detailed insights" (TSP 2007, p.15), and the division depends on the examined features (geographical position, climate, social, economic state etc.). The standpoints determine the type of a macro-regional division.

In the 19th century, geography used already the classical division based on climate and cardinal points: North-Europe, South-Europe, West-Europe, East-Europe; in this case typical social and economic features are associated with the different natural features. In this system the central part of the continent, Central Europe appeared with intermediate state and indistinct borders; there were many viewpoints in which regions are parts of this area and how it can be characterized. In the second part of the 20th century Central Europe lost its unity because the "Iron Curtain" divided it. The east and west part moved on different paths and drifted apart, so at present these areas differ from each other in social and economic features; it is the base of the distinction between East Central Europe and West Central Europe. But the existence of East Central Europe is significant in other respect as well: this area distinguishes itself from East Europe. The association of East Central European countries with the EU strengthens this distinction. (After the political transformation Central Europe was restored to life, and became an issue in the political and geographical discussions.)

Between 1965 and 1970 the European Council organized expert conferences to establish the division of the continent. The accepted recommendation was based on the division described on Fig. 1 and was applied in the geography of many countries and after a time in public opinions (Probáld-Szabó, 2005). In this recommendation the existence of Central Europe is admitted, and South-East Europe appears like an independent macro-region.

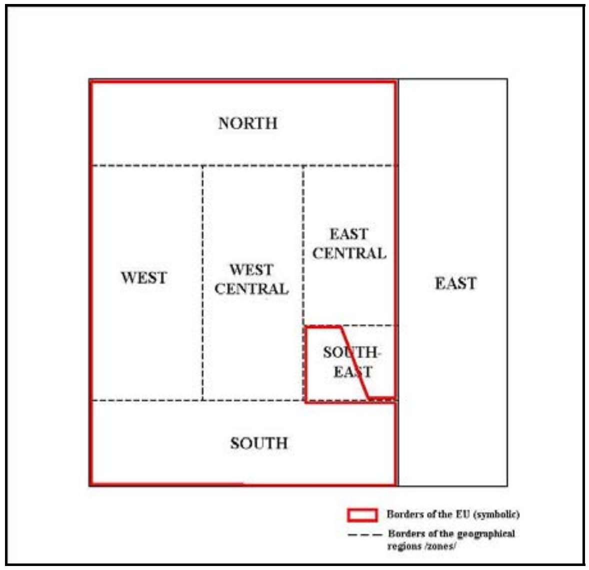

Fig. 1 A Typical Division of Europe in Terms of Regional Geography (after Probáld, F., Szabó, P. 2005)

And what about other opinions? There are a lot of different macroregional divisions of the continent, for example 11 macroregions in an EC document (1994), 7 macroregions in Lever's article from 1996, 3 macroregions in another EC document (2001) and 5 macroregions in Terrasi's work from 2003. Jordan (an American geographer) in his book ("The European culture area", 1996) described Europe in different respects (population, agriculture, industry and so on) and he came to the conclusion that the recurrent regional patterns presented on the continent are east versus west, north versus south, and core versus periphery, which contrasts are similar to those mentioned above. These relations are current and are discussed in numerous studies, but it seems that there were periods when one was more important than the others.

The developed North and underdeveloped South was the popular macroregional contrast in the seventies and eighties (before the fall of the communism) (Kunzmann 1992), when “western” regional researches only referred to Western Europe. Later, the centre-periphery paradigm, then the “united continent” pushed this relation into the background, and even the economic growth of “European sunbelt” weakened this contrast. In spite of these, the north-south dimension is not a forgotten issue (Armstrong, 1995), and there are a lot of social and economic features whose patterns show this contrast.

The centre versus periphery was the most frequently analyzed contrast in different studies in the eighties and nineties, and the center/ periphery contrast became the main paradigm at this time. The central economic zone is known from the economic history of our continent as the ”backbone of Europe”, but most people know this zone as the “blue banana” due to Brunet, or rather after a journalist’s comment (Lever, 1996). In the official documents of the European Communities (firstly in EC 1999) in the last few years the “pentagon” has been a useful model to identify the economic centre of the EU (“the core area of the EU, the pentagon defined by the metropolises of London, Paris, Milan, Munich and Hamburg.” [EC 1999, p.20.]). (About this topic see Szabó, 2008.) The centre-periphery contrast is still analyzed in some studies, although the new mainstream, the “polycentrism” pushes this relation into the background.

The third contrast is the developed West and underdeveloped East. It became a popular contrast in the nineties, after the fall of communism and at the time when the enlargement of the EU was approaching (Heidenreich, 2003). Probably the main dividing line of Europe is the western border of the post socialist countries, this line separates the continent into two parts in the case of most social and economic features.

Measuring these contrasts is a way to analyze them: for example our previous researches show that in the EU27 in the case of GDP and GDP per capita the east-west is the main contrast, and the centre-periphery is the second, but both of them are weakening; the north-south division does not play an important role in this comparison (Szabó, 2006). The results reflect that the development map of Europe is becoming more and more mosaic-like, and so the comparison of these macroregions is becoming more and more disputable in this case: for example, some studies emphasize that we cannot make a simple model for Europe’s spatial structure, and other articles emphasize that polycentrism is the main feature of the continent’s development spatial structure (this opinion reflects the increasing contrast of cities and rural areas in Europe). But we cannot forget that there are social, economic features which divide and will divide the continent into macroregions, and among them there are north-south, east-west and centre-periphery with a determinant role. Therefore, Terrasi (2003) emphasizes that the European regional policy must pay more attention to the macrospatial structure which lies behind the regional development processes.

Currently, there is no universally accepted macro division of Europe – in geographic terms (trying to take more features into consideration) Europe is usually divided to seven parts (or six parts, if South-East is not separated from South): North, South (and South East), West, West Central, East Central and East. (Fig. 1) In our division there are four parts: North, South, East Central and West & West Central, because in the present the area of the EU does not extend over East Europe and South East Europe (and TSP and TA focuses only on the EU’s territory), and West and West Central are not separated, because the dividing lines of social and economic features are faint between them. (Of course these macro-regions can be subdivided into more types, like urban-rural, coastal-inland, mountainous-plain zones, and the macro-regions partly overlap each other).

During the DT meetings came up the idea to consider the relationship of these main zones with regions of current transnational programmes. Regarding to those current mezzo regions of Transnational Programmes under the European Territorial Cooperation Objective in our opinion there is unambiguously strong coherence with the recommended zones. If we group some of these mezzo regions (e.g. Baltic Sea and Northern Periphery constitute the NORTHERN zone) the result is very similar to those 4 units identified by the new subchapter. Vast majority of the functional mezzo regions of the European Territorial Cooperation Objective is included in the 4 greater zones that are being identified. To show the relationship between these main zones and the transnational programme of regions and to avoid misunderstandings and to enhance transparency, in Fig. 2 we present the 4 zones and the transnational mezzo regions simultaneously.

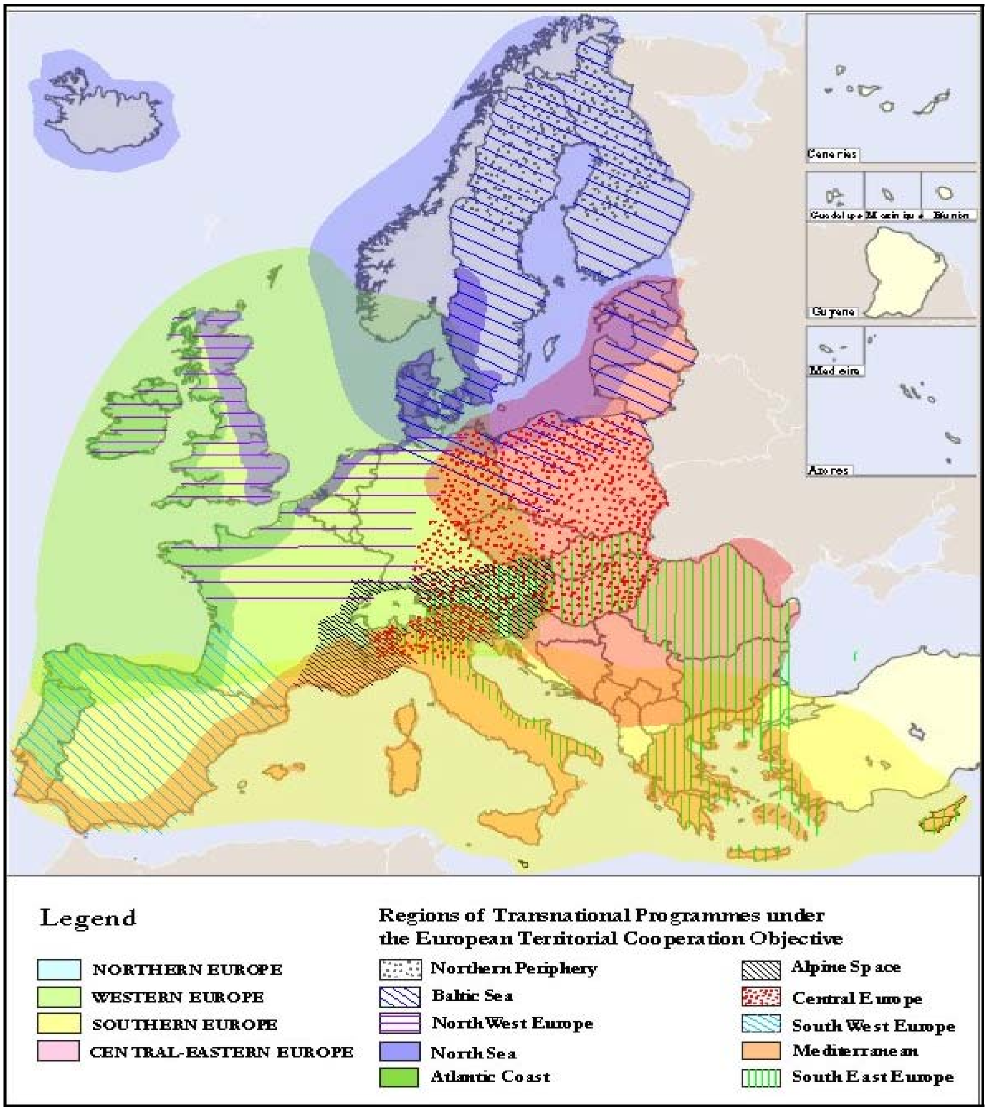

Fig. 2 The hypothetical geographical regions of Europe and their relations to the regions of Transnational programmes within the period 2007-2013

Additionally, important characteristic of the identified zones is that their borders between each other are not sharp boundaries but overlapping frontiers. For instance some areas (e.g. the Baltic States) can be defined as part both of the "Northern zone" and in the same time of the "Eastern zone" with special challenges related partly to the "northern" and partly to the "eastern" problems. The new subchapter shortly introduces these zones, their basic endowments and characteristics and furthermore the main (territorial) challenges they are facing.

All in all, for the identification and delimitation of bigger zones within Europe as "common denominator" of existing regionalization theories, results of scientific projects, practical life and real flows, currently the above mentioned 4 main zones seem to be the most compromising solution.

The Improvement of the territorial content in TA – new challenges, new priority structure and a completely new chapter

Regarding the Territorial Agenda the enhancement of territoriality seemed to be necessary as well as in the case of the TSP. The structure of TA and the content of its main parts have changed significantly during the planning process so far. The main changes can be summarized below.

The „Old TA" (TA 2007) comprised only a short introductory chapter with the title „Strengthening Territorial Cohesion" mostly about related aims and principles. The new TA being currently prepared will dedicate a longer chapter for the topic as an indication of the extended role of territorial cohesion, dealing with the issues of territorial cohesion's appearance in the Lisbon Treaty; its contribution to the EU 2020, utilization of territorial diverse local potentials; the wise management of territory and space consciousness. This extended chapter can be assessed as a reaction to the changed policy framework.

The "Old TA" contained 6 challenges. The new one – as things stand – will comprise 6+2; the first six are similar with the old ones, but with improved territorial dimension; the 2 additional ("Long term effects of global economic and financial crisis on Europe" and "Territorial exclusion") try to react to current challenges and territorial matters.

The priority structure of the TA 2007 will also be changed. Instead of the original six priorities in the new material the priority chapter will be split up into 2 main parts. The first one ("Overall territorial priorities") will comprise those priorities which were also present in the old TA but they were made more territorial. Good example is the "Strengthening of ecological and cultural networks" priority in which special types of territories will be mentioned regarding their difficulties and challenges they are facing with as a consequence of climate change's impacts. Second part of the priority chapter is about specific considerations for different types of territories such as shrinking urban regions; regions of structural transition; diverse types of rural territories; remote peripheral areas; urban motors; areas of cross border and transnational cooperation and regions with special geographic characteristics. The new TA will comprise recommendations for these unique territorial types. Figure 3 summarizes the new challenges and the priority structure.

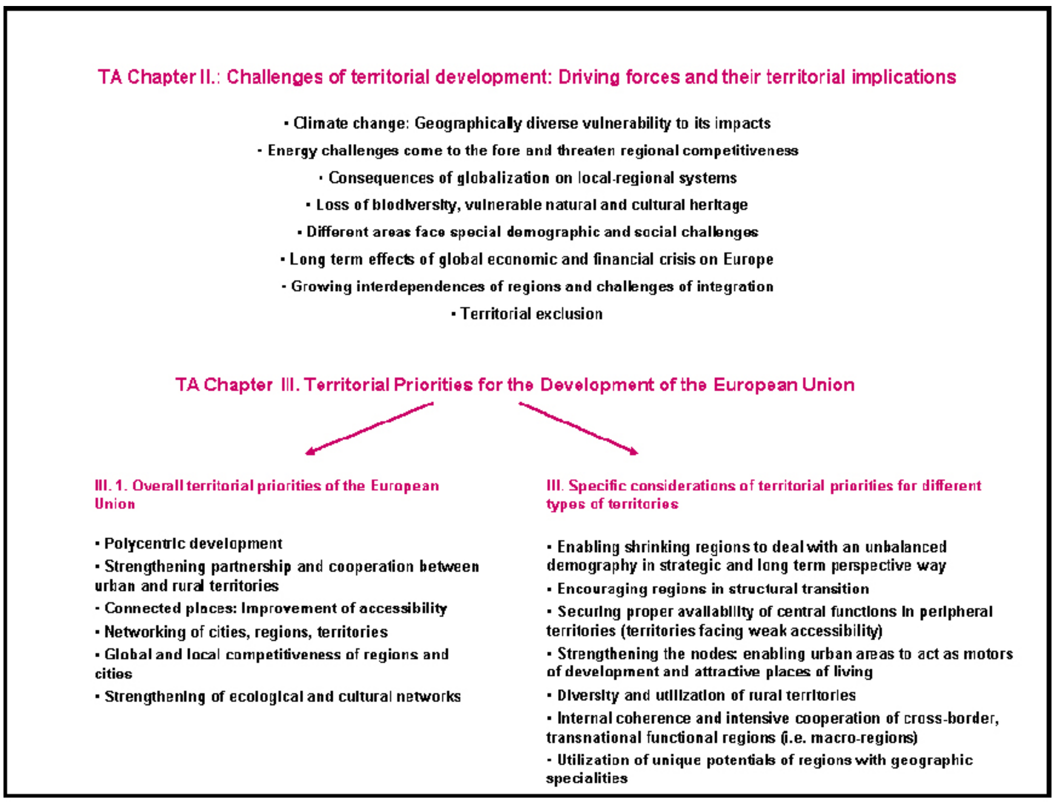

Fig. 3 Current, hypothetical structure of challenges and priorities of the TA2020 Outline

The "Implementation part" about the implementation of TA's recommendations was not a strong chapter in the TA 2007. In contrast with it, the revised version will deal with the ways of Territorial Cohesion in a longer chapter that will be more concrete than the old one and will put greater emphasis on the question of "How can the objectives and priorities of the TA be implemented?".

Finally, TA 2011 will comprise also a brand new chapter with special recommendations for the sectorial polices in order to enhance territory-consciousness of sectorial policies as well. As things stand, this new part of TA recommended by VÁTI is supported strongly by the Drafting Team and Working Group members as a good tool to enhance territorial aspects dimension of sectorial policies at the EU level.

Afterword

Nevertheless the new mentioned TSP and TA chapter ideas, document structures, analytical tools, the new TA challenges and priorities recommended are now only suggestions. They could be in force only if the European Commission would adopt it after a long series of reconciliations, partnership process, lobby activities and so on. But the working group's and the drafting team's intentions are clear – to strengthen the territorial content and spatial conscious approach of both TSP and TA as much as possible based on the current relatively favorable policy context and on the European regional development scene.

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THE SUBSIDENCE CAUSED BY THE WASTE-COAL SELF-IGNITION PROCESS IN THE ANINA TOWN (ROMANIA). PRELIMINARY STUDY

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Abstract

Uncontrolled subterranean coal fires, mainly developed through the process of self-ignition, represent a challenging hazard of local dimension, but with global-scale distribution. One important effect of this spontaneous ignition process is the surface subsidence. Porosity and particle size fraction of the coal particles in the deposit, water and oxygen play the main role. Anina sterile heaps present a non-typical situation of waste-coal self-ignition. The fine coal is found in the sterile heaps distributed all over the actual urban area, being covered by human activities and residential buildings, so that, the human risk is present in several forms.

Keywords: *coal self-ignition, sterile-heaps, subsidence risk, Anina*

Rezumat

Subsidența cauzată de autoaprinderea haldelor de steril din orașul Anina (România). Studiu preliminar. Arderea subterană necontrolată a cărbunilor, de multe ori rezultat al procesului de autoaprindere, reprezintă un fenomen de risc de dimensiuni locale, dar cu distribuţie la scară globală. Un efect important al acestui tip de arderi este subsidenta terenului. Porozitatea şi dimensiunea particulelor de cărbune din depozit, apa şi oxigenul joacă rolul principal. Haldele de steril din Anina prezintă o situaţie atipică de autoaprindere a cărbunelui mărunt înglobat în structura lor. Cărbunele mărunt apare în haldele distribuite pe toată suprafaţa urbană actuală, acoperite fiind de activitățile umane şi clădiri, astfel încât riscul uman înbracă mai multe forme de manifestare.

Cuvinte-cheie: *autoaprinderea cărbunilor, halde de steril, risc de subsidenţă, Anina.*

INTRODUCTION

All over the world, spontaneous combustion represents a major risk during coal mining, but also after the resources exploitation, in the management of coal waste heaps. Problems with large-scale coal fires have been reported in China, USA, India, Indonesia and South Africa (Wessling et al., 2008).

The subsidence, as the effect of the coal mining activities, is a *geological risk* that might appear slowly with insignificant effects at the beginning and serious damage in the end. Unlike earthquakes and volcanism, this category of geological risk, when it occurs, affects a small number of people. If the phenomenon has negative impacts, for example on some important transport infrastructure, the number of those affected increases (by blocking an industrial or commercial stream etc.) (Fig. 1).

Subsidence as the effect of the mining activities is generally defined as the lateral or vertical slowly “sinking” of the earth, as the consequence of the present or past mine excavations which appear as underground cavities. There are also some other potential causes – physical, chemical, hydraulical – that may induce subsidence processes and new cause-effect geo-system dynamics. Our present case study refers to such a non-typical situation: the waste-coal self-ignition.

Self-ignition is caused by the exothermic reaction between coal and oxygen and the related release of thermal energy; if oxygen is sufficiently supplied, but the energy is not removed, the reaction becomes self accelerating until combustion occurs (Wessling et al., 2008).

Site conditions. Human interference and implications.

In the case of Anina town, the anthropic activity has changed the natural landscape (special the land forms and the natural vegetation) as a result of not only early underground mining, but also of the storage of excavation waste on vast lands and in many sites, all over the present urban area. Most of these heaps are hardly visible now because they are covered by big industrial platforms, buildings and natural vegetation (Fig. 2).

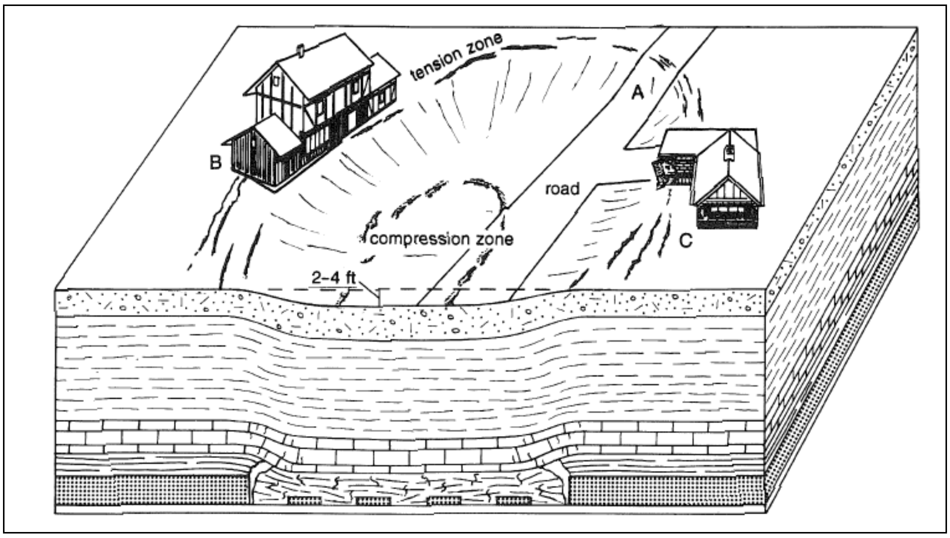

Fig. 1 The surface affected by the subsidence trough (according to Bauer et al., 1993)

Thus, the forms, the methods of manifestation and the impact on the geo-system are multiple, the direct ones – like temporary or permanent occupation of land surfaces, and the indirect ones – like the degradation of the relief forms and the landscapes, the air pollution, the degradation of groundwater and surface water; most of them are long term effects.

The entire city centre is built on some sterile-coal heaps dating from the first half of the 19th century, when the mining operation of Breuner pit started and when the whole economic activity made great strides (Fig.3).

In those days, the small parts of the coal mass were not used, so it had no economic value and it was thrown in the waste dump together with the sterile. Only later, starting with 1921 this was used to manufacture the metallurgical coke. The presence of such *lenses* of coal in the dump mass, together with a critical drainage led to the water penetration into the depth and, by oxygenation, brought to a phenomenon known as *self-ignition*. The small coal, in the presence of oxygen from water, kindles and starts smouldering. The phenomenon may last for days, weeks or even months, and it is distinguishable at the surface by thermal changes (such as the heat propagated in the sterile makes the ground to become warmer in some parts and releases heat in the atmosphere), by chemical changes (such as the elimination of a large quantity of carbon monoxide in the air that may be olfactory perceptible) or by mechanical changes (such as the structure and volume change of the dump leads to subsidence) (Fig.4).

Gas products from coal combustion have five different forms (Deng, 2010): between temperatures of 30~100°C, H_2O and CO_2 are formed; when the temperature ranges from 105 to150 °C, CO is formed, and when temperature exceeds 170°C, CH_4 and C_2H_4 are produced. At Anina, the carbon monoxide seems to be the most dangerous, easily detectable by human smell; the gas rests near the surface and causes unfavourable air mass movements. (Fig. 5).

Due to the fact that the heat generation is a result of carbon oxidation reaction, the key parameters which influence the self-ignition can fall into three groups (Lohrer et al., 2005):

a. *material properties*: porosity, particle size fraction (tab.1-2), water content, heat inductivity, bulk density, specific heat capacity and diffusion coefficient of the material;
b. *surrounding deposit characteristics*: oxygen volume fraction, convection of air, relative humidity;
c. *the volume to surface ratio (V/A)* of the incandescent deposit area (Fig. 6).

After Chong (cited by Lohrer, 2005), the self-ignition is also affected by the penetration of water (if as liquid or vapour) into the void volumes. The process called by Lohrer *the heat of wetting*, the condensation phase of this water, represents an additional heat transfer, and consequently, the temperature inside the deposit increase much faster compare to the dry surrounding. One of the essential parameters that are disregarded in the management of the sterile heaps in Anina was/is *the drainage*.

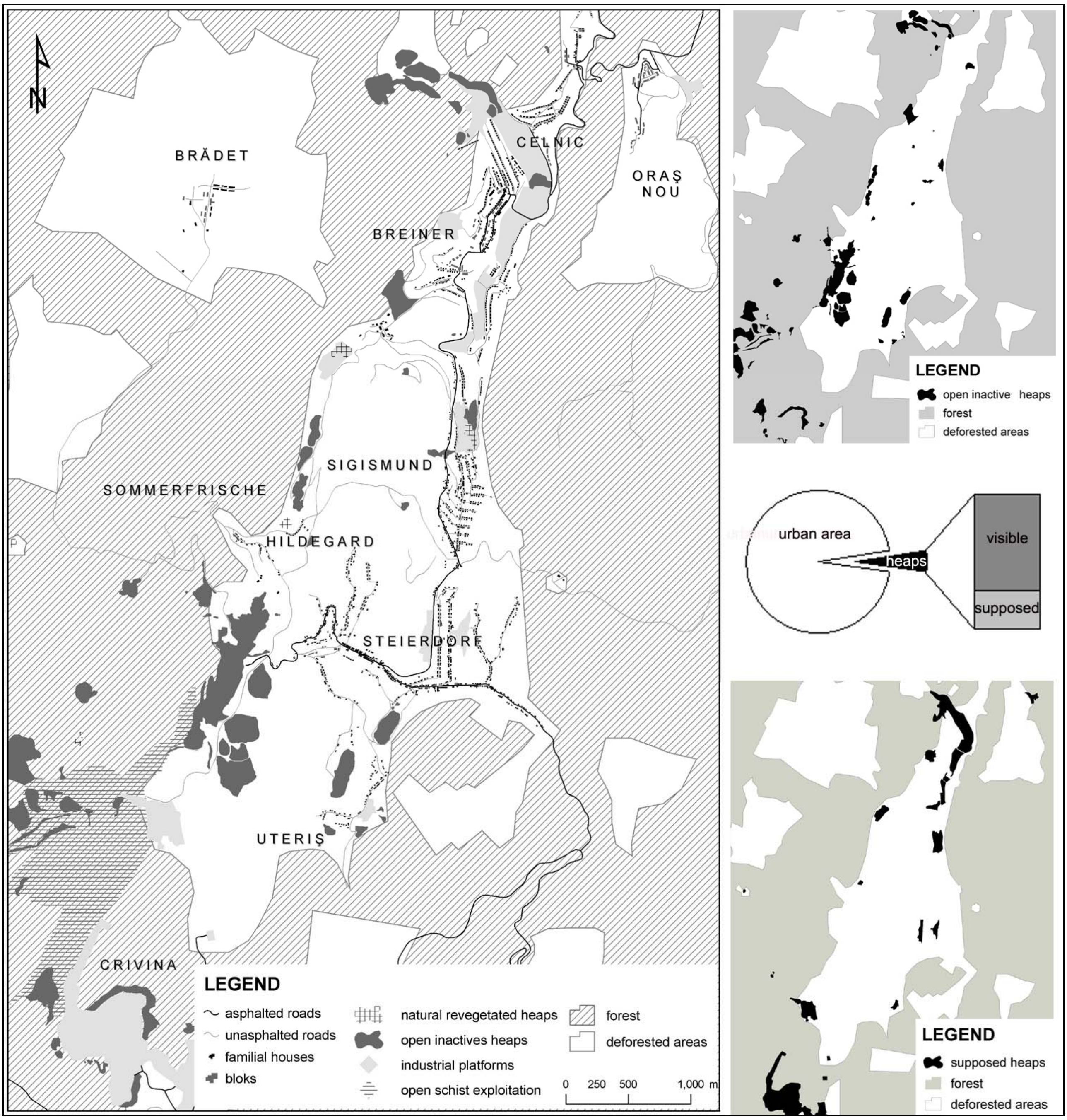

Fig. 2 Spatial disposition of visible and supposed coal-heaps in the Anina urban area (Satmari, 2010)

Table 1 Particle size distribution of two fractions of coal in %*(according to Lohrer, 2005, modified)*

Particle fraction (µm)	Fraction A (%)	Fraction B (%)
<20	25.3	-
20-40	20.7	-
40-63	18	-
63-125	20	-
125-200	11	9.8
200-315	5	4.3
315-500	-	2.4
500-1000	-	10.1
1000-2000	-	60

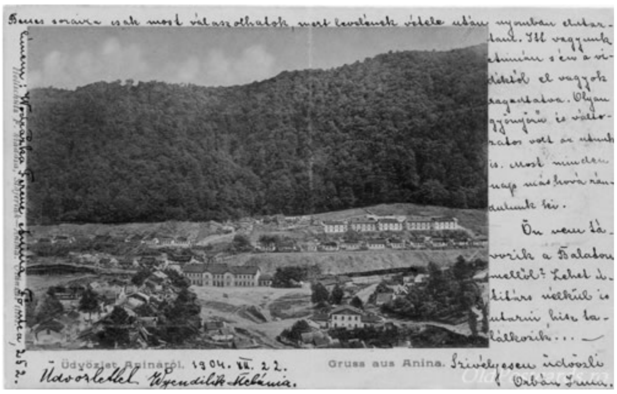

Fig. 3 Anina at the year 1904, a town built over a heaps-land. (www.oldpostcards.ro)

Table 2
Self-ignition temperatures (SIT) experiments for coal

Volume (mL)	Fraction A	Fraction B	obs.
31	138	140	The biggest
100	**124**	**129**	deviation
400	113	112	Equal SIT
800	110	110	

(according to Lohrer, 2005, modified)

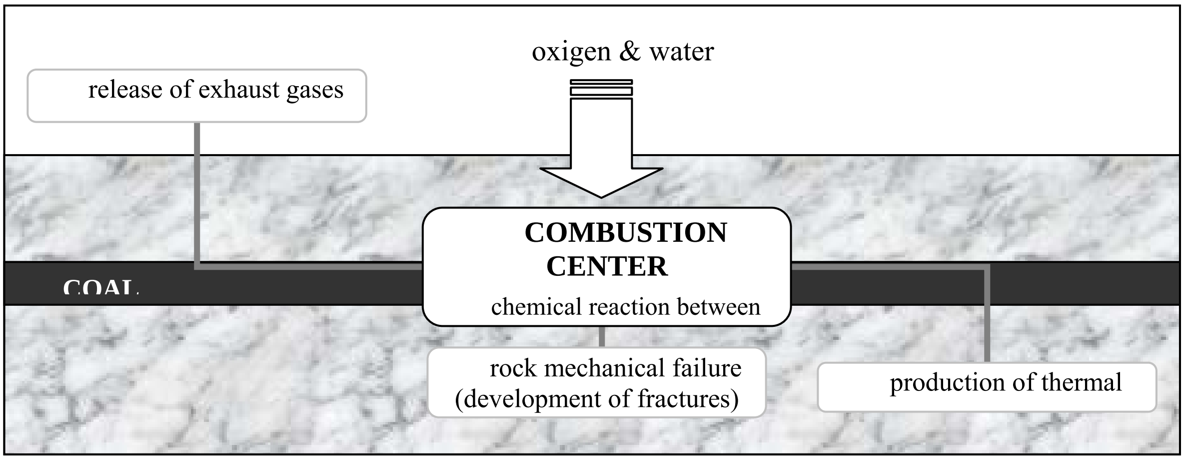

Fig. 4 Coal self-ignition in heaps deposits scheme (according to Wessling, 2008, modified)

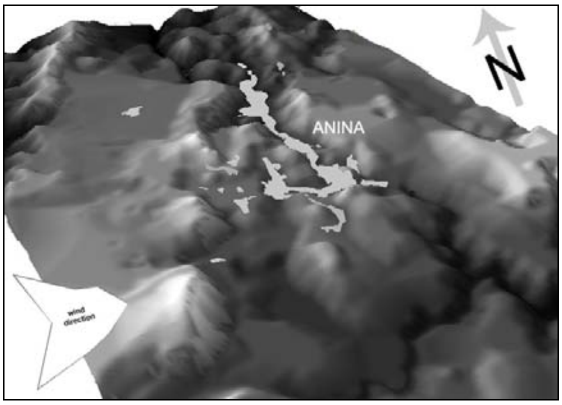

Fig. 5 The local geomorphology and the wind frequency do not help CO ignition product to disperse. (Satmari, 2010)

A special case refers the dump fire in the central park of the town. The dump was made between 1851 and 1900 from the operating sterile of Thinfeld I pit; the sterile contained sandstones, stone, schist, shale and coal dust. This dump occupies a total area of about 14 sqkm, and its thickness is about 14 m. The discharge of hot ash at the base (bottom) of the dump was the cause of the fire in the winter of 1986-1987 that lasted more than 20 years, until 2002. Among the damages, it is worth mentioning: the subside and settlement of the heating station, the first railway line and the out- of-use wagon scales, the park of the town became uneven and the vegetation was destroyed, the road to Steierdorf became uneven, the apartments on the ground floor of Block G and the shops on the ground floor of Block E were invaded by smoke and vaporous (other related possible risk is the carbon dioxide accumulation near the soil surface).

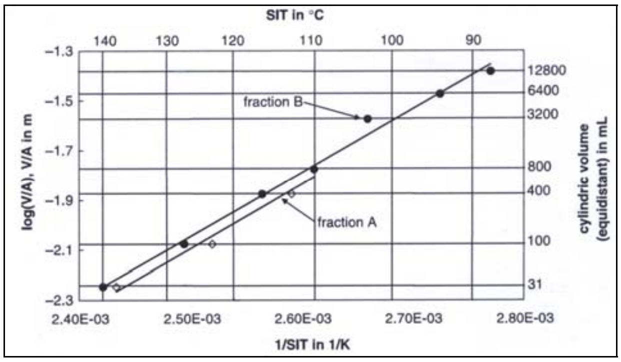

Fig. 6 The local geomorphology and the wind frequency do not help CO ignition product to disperse. (Satmari, 2010)

At present the fire is less intense, but it still burns, because the recent dynamic of its effects are visible at the surface by the land subsidence of the small buildings located on the dump (Fig.7). The part of the road that crosses the centre of the town has been raised several times in order to be used.

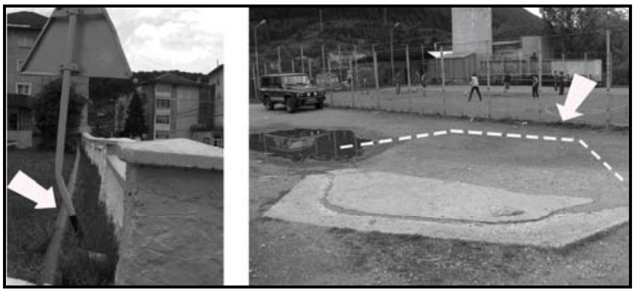

Fig. 7 Subsidence consequences in the central park of Anina (Satmari, 2007)

A study made by an international team of volunteers and coordinated by an NGO from Romania (Hobby Club Jules Verne Buziaş) specifies some data measurements taken in September 2002: at that time in Breiner centre, in the collective block-dwellings, the drinking water feed pipes had a temperature of 50-60°C and the ground continued to present some sinking tendencies and thus increasing the cracks in the walls nearby.

The main site conditions that caused the self-ignition and maintained the underground combustion were: the presence in the sterile mass of some small coal lenses with high humic acids content (this characteristic gives them a higher speed self-ignition), facilitating the oxygen absorption by the uncovered slopes of the dumps and the high degree of the settlement (this influences both the self-ignition and fire spread), the presence of heavy buildings such as the multi-story buildings and a heavy lorries road traffic.

CONCLUSIONS

In Anina, the coal self-ignition risk area overlaps the area where the society has developed, being covered by human activities and residential buildings. This situation makes the risk of self-ignition more dangerous. Over the years, the subsidence affected small proportions of the ground surface, but in many local sites.

The presence of water (vapour, liquid, moisturised) and the possibility of heaps oxygenation are the uncontrollable starting factors of the spontaneous combustion of old coal exploitation heaps in Anina.

Due to the studies that were made, the phenomenon can be stopped by injection of a small-diameter drillings (a mixture of water, cement, ash and other aggregates) in the heaps-mass (Toth et al., 2010).

The properties of this mixture might play the greatest role in the success of the operation: the ability to flow (due to the liquid content and the sliding property of the ash particles), the type of aggregate (it directly affects the capacity of water discharge), the setting time, the hardness of the stiffened blending. But, because the cost of this “treatment” is too high, and the municipality doesn’t trust the phenomenon until the human risk appears, the uncontrolled self-ignition still occurs.

The human history shows us today that the progress has always its price, that wealth and poverty can succeed each other. In our opinion, the sustainable development and economy is the pair of antonymic situations which continues to define the 21st century.

We intend to continue monitoring this case, including geophysical investigations, remote-sensing based analysis of temperature anomalies near surface and gas compositional measurements, attractive approaches to investigate underground spontaneous coal-fires from the surface, and to enable a practical application based on the following simple reaction model:

coal waste + water + oxygen → solid products + gas products + heat

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CHARACTERISTICS OF THE INDUSTRIALIZATION PROCESS AROUND THE MOMENT OF COLLAPSE OF A CENTRALIZED POLITICAL SYSTEM. ROMANIA AS A CASE STUDY

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Abstract

Although a country with a relatively small area, Romania has a variety of natural resources, which in time were favourable prerequisites to the development of processing activities. Most of these resources are not able to provide entirely the requisite, but cover parts of it in certain proportions. The territorial distribution of natural resources and the different cultural influences have fostered the development of certain regions or industrial centres of the country. The dynamics of the industrial exploitation of these centres has grown continuously, reaching a paroxysm in the centralised regime, when some of the resources have been largely exhausted. Rapid and often risky industrialisation, relying mainly on the basis of propaganda and not of economic efficiency has led to a falsely balanced development. New industrial structure, both territorial as well as sectorial has proven ineffective in the very first year of transition from the centralised system to the market economy.

Keywords: *industrialisation process, communist regime collapse, very early transition period, Romania*

Rezumat

Caracteristici ale procesului de industrializare in jurul momentului de colaps al unui sistem politic centralizat. Romania ca studiu de caz. Deşi o ţară cu o suprafaţă destul de mică, România are o mare varietate de resurse naturale, care au devenit în timp premise favorabile pentru dezvoltarea activităţilor de producţie. Mare parte a acestor resurse nu pot constitui în întregime o premisă, dar pot acoperi părţi din aceasta într-o anumită proporţie. Distribuţia teritorială a resurselor naturale şi diversele influenţe culturale au impulsionat dezvoltarea anumitor regiuni sau centre industriale ale ţării. Dinamica exploatărilor industriale din aceste centre a urmat un permanent trend ascendent, atingând paroxismul în regimul centralizat, când unele dintre resurse au fost în mare parte epuizate. Industrializarea rapidă şi adesea riscantă, bazându-se în principal pe propagandă şi nu pe eficienţă economică a determinat o aparentă dezvoltare echilibrată. Noua structură industrială, s-a dovedit ineficientă atât teritorial cât şi sectorial încă din primul an de tranziţie de la sistemul centralizat la economia de piaţă.

Cuvinte-cheie: *proces de industrializare, prăbuşirea regimului comunist, perioadă de tranziţie incipientă, România*

INTRODUCTION

Twenty years since the fall of the totalitarian regime a retrospective analysis on the industrialisation process in a country that has experienced among the highest forms of centralisation may be an important document for the acquaintance with the mechanisms of transition from a totalitarian society to market economy and democracy. Since the political collapse, the insertion of changes in the dynamics of the industrialisation process shows that industrialisation had created the premises for achieving political changes. Socialist industrialisation meant hypertrophy of the working class, concentrated in large and very large enterprises. The degree of technical concentration caused a concentration of thousands of workers in certain places (Ianoş, 1993), who represented the force removing the communist regime during the popular uprising of December 22, 1989.

Obviously, the moment of removing the dictator in Romania was strongly influenced by the international political situation, the "mistake of organising a rally turned against the regime", as well as promoting intellectuals, as a long-term impact on political leaders, particularly after 1965. Their duality, which clearly knew the effects of the communist government and anticipated the opportunity of changing, generated the chaotic reaction of the regime at the beginning of the Romanian revolution, by their lack of involvement and the support of the uprising (Ianoş, 2009).

THE ROMANIAN INDUSTRY DURING THE INTERWAR PERIOD

Before the First World War, the industrial activities in Romania continue the growth and diversification started at the end of the nineteenth century. Many factories dating from this period, later became defining for the economy of some towns. Basically, the explosion of the number of factories reaches all industries, the most important seeming to be metallurgy and machine construction, revitalised around the beginning of World War 1st and after this moment. For example, only during 1914, the mechanical-metallurgical and mechanical equipment factories were created in Ploieşti, Iaşi and Bucureşti, shaping their production for war. Light industry is also filled with some textile and footwear enterprises that have become traditional (Suveica Bucureşti, Codlea, Arad and Craiova textile factory, Lugoj silk spinning factory, Cisnădie carpet factory, Clujana in Cluj, Guban in Timişoara, etc.).

Since late 20th century, an infusion of foreign capital penetrated the Romanian industry, particularly the German, English, French, Belgian, Dutch and American capital. Besides the national capital development, a restructuring of the hierarchy of foreign capital occurred immediately after the 1st World War by replacing the German capital mainly by American, English and French ones. They took advantage of the favourable situation after the war and moreover, the loans taken by Romania from banks in New York, London and Paris. Nevertheless, the general effects of these loans were beneficial for the Romanian economy and especially for the industrial activities.

The following range among the most important groups or concerns: the English "Wickers", represented by the English group "Auschnit" (in siderurgy and machine construction), the German concern "I.G. Faberindustrie" in the chemical industry, the "Malaxa" Romanian concern in machine construction and the Belgian trust "Solvay" in the chemical industry.

The industrial development of the country reaches a paroxysm in the interwar period due to the numerical increase of enterprises and workers in the already existent industrial enterprises. The number of large industrial enterprises reaches 186, representing all branches, including those of high-tech at that time (electro-technical, aviation, chemical industry, medicine). It was only in the period 1929-1938, for example, that the national industrial production registered an increase of 55% materialised in a rebalancing in the branches' structure.

Among all industries, food and light industry (textile, leather and footwear) stood out, covering almost 50% of the total industrial production. The second place was taken by oil industry (13%), followed by other branches, such as machine construction and metal processing (10,2%), exploitation and wood processing (9,5%), chemical industry (2.2%), etc. Overall, consumer goods industry had 54.5% and the other category of branches involved in the development of industrial production and other economic branches had 45.5%. Basically, a certain balance between the two categories was reached.

The process of technical concentration of the production was an important feature of the industry development in the interwar period. That is why in 1938 the number of enterprises falls by 8% as compared to 1927, while the number of employees increases by 35% and the production by 56%. This situation is also reflected by the fact that although the number of enterprises with more than 200 employees only represented 10% of the total number of enterprises, these owned 65.4% of all employees and 69.1% of the installed engine power. Almost all industries were guided by criteria of efficiency, various cartels operating within these, integrated into the international market. By 1938, there were 94 cartels gathering 1600 industrial enterprises. These cartels ensured the functioning of the economy that was getting integrated in the European economy, although this one was already influenced by the preparations for the Second World War.

Participation of industry in The National Income grew very quickly, holding 30.8% in 1938, as compared with the share of agriculture which was reduced to 38.5%. Taking into consideration the level reached in some industries, Romania was situated on a leading position that would have provided a further upward development. From a very low level of industrial production at the end of World War Ist, important achievements had already been made by 1938 and they were materialised in oil industry, metallurgy, machine building and even chemical industry.

Considering the criteria of efficiency and accessibility, Romanian industry was mainly concentrated in a few areas and centres. Thus, Bucureşti, Valea Prahovei, the central-southern part of Transilvania and Banat owned about 60% of the global production, forming in fact the economic heart of the territorial location of industry, the important role of natural resources, the engine that drew the Romanian industry into a competitive European level.

Table 1. The production achieved for some industrial products in 1938

Product	Measurement unit	Production
Electricity	million kWh	1.130
Oil extracted	thousand tons	6.594
Steel	thousand tons	284
Finished rolled articles	thousand tons	318
Sulphuric acid	tons	43.900
Sodium carbonate	tons	35.000
Cement	thousand tons	510
Sugar	tons	95.100
Edible oils	tons	17.800

Source: Statistical Yearbook of Romania, 1939-1940, p.76

In Romania, there were six industrial concentrations in 1938, among which *Bucureşti, Valea Prahovei, Braşov* stood out with over 24% of the number of employees and more than 1/3 of the value of the industrial production and the area contained in the *Valea Jiului - Hunedoara - Arad - Reşiţa* square by about 17% of employees and 15% of the value of industrial production. The other industrial concentrations were dominated by the one in the centre of Transilvania by about 10% of both indicators at the national level.

QUICK SOCIALIST INDUSTRIALIZATION, AN END IN ITSELF

Immediately after the 2nd World War, Romania entered into the sphere of influence of the former Soviet Union as a result of the Yalta Agreement, which meant changing the capitalist market with the centralised (over-centralised) communist one. Right from the beginning of the transition towards centralism, the importance of industrialisation was emphasized, being considered a decisive factor of 'the general progress of society'.

Given the status of an ideological slogan, industrialisation became one of the main directions considered characteristic of communism, the key factor through which, in a very short time, both social homogeneity and harmonious economic development of all country areas could be simultaneously achieved.

Poor quality products were accepted, quantity was the only thing that mattered, the latter being the only criterion included in international statistics; the change transformed a purely economic process into a product for the political embellishing of society. The assessment of the levels of development, mainly through the level of industrial production and especially the one reached in heavy industries, led to the idea of transforming the industrial activities in an aim in itself but not in their correct integration within the national economy, in increasing their incentive role for other economic branches or for the actual living standard of the population.

Generally, one can distinguish two phases in the process of socialist industrialisation: a slower development between 1948 and 1965, mainly oriented towards regional centres and the construction of new industrial centres with a high degree of specialisation; and a second one, of rapid development and concentration of industrial activities in gigantic units. Basically, taking into account the particularities of these two phases, the first one stands out, closely following the Soviet model (most decisions were taken by consultation with Soviets specialists) and the second one, originating in Romania, born from the megalomaniac ideas of *Ceauşescu* is related to industry development.

The subsequent evolution of economic life, even under the over centralised regime, has demonstrated the inefficient nature of the structure and the evolution of Romanian industrial activities. The isolation policy promoted in all fields. including the economic one, the strictly autarchic orientation of general development, the excessive use of figures, more or less true, about industrial production, for propagandistic purposes, these may altogether lead to the idea that rapid industrialisation was in fact, an end in itself.

THE PRE-*CEAUŞESCU* STAGE OF INDUSTRIALISATION - INDUSTRY, A REAL SLOGAN

The preserved high pace of development was an important feature of the industrialisation during this first stage and moreover, throughout the entire communist period. This high rate has made the Romanian industry share to increase from 0.30% in 1938 to 0.98% in 1965 within the worldwide industry. The pace was different for specific branches of heavy industry and industry producing consumer goods. In 1965, as compared to 1950, the industrial production was almost 6.5 times higher, with a doubled dynamics of heavy industry, which grew by 8.2%, as compared to that of consumer goods which only recorded a rate of 4.6%.

The comparative analysis of the contribution made by industry in the national income shows a continuous growing, this contribution coming close, in 1965, to 50% (48.9%). It is interesting to notice the variation in ratio of these activities, the phenomenon showing no correlation with an increase or decrease of the industrial activities. Thus, in 1950, the industry contributed with 44% to the national income, so that in 1995 it fell below 40% (39.8%). It was only in 1960 that the share reached the value recorded in 1950 (Table 2), although the industrial production value was over 3.4 times higher this year. This disturbance was due to a very low level of the Romanian agriculture in the years 1946-1950, as a result of totally adverse climatic conditions and therefore of its low contribution to national income.

Table 2 The share of industry in the national income during the period 1938-1965

Year	National income - total -	The share of industry in the national income (%)
1938	100	30,8
1950	100	44,0
1955	100	39,8
1960	100	44,1
1965	100	48,1

Source: Statistical Yearbook of Romania, DCS, 1983, p.44

These positive evolutions of the industrial activities were due to some investment programs propelled from the central level. Thus, during the period 1951-1955, 53.8% of the total investments were allocated to industry and in the next 10 years they were maintained at about 45%. The orientation of these investments was towards the heavy industry, which was considered the hub of the communist economy. Thus, over 85% of the total industrial investments were directed to these branches, in 1965 the share even approaching 90% (89.2%).

As a result of the preferential orientation of investments to certain industries in the global industrial production, the main branches experienced important transformations (table no.3). Thus, overall, the heavy industry recorded an increased share, reaching from 45.5% in 1938 to 53.0% in 1950 and 65% in 1965. At the same time the industries of consumer goods reveals a pronounced decrease, reaching 34.8% in 1965.

Table 3 The structure of global industrial production by main branches (%)

Industry branch	1950	1955	1960	1965
Industry - total	100	100	100	100
Heavy industry	53,0	55,8	62,9	65,2
Consumer goods industry	47,0	44,2	37,1	34,8
Energy industry	13,2	13,1	11,6	9,6
Ferrous metallurgy	5,4	4,2	6,3	8,3
Non-ferrous metallurgy	2,1	2,3	2,1	3,2
Machine construction industry	13,3	18,8	24,0	21,2
Chemical industry	3,1	4,7	6,1	6,7
Construction materials industry	2,4	3,2	3,2	3,3
Wood industry	9,9	8,9	7,5	8,2
Pulp and paper industry	1,3	0,9	1,0	1,2
Glass, porcelain and earthenware	0,7	0,7	0,7	0,6
Textiles and clothing industry	18,6	15,7	13,5	11,6
Leather and footwear industry	4,0	3,5	2,8	2,4
Food industry	24,2	21,7	18,9	22,0
Other branches	1,8	2,1	2,3	1,7

Source: Statistical Yearbook of Romania, DCS, 1981, p.164-165

The most spectacular increase was obtained during 1950-1965 by the chemical industry (from 3.1% to 6.7%) and machine building industry (from 13.3% to 21.2%). Slight increase was recorded by the ferrous metallurgy industry (from 5.4% to 8.3%) and by the non-ferrous metallurgy (from 2.1% to 3.2%). Meanwhile, other industries such as textile and clothing decreases from 18.6% to 11.6%, leather and footwear industry from 4.0% to 2.4%, wood from 9,9% to 8.2%. Other industries have remained at an approximately constant weight (industry of glass, porcelain, earthenware, pulp and paper, food). The energetic industry, overall, registered a significant decrease from 13.2 reaching up to about 9.6%.

Table 4. The share of population employed, employees and workers in industry on total economy (%)

Year	Employed population	The number of employees	The number of workers
1950	12,0	38,3	52,4
1955	13,1	36,8	46,6
1960	15,1	38,6	46,8
1965	19,2	38,9	46,3

Source: Statistical Yearbook of Romania, DCS, 1981, p.98-99

These changes, under the impulse of directed investment, led to an increase in employment in industry during 1950-1965, by over 850,000 people, raising its share in the structure of employment by about 7.0% (Table 4).

At the same time, an obvious stagnation in the share of working staff and also a decrease by over 6% of the share of total workers in the economy. This shows, in fact, a weighted industrialisation of the Romanian economy in the first stage, with structural changes, but quantitatively a relatively low progress.

Synthetically, we can conclude that in terms of structure and quantity, during that stage, the extractive industry, as compared to manufacturing industries, show the second type of activities to be favoured and an increase in the gap between heavy industry and the production of goods consumption to the detriment of the latter, on a background of overall industry diversification and increase of variety.

The changes in the territorial location of industry occurred in two directions: one aimed at developing the regional residence centres and the second aimed at setting up and developing new industrial specialised centres often located in areas with natural resources considered of strategic importance.

The first direction was largely determined by the administrative restructuring in that period, and the 16 resulting regions. Residence centres were the main points of concentration of investment in industry during 1950-1965, under the pretext of alleviating regional disparities. Thus, these numerous investments meant new branches arising in industrial cities such as Craiova, the capital of Oltenia region (the electrical industry, chemical industry), Constanţa, the capital of Dobrogea region (pulp and paper industry, furniture industry), Iaşi, the capital of Moldova region (the electrical industry, drug industry), etc. Targeting investments mainly to the residence centres of the regions generated great intraregional disparities, which have resulted in the increase in migration toward these centres due to economic stagnation or decline of the other cities.

The second direction was imposed by the idea of immediate exploitation of natural resources, sometimes up to exhaustion, as it was the case of Nucet industrial centre (known for the major nearby uranium deposits). Some specialised industrial centres were created on bare land, being either mining centres (Motru, Nucet) or chemical industry centres (Oneşti, Victoria).

Despite the efforts made to alleviate regional imbalances, large differences between the major regions of the country are noticed at the level of 1965. Basically, the same regions which in 1938 had formed the group of the most developed ones, respectively, Bucureşti, Braşov, Prahova, Hunedoara, Banat and Cluj stood out even now while the regions of Oltenia, Dobrogea, Iaşi, Suceava, Maramureş and others remained clearly underdeveloped. Even if new industrial centres appeared or the existing ones were developed, intraregional disparities reached maximum levels, the effects of which would have been catastrophic in respect of the future demography and the standard of living.

INDUSTRIALISATION IN THE TIME OF CEAUŞESCU AND ITS MEGALOMANIC FORMS. INDUSTRY FROM SLOGAN TO MYTH

The vestiture of Ceauşescu in the leadership of Romania in 1965 led to the transformation of industrialisation from a slogan into a true 'myth'. The Invasion of Czechoslovakia (August 1968) was a reason for speeding up the industrialisation and the economic separation from the former USSR. Consequently, Romania's idea of economic independence was launched, but also, the idea that the Romanian industry can produce anything and at the highest standards. Ceauşescu's opposition to Moscow was supported by the West, which in various forms, especially in the beginning, encouraged Ceauşescu to materialize his dream of economic and especially energetic and industrial independence.

The fear of a potential Soviet aggression pushed him to a spatial distribution of the heavy industry, offering the possibility of a long-term resistance in case a part of the territory was invaded. This meant that all counties would hold a diversified industrial structure that could easily be converted into an industry of war. In the context of such fears another idea took shape: that only large combines and giant industrial units can provide, at minimum cost, achieving a single integrated flux of the most complex products, machinery or equipment.

But all these facts were premises for an almost enclosed industrial development, because the over centralization of power in the hands of one family created megalomaniac forms of industry. The desire to enter history through 'great achievements', like the Egyptian pyramids, led to a high level of technical industry concentration, the birth of a system of giant industrial units, which were doomed to die even by the absence of 'food' .

THE DYNAMICS OF THE ROMANIAN INDUSTRY AFTER 1965

The analysis of the development of industrial activities between 1965 and 1989 highlights two characteristic periods: one, which stands out through the rhythms of industrialisation at the highest levels in the world, between 1965-1980, and another, characterized by a stagnation or even slight decrease in this rate after 1980.

The first period can be characterized as explosive in terms of growth rate that exceeded the threshold of 10.0% in the first three years of the "five year plan": 11.8% between 1966-1970, 12.9% between 1971-1975 and 10.1 % between 1976-1980. These rates have led to an improved share of the Romanian industry in the global industrial production (from 0.98% in 1965 to about 1.5% in 1980). The volume of the global industrial production was multiplied by almost 1.7 times every 5 years as compared to 1965. So that industrial production was 5.1 times higher in 1980 as compared to the first year of the period and heavy industry more than 7 times.

The explosive evolution of the industrial production was based on a growing volume of investments allocated to industry. Throughout the period, the investments allocated to this economic branch reached about 50% of the total for the national economy. There must be reported the excessively large gap between the group of heavy industry and the group of consumer goods industry, the first having the benefit, on average, during the period 1965-1980, of over 855 from the total volume of investments. As a result of this dynamics, the share of industry in the national income constantly increased, reaching from 48.9% up to 58.5%.

The explosive growth of industrial production was achieved through an extensive type of industrialisation, by increasing the number of industrial units or by developing the existing ones to huge dimensions. In this sense, about 1800 industrial units started to operate almost every 5 years (1966/1970 - 1580 1971/1975 - 1869 1976/1980 - 2266), representing independent companies or their divisions. Most of the Romanian industry giant units, concentrated in the same place of production, date from this period: Colibaşi car plant - 28,000 employees, Braşov truck plant - 20.900, Hunedoara steel mill and Braşov tractor plant with 19,800 per one, Faur Bucharest plants - 19,300, Iaşi heavy equipment factory - 18,700, Ploieşti oilfield equipment plants - 16,600, etc.

The extensive nature of the industrialisation process is reflected in the allocating of investment in each County. It was only two counties that received investment of over 10 thousand millions lei in the 1966-1970 period (Galaţi and Argeş); in the next 5 years this threshold was exceeded by 9 counties and by other 16 during the 1976-1980 period (provided that the value of national currency kept the purchasing power). When comparing with the first period, there was an over 3 times-increase in the 1971-1975 period, in the counties considered to be less developed (Bistriţa-Năsăud, Botoşani, Dâmboviţa, Gorj, Sălaj, Tulcea, Vaslui). In the 1976-1980 period the investment volume increased over 15 times in Sălaj and Vaslui, considered to be the most disadvantaged.

As a result of these investments, the average annual development rates were very high in some counties in relation to the national average (9.5%). Thus, in the 1976-1980 period, the highest rates have been observed in the counties Bistriţa- Năsăud (21.2%) and Sălaj (20.6%), counties with a very low industrial start base. They were followed by other counties, where not even one large industrial centre (urban) or a well shaped industrial area were present: Covasna (17.7%), Tulcea (16.6%), Vâlcea (16.2%) Botoşani (16.1%), Vaslui (16.1%).

One of the main effects of this investment policy has been the employment growth in industry and the size of this increase demonstrates the extensive nature of the process. At the national level, only during 1970-1980 the number of employees increased by 60.2%, meaning a total of 1,201,300 people. This is the largest annual average increase in the number of employees in industry (by over 120,000 people). The increase was due to a very high demand for workforce that was covered as a result of the migration flows from rural areas.

The most important increases of employees in industry, in the same period, have been recorded in the basic industries at the time, as it was the case of machine building industry (234.5%) and the chemical industry (186.1%). Similar significant increases can be also noted for other branches, closely connected with house building and industrial programs. These were held in parallel with the process of industrialisation, the basic branches being the construction materials industry (180.0%) and that of glass, porcelain and earthenware (206.7%). These programs have provided minimum conditions for the massive masses of migrants from rural areas, becoming inhabitants of the town overnight.

The territorial variation of the increase in the number of employees reveals relatively high values for the new counties, with a high degree of rural characteristics, without historical past. Thus, the highest values are recorded in Olt County, where in just 10 years the number of employees in industry increased from 11,551 to 42,672 (over 3.7 times), Vaslui from 13546 to 38145 (of over 2.8 times), Bistriţa-Năsăud from 8,334 to 22,642 and Sălaj from 7805 to 20,959 (both more than 2.7 times). The explosion of industrial activities in these counties was not widespread, being focused in only a few urban centres, which had profound implications in the dynamics of rural-urban ratio.

Yet, quantitatively, the developed industrial districts also recorded the most important values of the volume of employees. For example, Bucureşti has increased the number of employees by 152,965 people, Braşov and Prahova counties by over 63,000 and respectively, 62,000 people. These increases are equivalent with the increase of some of the counties that have reached the highest relative increases.

These mutations occurred at the level of some indicators, but also reverberated in the dynamics of the industrial production, which was particularly influenced from 1970 to 1980. The overall national industrial production increases more than 3 times, with some differences between branches. Thus, branches like machine building (4.1 times), chemical industry (3.3 times), and clothing industry (3.3 times) were located above the national average. The branch with the lowest increase in production was food industry (1.92 times), which was also reflected in a very low diversification of products on the market. These growth rates below average of this industry were maintained throughout the period of the totalitarian regime, demonstrating the demagogic discourse of the representatives of the regime regarding the living level and the place man had in the policy they promoted.

The materialization of these dynamics was the natural products that entered the productive chains of the industry giants or being export-oriented in order to ensure the raw material for these large consumers. The interval 1970-1980 was the most significant for the industrial boom in Romania. Now the production of electricity almost doubled (ranging from 35 to over 67 thousand million kWh) and the volume of some basic industrial products for a country's economy has experienced the same effect: steel from 6.5 to 13.2 million tons (by the entry into service at full capacity of Galaţi steel mill and the one in Târgovişte), aluminium from 101 at 241 thousand tons, chemical fertilizers from 0.9 to 2.5 million tons, chemical fibres and threads from 77 to 206 thousand tons, cement from 8 to 15.6 million tons etc.

The support for such industrial development was not always based on local natural resources or raw materials. The import of main raw materials, particularly for the petrochemical and steel industry has increased several times, this also increasing the economic and power dependence on other countries, especially third world ones. In order to reveal this strong correlation, we mention, for example, that between 1970 and 1980 the import of iron increased by over 2.5 times (ranging from 6,3 million tons to about 16 million tons) and of crude oil?? almost 7 times (from 2.29 million to about 16 million tons). The main countries from which the import of oil was realized were, in order: Iraq, Iran, Libya, Nigeria and Syria.

THE ROMANIAN INDUSTRY STAGNATION AND EVEN DECLINE AFTER 1980

Early '80s on the entire socialist system level is characterized by a strong stall, by blocking economic circuits, which inevitably would have led to an impending implosion. Romania, Ceauşescu's regime, which enjoyed, during the ’70s, the obvious support of the Western countries, loses credibility and stands out as one of the harshest communist regimes.

Ceauşescu's megalomania reached its peak in the period following 1980, when the place of big factories and mills with tens of thousands employed was taken by the achievement of large scale objectives, which exceeded the strength of achievement of the nation. So, for example, the works for the Danube-Black Sea Canal completion were amplified, the works for the first nuclear power plant in the country (Cernavodă) started, the work on building the Danube-Bucharest Canal (including the two ports that would have served the city - Glina and 30 Decembrie), the works for Bucureşti’s metro were extended, the complex program to transform Dâmboviţa river into a genuine 'canal' was put in place and the building of the new centre of the capital started.

Besides all these great buildings, which meant huge economic and social costs Ceauşescu regime's ambition to pay in three years the entire external debt was added, amounted to more than 10 thousand million dollars. The result of such actions was the depleting of the country's reserves and resources, worsening the living conditions of the population.

Basically, we can individualize a period of stagnation during the last 10 years of communism, until 1986 and another of decline following this year, period overlapped with the one of the effort to pay the foreign debts. This sequence is also noticed in the volume of investments in industry, which, after having slightly increased between 1980 and 1986 (16%), gradually decreased until 1989 with more than 4% below the 1980 level, this, without adding the slight depreciation of the currency.

Yet, the number of employees increased in the same time by about 15%, reaching 3690 thousand persons in 1989. This growth was differentiated by branches, fuel industry standing out, where the increase was 88.8%, 14.8% in ferrous metallurgy, machine building industry with 14.0% and 11.3% in non-ferrous metallurgy, the last three branches being situated below the national average. Light industry as a whole marked a slight increase (textile and clothing - 10.3%), except for leather and footwear industry that grew by 23.4%. Instead, food industry remained absolutely at the same number of employees (192,571 people). Some branches were clearly declining, like construction materials industry (-10.0%) and chemical industry (-6.0%), the first due to the reduction of housing construction program and the second by the slight reduction in the import of crude oil for petrochemicals.

Territorial differences in the number of employees shows a continuation of its growth in less industrially developed districts, where values frequently exceeded 40.0% (Vrancea 61.2%, Ialomiţa 53.8%, Vaslui 44.5%, Suceava 42.0%) or even 70% for Sălaj (71.2%) and Bistriţa-Năsăud (70.6%). A lower growth was noticed in the counties with an important share of energy (Gorj 30.5%, Hunedoara 23.5%, Brăila 20.2%, Dolj 16.2%). In all other counties there was noticed a very slight increase in the number of employees, except for Giurgiu County (created in 1981 and characterized by the highest degree of rural characteristics), where the number of employees surprisingly decreased between 1980 and 1989 by almost 25% (from 30,396 to 22,852 people). For the first time in this case, the bankruptcy of chlorine-sodium products and heavy equipment enterprises built here is reflected in the statistical evidence.

If in terms of value, the overall industrial output manifested some increases in the analyzed period, in terms of physical production, its decline is obvious. The first indicator measured in lei expresses not actually the real evolution of the industrial production, while physical production is a reliable indicator in assessing the dynamics trend. For example, while the production of metallurgical industry, expressed in lei, increased by over 20%, steel production fell by over 4 million lei (from 13.2 to around 9.0 million tons) and the one of cast iron remained at the same level. The same situation was also in building materials industry, which grew by 33%, while cement production declined by more than 2.3 million tons and the prefabricated production with over 1.2 million cubic meters.

Despite the efforts made at the central level, the decline of the industrial production and the difficulties industrial "mammoths" built in the '70s surpassed were obvious. The fact that these phenomena have also been noticed by the old regime is reflected by the 'recommendations' given for prior development of small industry and small industrial units in the '80s, as a result of the decentralization of activities in the large companies. That is, for example, in the period after 1980 a number of sections of the companies from major cities or County centres industrialized during 1965-1975 were operating in small towns or countryside. For example, as a result of the decentralization of industrial activities in Timişoara, units of various profiles were developed in cities such as Sânnicolau Mare (a department of socks factory, a section of the former Electrometal enterprise, a section of the Mobitim enterprise) and Buziaş (a section of Garofiţa factory, a section of Electromotor plant), or in the countryside, as Recaş (a section of Modern factory), Lovrin, and Variaş and Jebel (divisions of Electromotor company) etc. In the new established poorly industrialized counties departments of enterprises from cities of residence were founded in towns and countryside: for example, in Botoşani County, spinning mills and textile enterprises from Darabani, Săveni - both cities, and Flămânzi - rural place were divisions of the enterprises of the same field from Botoşani).

The industrialisation of the countryside was an evident trend in the '80s considering the numerous established companies with very diverse profiles. The vast majority of these enterprises were completely artificially implanted, without any relation to local sources of raw materials, with existing traditions of the area, with a favorable geographical position. In contrast, others which used local raw materials were often oversized, as was the case of sugar factories in some rural localities as Lechinţa Teiuş, Truşeşti, Fundulea, Liestal, Fălciu, etc.

In conclusion, it can be pointed out that industrialisation was a continuous process during the communist era, a process that gave rise to huge units exceeding the real power of their economic integration. The explosion of industrial activity took place during the decade VIII (1970-1980), and their concentration in cities has increased rural-urban migration, which resulted in a true urban explosion. The closed nature of the Romanian economy in the last 15 years of the former regime has diminished the level of modernity of the industrial plants, which even though they were new, they were in an advanced state of obsolescence (intensive energy and materials consumers). Populist expression of industrialisation results from the latest developments of industrial production and number of employees who have different trends in favour of the last indicator.

Industrialisation at any price and with absolutely inappropriate types of industry of all counties created artificial territorial structures that could not resist for long even while maintaining the centralised system. Short-term social effects seemed to be favourable, but on long term it proved to be downright catastrophic both for the national economy, the system of settlements and for individuals or local communities.

THE DRAMATIC DECLINE OF INDUSTRY IN THE POST-SOCIALIST PERIOD

The increased distortion in the Romanian economy in the first two years after the collapse of the communist political system is reflected in the gradual reduction of production, in the lowering of the internal production potential, in the increasing prices and the ongoing deterioration of social conditions. The transition from the over centralised, command economy system to market economy system was a very complex and contradictory process through practical application, taking into account, on the one hand, the different speeds of changing and reacting of some components of the economy and on the other hand, the social and psychological issues resulted.

The period following December 1989 has meant a real turbulence stage for the Romanian industry, during which, the processes in the basic cells level (of the enterprises) were often chaotic. The dismantling of the network of relationships between enterprises, the decentralization and autonomy of decision-making of industrial units, in terms of no private property in this sector have resulted in a constant regressive evolution of production and its quality and even in the loss of control of the change process.

THE INDUSTRY STATE WHEN THE POLITICAL SYSTEM COLLAPSED

Forcing the pace of industrial development compared with other economic sectors and especially with the tertiary sector resulted in a contribution to national income with 58.1% in 1989 and with 66.8% to the total social product. Despite this very high weights, as outlined after the year 1980, it was noted a slight decrease in industrial activities and a weight loss in the national income by 1% for example, only between 1988 and 1989. Besides, during these two years, the industry recorded a regression, industrial production decreasing by over 2%. The effects of the strain of the productive apparatus were more obvious, also the effects of the imports of machinery reduction and technically non viable solutions, sometimes improvised, under the conditions imposed by the regime in order to rapidly repay the external debt of Romania.

Romanian industry structure in 1989 reveals the dominance of enterprises with over 1,000 employees (1075), which although represented about 47% of the total, held approximately 83% of the number of employees. Very high degree of technique concentration revealed a concentration of over 60% of these businesses in the County city centres (in 41 localities). In the countryside, there were 43 enterprises with over 1,000 employees.

Small and craft industry, which at one time was part of the territorial development policy, was very poorly represented. The number of enterprises with fewer than 200 employees was only 169 at the country level, with very different profiles, but light industries were dominant.

Between the branches of the national industry, in 1989, the machine building has come off with a share of 27.7%, followed by food industry (11.6%), chemicals (9.8%), ferrous metallurgy (6.8 %) and non-ferrous metallurgy (6.8%). Overall, light and food industry had only 25% of the national industrial production. The idea pursued tenaciously by the old regime after 1965 was to demonstrate that Romania can be economically independent, producing the full range of industrial products. As a result, the excessive diversification of industry, instead of widening branches of tradition, internationally competitive, stressed the dependence between enterprises and reduced the possibility of their functioning, especially after the energy crisis triggered at the beginning of the 8th decade. Exaggerated development of metallurgical and chemical industry, which are industries with high consumption of energy and raw materials, that exceeded the internal possibilities, has increased the depletion of the available reserves.

As a result of these evolutions, the Romanian industry was not bankrupt at the time of the collapse of the political system, but move to a clear degradation, which, however, would have grown during the next stages.

THE IMPACT OF DECEMBER 1989 EVENTS ON INDUSTRY

The surprising fall of the political system in Romania, in late December 1989, resulted in a

critical condition at the national economy level, because of the existing gap between the desire to quickly move to market economy and a democratic society and the real possibilities of building this. The main elements which left their mark on the future development of production were:
- the information break and decision-making jam at the enterprise level, caused by the sudden removal of the central-planned system of management (dissolution of power, the plan and planning);
- the abandonment of the criteria for assessing the performance achieved by the management of an enterprise, in order to avoid confrontations with employees, most enterprise leaders have accepted unjustified claims of employees and acts of indiscipline were tolerated in the workplace;
- the elimination of all instruments for quality control of products, which was passed on to production and technological discipline, the prestige of enterprises in conditions of free competition;
- the inappropriate behaviour of some traders, who have treated superficially the contractual duties, losing significant market outlet for products;
- the populist policy of the transitional government (the unjustified economical reduction of the working time to 40 hours weekly, providing exaggerated salary bonuses, reinstatement of new employees, block promotions policy without a proper assessment of the potential and skills of the candidates etc.);
- the legislative vacuum and then the legislative confusion generated by the existence of new laws together with the old ones, which favoured the establishment of chaos, especially in the cooperation between enterprises;
- the inadequate training of managerial staff in enterprises, given the criteria by which employees were selected in early January 1990.

The effects on industrial production were becoming more evident, so, at the end of 1990, industrial production was only 81% of that of 1989, while the number of employees increased by 1.6%. This shows the effect of applying a policy through which the new power aimed at preserving the public support after highly controversial events: permanent political movements, the events of March 1990 in Târgu Mureş, the Piaţa Universităţii phenomenon, the event involving miners in June 1990, etc. Statistical analysis (Table no. 5) shows that the only sectors in which there was an increase were heat energy (102.9%) and printing industry (100.3%). The first grew slightly due to the priority given to housing heating after about 20 years of reducing the heat and the second barely managed to cope with the avalanche of newspapers appeared during the post-revolution period at central, local or regional level. The most significant decreases were noted in the coal industry (58.6% of 1989 level), building materials (69.6%), crude oil processing (69.7%), ferrous metallurgy (69.8%) and non-ferrous metallurgy (70.7%).

Table 5. The populism of 1990 reflected by the opposite trends of industrial production and number of employees (1990 versus 1989)

Industry branch	Industrial production in 1990 (1989 = 100)	The number of staff (1989 = 100)
Total industry	81,0	101,6
Electricity and heat	102,9	128,4
Fuel	73,2	102,5
Ferrous metallurgy	70,0	103,9
Non-ferrous metallurgy	70,7	103,6
Machine construction	80,4	99,7
Chemical industry	76,1	104,1
Construction materials industry	69,6	101,2
Wood industry	78,7	99,4
Textiles industry	79,1	100,5
Clothing industry	85,6	97,1
Leather and footwear industry	77,7	98,0
Food industry	93,4	112,3
Print industry	100,3	113,4

Source: Statistical Yearbook of Romania, DCS, 1991 p.430-431; 484-485

Simultaneously, however, a growing number of employees could be noticed in almost all industries in 1990 as compared to 1989. Overall, the growth was 1.6%, but with large differences between branches. Decreases in the number of employees were found only in 4 industries: the clothing industry (2.9%), leather and footwear industry (2.0%), woodworking (0.6%) and machine building industry (0.3%). All other branches recorded an increase, the largest of which being recorded for heat and power industry (28.4%), printing industry (13.4%) and food industry (12.3%).

This contradictory trend of production and number of employees in industry had direct effects on the index of labour productivity per employee, causing a greatly reduced value compared with that recorded in 1989. For the entire industry labour productivity index stood in 1990 at 80.3% of the index registered in 1989. The lowest values were observed in the branches of ferrous metallurgy (67.1%) and non-ferrous metallurgy (68.3%), the chemical industry (72.9%) and construction materials industry (74.9%). Labour productivity in the mining industry stood at about 70% and the most dramatic decrease was recorded for coal extraction, only 58.4%.

In order to assess more accurately the impact of changing the political system on industrial production it is sufficient to mention the quantitative decreases of some industrial products in 1990 compared to 1989. Thus, electricity production has decreased by over 11.5 thousand million kWh, coal by 26 million tons and the crude extract about 1.2 million tons. Equally dramatically the level of some products decreased, which demonstrated once again 'the vigour of the Romanian economy': steel (from 14.4 million tons to 9.8), aluminium (from 282 to 178 thousand tons), chemical fertilizers (from 2.8 to 1.7 million tons), plastics (from 640 to 473 thousand tons), cement (from 13.3 to 10.4 million tons), etc.

The perception of this decline in County profile was closely correlated with the extent of industrial activities and their profile. In general, counties with a less developed industry have felt less intensely the shock of abandoning the system of centralised management of the economy, while the industrialized ones during Ceauşescu period marked a very significant decrease of the industrial production. At the same time, counties with a profile belonging to the industries most affected by the severance of relations between enterprises have seen the same regression (the case of counties with coal mining and large metallurgical enterprises).

At the industrial production level it is noticed a decrease for all counties, in a range between 1% (Ialomiţa County) and 29% (Mehedinţi County), between the two years at the beginning of transition. The counties that have least experienced on the overall the shock of regime change were those located in agricultural areas, in which food industry holds an important share. Thus, in addition to Ialomiţa County, minimal decrease recorded Satu Mare County (2%), Călăraşi and Tulcea (9% each), known by the presence of large complexes of meat and cheese processing, respectively the fishing and fish processing (Tulcea County).

The counties in which the mining industry, ferrous and nonferrous metallurgy have a significant share marked decreases from 20% (Mehedinţi County-coal mining, ferrous metallurgy, Hunedoara-26%, specialised in mining and ferrous metallurgy, Caraş Severin-25% mining and ferrous metallurgy, Bihor-24%, with mining and non-ferrous metallurgy, etc.).

A great variety of circumstances was noticed in the evolution of the number of employees in each County. Even if at the whole country level the number of the employed staff increased, the evolution is very different in each County. Thus in 15 counties the number of employees decreases and in the other 3 it stagnates. So, basically, only for half of the counties the number of employees increases during the two years comparatively analysed. Bucureşti stands out within the counties with decreases of the number of employees, where the value of decreasing is over 46,000 employees (8.8%). Braşov County (with a decrease of 5.3%, representing 9,500 employees) and Caraş-Severin County (with a fall of over 10%, or 7,100 employees) follow.

The counties that retain the same number of employees have very different industries and are located in different geographic conditions: Harghita, Ialomiţa and Mehedinţi. With some exceptions, it can be concluded that counties traditionally characterized by consistent industrial activity experienced a decrease in the number of employees. This is due to more developed services, which could draw a part of the workforce immediately after the events of December. At the same time, relatively recently industrialized counties under the pressure of workforce surplus in the area and due to low level of other economic sectors, especially services, increase the number of employees. Among these, the most important are: Vaslui (11.9%), Botoşani (11.2%), Teleorman (10.2%), Dâmboviţa (7.2%), Bacău (6.9%), Suceava (6.6%), etc. These are counties where the Frontul Salvării Nationale headed by Ion Iliescu has achieved over 90% of voters during May, 1990's elections.

One of the exceptions to the above mentioned is Prahova County, a County with industrial tradition, with a very important share in national production, but which in the period 1989-1990 marked a steep increase in the number of employees, of 9.2%. In absolute values this means more than 17,000 new employees, representing, for example, more than half of industry employees in Tulcea County.

Knowing the inefficiency of large enterprises in the market economy conditions and the flexibility of small industrial units, a process of dividing large enterprises started. This resulted in a growing number of enterprises with 142 new units. For example Faur, or Apaca Titan Industrial Group companies in Bucharest were divided into 8, 13 and 7 units of much reduced size. This division, however, at least for the moment, increased the production and labour productivity reduction, whereas the number of persons that deals exclusively with administrative matters increased (more directors, new accounting, supply and sales of production services) on the one hand and on the other hand, there was a fragmentation of the technological chain. This fragmentation has led to an increase in the price of production of a finished product, without increasing production itself.

CONCLUSION

The review of the dynamics of the industrialisation process over a century, in Romania, focusing on periods around the moment of transition from communist society to the one based on market economy, revealed the sequence of some steps the characteristics of which show the limits of a forced industrialisation. In addition, indirectly, the importance of extensive industrialisation is revealed for the fall of a totalitarian regime, through the geographical concentration of huge numbers of employees. Their general dissatisfaction quickly turned into a widespread revolt "in the moment of the spark ignition".

The model of increasing and decreasing of the industrialisation process over the entire analysed period is characterised by the following sequence, performed throughout the period of implementation of the utopian ideology of communism and its replacement:

a) the nationalisation of the industrial enterprises and radical change of management,

b) the orientation of the industrial production for heavy industries (machine construction, steel, chemistry),

c) the construction of large businesses in geographic regions considered underdeveloped, although it had no economic justification,

d) the hypertrophy of large industrial urban centres - regional capital cities,

e) the suffocation of big cities as well as overgrowth of industrial mono-specialised centres, leading to visible negative socioeconomic effects,

f) promoting the idea of small and medium enterprise as a remedy to the inefficient tendency of large industries. While fully maintaining the state ownership and the same type of management, the ideas promoted by the Ceauşescu regime in the period following 1980, naturally, did not give the expected results;

g) the disaster of economic and social policies favoured the fall of a system built on utopian ideology and a limitation of individual rights,

h) the fall of the political regime attracted, in the first instance, an economic populism of the new government,

i) the short period of apparent economic recovery is followed by deep industrial restructuring processes with variable duration.

The focus on spatial dimension of the effects of industrialisation and deindustrialisation is just one aspect for understanding the complex effects of pushing to the extreme of this process. Such an approach has also the function of prompting the researchers to continue a more analytical approach and integrated into the social and economic changes arising from the sudden transition of a country from a centralised to a market economy.

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THE USE OF THE DIGITAL TERRAIN MODEL IN ANALYZING THE NATURAL POTENTIAL OF THE MUNTELE MIC - POIANA MĂRULUI - ŢARCU MOUNTAINS TOURIST AREA TO EXTEND AND PLAN THE SKI DOMAIN

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Abstract

The present study aims at examining the natural potential of the region as a prerequisite for the planning and the expansion of the ski domain, in order to reinvigorate the resorts Muntele Mic and Poiana Mărului. The factors taken into account to identify the best areas for planning new ski tracks are: the altitude, the slope, the orientation of the slopes to the solar radiation, the duration and the thickness of the snow layer, the land use, the risk of snow avalanches occurrence and the degree of accessibility. Because the factors considered don't have the same importance for the favorability, before the combination of the factors, we used the Analytical Hierarchy Process (AHP) implemented by the IDRISI Andes software to assign for each factor a relative weight to use in the analysis. The risk of snow avalanches occurrence was considered as restrictive factor (Boolean factor). The combination of factors by Weight of Evidence method resulted in the creation of the final model, which presents the probability map for new ski tracks. The probability degree varies continuously in space, from a very high probability (255) to a very low probability (0) depending on the combination mode in a certain area of the considered factors and their weight. We considered as optimal areas only the areas with values above 200. The best areas to expand the ski domain are the detached secondary peaks of Muntele Mic towards north and the northern slopes of the Nedeia Ridge. These areas could allow for the development of certain ski tracks at least the same size as the ones of the Prahova Valley. The development of the ski domain in these areas will connect the two resorts, Muntele Mic and Poiana Mărului, and could increase the touristic potential of the study area.

Keywords: *ski areas, GIS, Digital Terrain Model, spatial analysis, Muntele Mic, Poiana Mărului, Ţarcu Mountains*

Rezumat

Utilizarea modelului numeric al terenului în analiza potenţialului natural al spaţiului turistic Muntele Mic - Poiana Mărului - Munţii Ţarcu, în vederea extinderii şi amenajării domeniului schiabil. Studiul de faţă îşi propune analiza potenţialului natural al regiunii ca premisă pentru amenajarea şi extinderea domeniilor schiabile, în vederea revigorării staţiunilor Muntele Mic şi Poiana Mărului. Factorii utilizați pentru determinarea arealelor optime pentru amenajarea de noi pârtii de schi au fost: altitudinea, panta, expoziţia suprafeţelor faţă de radiaţia solară, durata şi grosimea startului de zăpadă, utilizarea terenului riscul de producere al avalanşelor și gradul de accesibilitate. Factorii au fost standardizați cu ajutorul familiilor de funcții fuzzy pe o scala de la 0 (nefavorabil) la 255 (extrem de favorabil). Doar riscul de producere al avalanşelor a fost considerat factor restrictiv (boolean). Deoarece factorii considerați nu au aceeași importanță s-a utilizat Procedeul Analitic de Ierarhizare (software IDRISI Andes) pentru a stabili ponderea fiecărui factor în parte. Combinarea factorilor s-a realizat prin metoda Weight of Evidence obținându-se harta de probabilitate a amenajării de noi pârtii de schi. Arealele optime au fost considerate cele cu valori de peste 200. Aceste areale sunt localizate pe versantul nordic al Masivului Muntele Mic și al Culmii Nedeia si ar permite dezvoltarea unor domenii schiabile de talia celor din Valea Prahovei. Totodată deschiderea unor noi pârtii de schi și a instalațiilor de transport aferente ar permite conectarea celor două stațiuni, Muntele Mic şi Poiana Mărului, ceea ce ar duce la o creştere a atractivității turistice a arealului analizat.

Cuvinte cheie: *domenii de schi, SIG, MNT, analiză spaţială, Muntele Mic, Poiana Mărului, Munţii Ţarcu*

INTRODUCTION

The analysis and the knowledge of the parameters of the terrain are essential for the constitution of a mountain resort, especially for ski practices. In this sense, the completion of the DTM and of the thematic maps of altitude, depth of fragmentation, declivity and aspect (Grimsdóttir and McClung, 2006; Tremper, 2001), but also the analysis of the vegetation and especially of the snow (Beniston, 1997; Beniston *et al.*, 2003; Breiling, Charamza, 1999) serve to establish the indicators of the ski slopes (Ţigu, 2001) and to understand the manifestation manner and the frequency of high-risk physical and geographical processes of the ski domain, such as the snow avalanches (Schweizer and Camponovo, 2001; Schweizer and Lütschg, 2001). At the same time the snow cover serves as a climate change indicator (Beniston, 1997; Breiling, Charamza, 1999; Hamilton *et al.*, 2005; Krapf *et al.*, 1999; Lise and Toll, 2002; Scott, McBoyle, 2007; Whetton *et al.*, 1996).

In this case, we have chosen for analysis the mountainous space of Muntele Mic - Poiana Mărului - Ţarcu Mountains, locally and regionally known, but insufficiently exploited. Our work may represent a perspective that can be taken into account in view of the enlargement of the mountain ski domain in this sector, according to the Urban Planning of the Area - Muntele Mic - Turnu Ruieni Settlement (Bocicai, 2006).

The Study Area

Ţarcu Mountains, covering a surface of more than1440 square kilometres, are located in the north - west of the Southern Carpathians, in the Retezat - Godeanu Mountains (Badea *et al.*, 2001) (Fig. 1).

Fig. 1 The position of the Ţarcu Mountains within the Retezat-Godeanu Mountains (Badea *et al.*, 2001)

Mainly developed on the crystalline schists of the Danubian Autochthonous and of the Getic Nappe, it unfolds between 300 and 2192 meters of altitude (Pietrii Peak), which places it among the highest mountains in Banat. The altitude and the location of these mountains in a region of oceanic climate influences explains the presence of a substantial snow cover, with an annual average duration of 148 days at Cuntu meteorological station (1450 meters) and 190 days on the highest peaks (Ţarcu Peak meteorological station, 2180 meters), which makes the practice of winter sports possible. The presence of the plateau of Muntele Mic (1802 meters), without forests and with gentle slopes, plus the location of the massive near large cities in the western part of the country, explains the practice of skiing in this area since the beginning of last century (Ţeposu, Puşcariu, 1932).

Nowadays, this ski area is poorly equipped and modernized as compared to other resorts and the slopes are insufficient in number and in the degree of difficulty. Given the fact that more and more skiers choose other destinations because of the causes mentioned above, this study aims at examining the natural potential of the region as a prerequisite for the planning and the expansion of the ski areas, in order to reinvigorate the Muntele Mic - Poiana Mărului - Ţarcu resorts (Photo. 1, a, b).

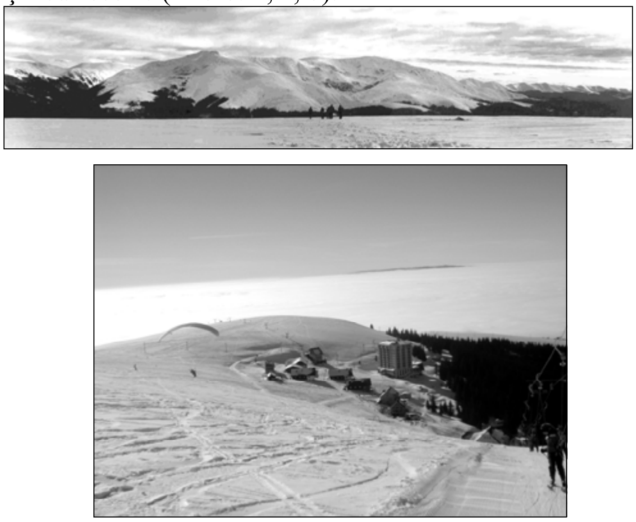

Photo. 1. a, b. Muntele Mic - Poiana Mărului - Ţarcu ski areas (photos by Voiculescu and Török, 2008)

MATERIAL AND METHODS

The data used for the analysis of the potential ski areas with the help of the geographical information systems (GIS) come from different sources:

- the digital terrain model (DTM) SPOT HRS (High Resolution Stereo) with a spatial resolution of 30 meters, obtained through satellite remote sensing; (Fig. 2) ;

- Landsat ETM + satellite images (bands 1, 2, 3, 4, 5, 7, and 8), date of acquisition: September 8th, 2006, with a resolution of 30 meters multi-spectral and 15 meters for the panchromatic band;

- topographic maps, scale 1:25,000, scanned and georeferenced in the Stereo 1970 national coordinate system;

- climate data from the Caransebeş (201 meters), Cuntu (1450 meters) and Ţarcu (2180 meters) weather stations, for the 1980 - 2004 period;

- field data.

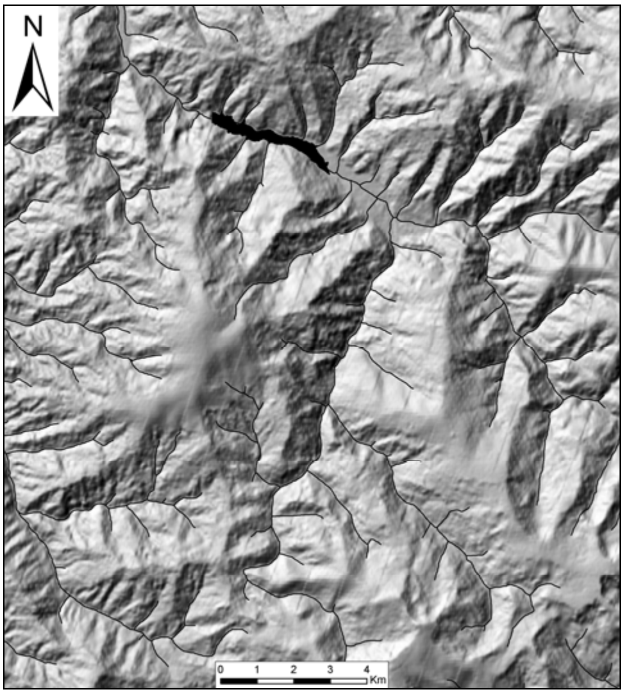

Fig. 2 The Digital Terrain Model (SPOT-HRS, 30m resolution) of the study area.

In the first stage, the factors to be taken into account in order to identify new areas that provide optimal conditions for skiing were established. These factors are: geomorphologic factors (altitude, slope, relief fragmentation density and aspect), climatic factors (the average duration of the snow layer and the exhibition of the areas to the sunlight), biogeographical factors (the type of vegetation and its coverage), risk factors (snow avalanches) and anthropogenic factors (the existing infrastructure).

In the second stage, each factor was represented in the form of a digital map. Because the factors were measured in different units their standardization is necessary. Almost all the analyzed factors vary continuously through space and they are seen as data sets with a continuous character, therefore the best method for standardization is the using of fuzzy membership functions. In this way the factors were standardized on scale of integer numbers from 0 to 255 (bytes).

Because the factors considered have different importance regarding the skiing favorability we assigned for each factor a relative weight. The attribution of the weight is difficult and it is relative when all the factors are simultaneous taken in concern. The distribution of the information in simple comparisons in pairs, in which two criteria are taken in concern at once, may facilitate the weighting process and will provide a much more stabile set of criteria weight. This technique of pair comparison, known as Analytical Hierarchy Process (AHP), is implemented in the IDRISI software. The factors are compared two by two, by giving notes on a continuous scale of nine values.

The combination of the factors by Weight of Evidence method allowed obtaining the final model, which presents the probability map for new ski tracks. The probability degree varies continuously in space, from a very high probability, or very high favorability, (value 204) to a very low probability, or very low favorability (value 0) depending on the combination mode in a certain area of the considered factors and their weight. We considered as optimal areas only the areas with values above 160.

Finally, we selected the most suitable areas for the development of new ski tracks using two criteria: the area (areas greater than 15 ha) and the accessibility (areas situated at a distance of maximum 1000 m from roads).

RESULTS AND DISCUSSIONS

The altitude is essential for skiing activities and, given the conditions of the temperate continental climate in which our country is located, it has to be of at least 1000 meters (Besancenot, 1990) in order to maintain a favourable snow layer for at least 3 months/year. The altitude factor was standardized using a increase linear fuzzy function with main point 1000 m for 0 values.

The slopes represent a factor of great importance for skiing activities. Also, the slope is the element that separates the practitioners of this activity into two large categories: skiers and beginners. The first category was defined as *users of skis, snowboards or other gravity-propelled recreational devices whose design and function allow users a significant degree of control over speed and direction on snow* (Penniman, 1999, pp. 36); the beginning skiers or the beginners were defined as: *those individuals who are using one or another of these devices for the first time or who possess marginal abilities to turn or stop on slopes with incline greater than 20%* (Penniman, 1999, pp. 36).

According to the declivity degree, there have been established the following categories of skiers: beginners (who make use of slope gradients with a declivity of 11.5º), intermediates (who use the slope gradients between 18º-19º), advanced skiers (who use the slope gradients of 19º), and experts (who use slope gradients that surpass 19º or even 39º) (Borgersen, 1977; Gaylor and Rombold, 1964, quoted by Penniman, 1999).

The optimum slopes for skiing are between 10° and 35°. The standardization of the slope has been made by using a symmetric sigmoid function by establishing as main points the values of 10 degrees

35 degrees for 255 value and the values of 5 and 40 degrees for 0 values (Fig. 3)

The slope orientation to the sun is an important factor in terms of depth and duration of the snow layer (Birkeland and Mock, 2001; Egli, 2008; Fitzharris, 1987; Höller, 2009; McClung, Schaerer, 1993) and it exerts a strong influence on the stability of the snow pack (Ancey, 2001).

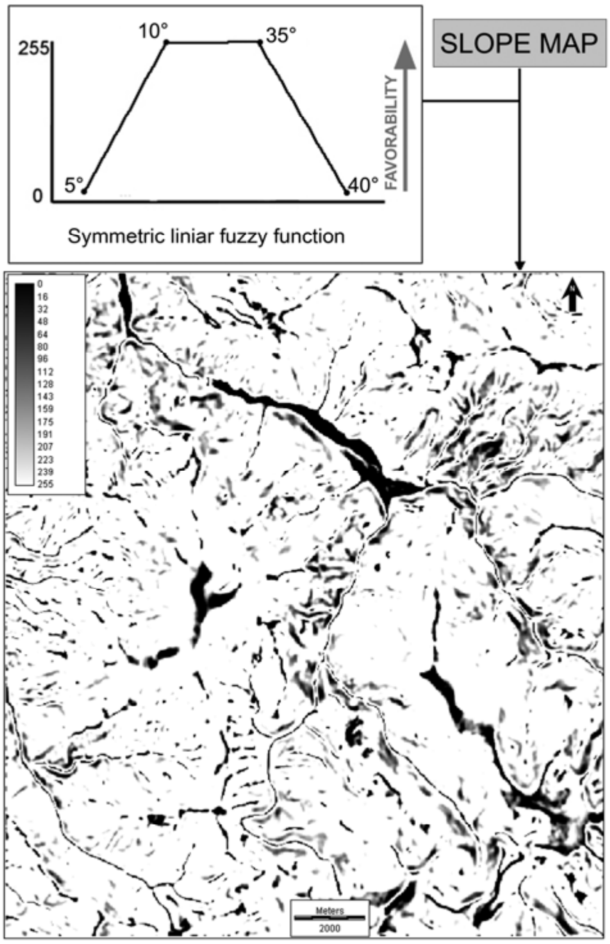

Fig. 3. The standardization of the slopes by using a symmetric linear fuzzy function.

The sun radiation controls the snow surface temperature more than the air temperature (Tremper, 2001). Also the aspect plays a very important role in the snow instability (McClung and Schaerer, 1993) and determines the snow avalanches in this context. We consider that northern slopes (N, NW and NE) are the most suitable because the north faces keep the snow cover compacter and for a longer period than the other faces. The standardization of the aspect has been made by using a symmetric sigmoidal fuzzy function.

The snow is an economic resource for winter tourism activities (Beniston, 1997; Beniston et al., 2003; Breiling, Charamza, 1999). Its minimum thickness that allows smooth ski practices must be at least 30 centimeters (Agrawala, 2007; Besancenot, 1990; Becken, Hay, 2007; Freitas, 2005; Hall Higham, 2005). In order to build the model of the average duration of days with snow layer, there were used the DTM and the values of average duration of days with snow layer recorded at the weather stations within the area, i.e. Caransebeş, Cuntu and Ţarcu. The linear regression was calculated between the average duration of days with snow layer and the altitude of the meteorological stations:

$$\text{No. days with snow} = 48{,}120 + (0.006251 * \text{Altitude}) \quad [1]$$

The value of the correlation coefficient, i.e. 0.998, demonstrates the close relationship between the two parameters and allows the use of this equation to construct the digital model of the average duration of days with snow layer. With the help of map algebra, and using the equation [1], in which the DTM was introduced as the altitudinal variable, we obtained the digital model of the average duration of the snow layer for the study area (Fig. 4). For skiing activities are necessary at least 120 days with snow cover so we standardized this factor using an increasing sigmoidal fuzzy function with two control points, 100 days for 0 values and 150 days for 255 values.

The vegetation type is important in order to establish weather deforestations are necessary for future developments and because the vegetation is an important geomorphologic factor that can enhance or diminish the erosion processes affecting slopes when snow is missing. Landsat ETM satellite images were used for vegetation mapping.

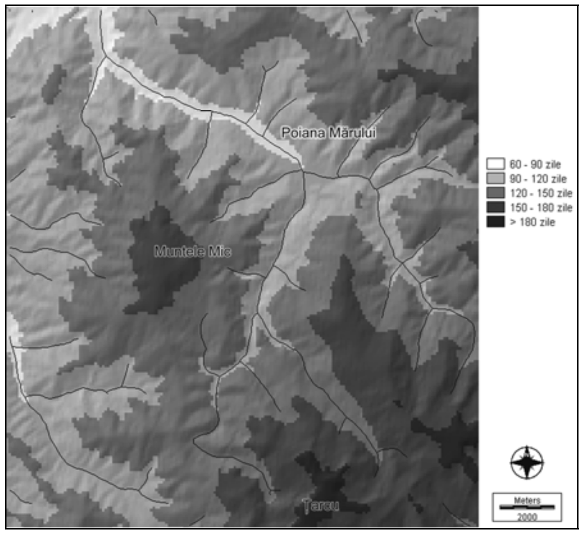

Fig. 4. Muntele Mic - Poiana Mărului - Țarcu ski areas - the multi-annual average duration of the snow layer

As in the mountain areas with rugged terrain, such as Ţarcu Mountains, the topographic effect is particularly severe and leads to the distortion of values of the reflectance issued by the same type of vegetation, the next step was to eliminate this effect. Because of the efficient outcome we used the modelling of the effect of illumination method based on the digital terrain model (Eastman, 2007).

The map of the present land cover was obtained from the corrected bands by the supervised classification of the satellite images, using the maximum likelihood classification (Idrisi Andes software). The map includes the following categories: rocky, alpine and mountain meadows, water (glacial and dam lakes), coniferous forests, deciduous forests and settlements. The areas covered by the alpine and mountain pastures were considered optimal for the development of the future ski infrastructure because they no longer require deforestation works (maximum favourability, value 255). The lakes, the settlements and the rocky steep slopes were considered "barriers" for the development of the ski domain (minimum favourability, value 0).

The risk of snow avalanches is an essential element that must be taken into account in planning new tracks because, if neglected, it could endanger the lives of the tourists and can cause serious damages. The skiing practices are an important factor influencing snow stability in the mountain areas (van Herwijnen and Jamieson 2007; Quinn and Phillips 2000) and, at the same time, they trigger snow avalanches (Grimsdóttir and McClung, 2006; Schweizer and Camponovo, 2001; Schweizer and Lütschg, 2001). That is why the snow avalanche map is very important to the development of zoning criteria: „*do not prevent avalanches; they reduce the probability of damage*" (Höller, 2007, pp. 96).

Identifying no risk, low risk, medium risk and high risk areas was possible by using the overlay technique and by combining the following factors: altitude, slope, aspect, presence/absence of the forest and the average snow layer thickness (Butler, 1979; Butler, Stephen, 1990; Stethem *et al.*, 2003). Only the areas with no risk or low risk of snow avalanches were considered favourable for skiing. Thus, it appears that the most exposed areas are typical for the Ţarcu Mountains, where the high relief, the slope and the snow layer favour the starting of snow avalanches. In the Muntele Mic - Poiana Mărului ski areas, these processes are not characteristic, the skiing resort activities taking place in good conditions (Fig. 5).

The anthropogenic factor taken into account was the distance from the communication routes (Fig. 6). In this respect, there was drawn up a map of distances (in meters) from the following communication routes: modernised roads, forest roads and cable transport infrastructure (Fig. 6).

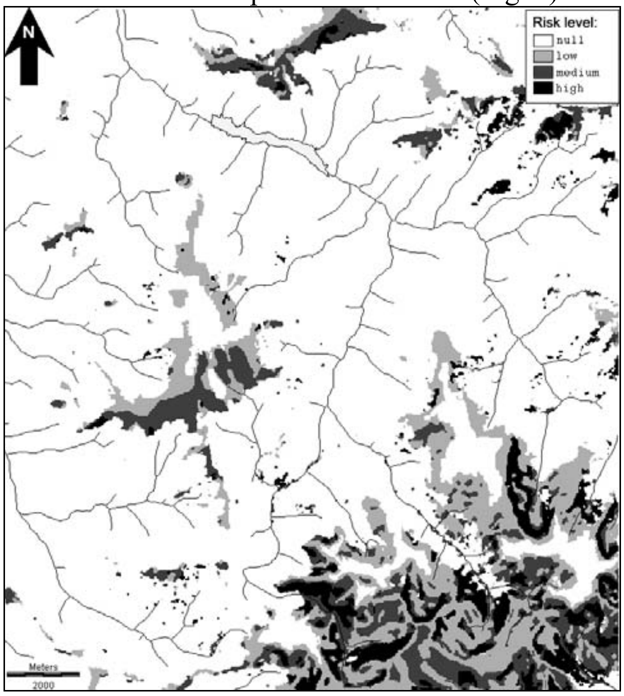

Fig. 5. Muntele Mic - Poiana Mărului – Ţarcu ski areas - snow avalanche risk map

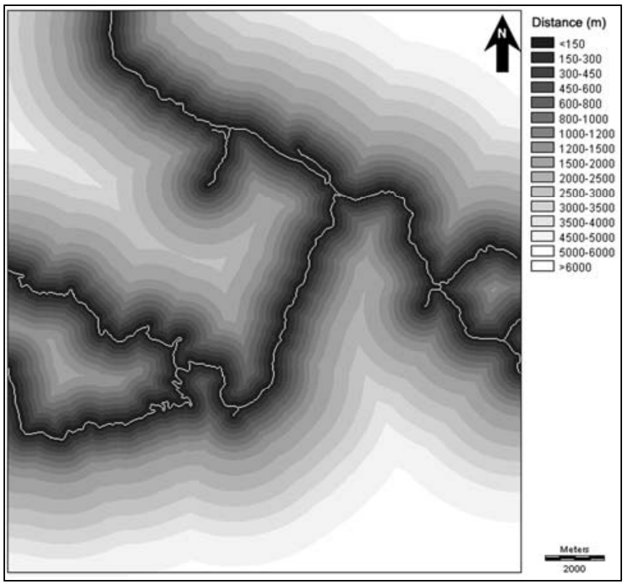

Fig.6. Muntele Mic - Poiana Mărului – Ţarcu ski areas – distance from roads.

The combining of all standardized factors by using the Weight of Evidence method (Idrisi Andes software) allowed us to obtain a model which presents the favorability for developing new ski tracks (Fig. 7). The values vary continuously in space, from a very high favorability, (value 204) to a very low favorability (value 0) depending on the combination mode in a certain area of the considered factors and their weight. We considered as optimal areas only the areas with values above 140.

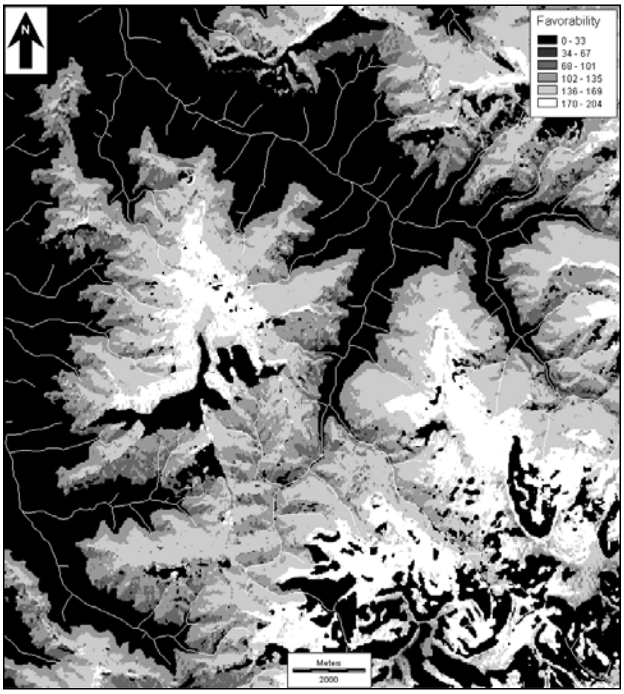

Fig.7. The favourability for the developing of the new ski tracks in Muntele Mic - Poiana Mărului – Ţarcu.

Among them, the areas within a distance of less than 1000 meters from the roads and greater than 15 ha were selected as the best ones, thus being identified the five best areas located on the slopes of Nedeia Ridge and on the secondary ridges, which are detached to the north side of Muntele Mic (Fig. 8). For each area there were calculated the main morphometrical parameters: the length, the maximum, minimum and average altitude, the altitudinal difference, the maximum, minimum and average slope and the average number of days with snow layer (Table 1).

CONCLUSION

Following the spatial analysis, there is to be noticed that the best areas to expand the ski domain are the detached secondary peaks of Muntele Mic towards north and the northern slopes of the Nedeia ridge. Their length and the elevation differences, together with the long duration of the snow layer, could allow for the development of certain ski tracks at least the same size as the ones of Prahova Valley, totalling 11,700 meters.

All the five areas are located in the proximity of the roads along the main valleys. There is to be mentioned that we take into account only the most suitable declivity values for skiing so, in reality, the tracks could be even longer, going down to a slope less inclined and arriving near the roads.

The extending of the ski tracks and the cable transport infrastructure in these areas would allow for a greater connection between the mountain resorts Muntele Mic and Poiana Mărului, leading to an important increase of the tourist potential of the region.

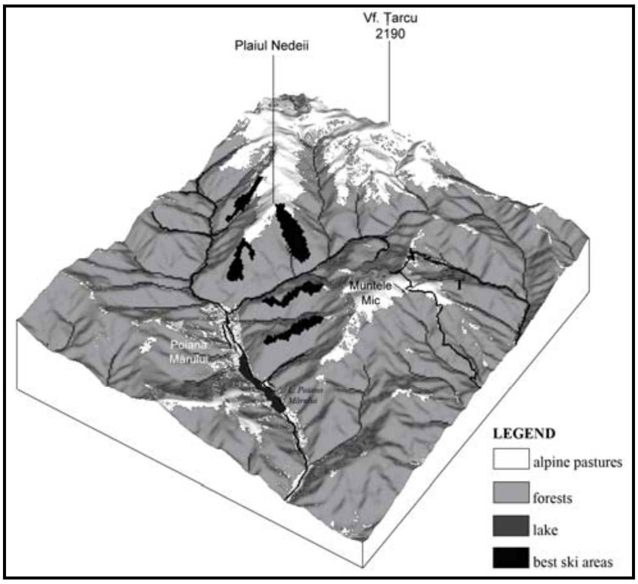

Fig. 8. Optimal areas for the planning of new ski tracks (3D representation) in the Muntele Mic - Poiana Mărului - Ţarcu area

The method used in this study allows the complex analysis of the ski potential of the mountains regions through the integration of diverse data from different sources (DTMs, satellite images, topographic maps, climate data etc.), taking into account both the physical and anthropogenic factors. The spatial analysis is, thus, an extremely useful tool to support decision making based on multiple criteria. The method can be adapted to the specific of the study area and can be improved by including additional factors into the analysis.

Table 1. Morphometrical data and average duration of the snow layer for the new ski tracks

Optimum area	Lenght (meters)	Altitude (meters)			Slope (º)			The average duration of the snow layer (days)
		Max.	Min.	Average	Max.	Min.	Average	
1	1682	1536	982	1226.8	10.7	32.9	20.2	129
2	2550	1427	1004	1238.7	9.3	34.7	21.9	130
3	2507	1337	1034	1189.4	10	32.1	21.2	127
4	2408	1779	1112	1414.7	10.9	26.8	19.9	141
5	2553	993	1754	1324.6	5.3	32.1	23.1	136

The method used in this study allows the complex analysis of the ski potential of the mountains regions through the integration of diverse data from different sources (DTMs, satellite images, topographic maps, climate data etc.), taking into account both the physical and anthropogenic factors. The spatial analysis is, thus, an extremely useful tool to support decision making based on multiple criteria. The method can be adapted to the specific of the study area and can be improved by including additional factors into the analysis.

ACKNOWLEDGEMENTS

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SOCIAL VULNERABILITY AND RISKS ASSOCIATED TO THE BALKAN ENDEMIC NEPHROPATHY IN MEHEDINŢI COUNTY

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Abstract

The Balkan Endemic Nephropathy (BEN), commonly known as "the dry kidney disease", was observed for the first time in 1957 in Ergheviţa village from Mehedinţi County. Although, the phenomenon was mainly studied by doctors for a period of approximately 50 years, the number of cases increased, but the actual cause of the disease was not discovered yet.
Among the mainly incriminated elements, there is to be mentioned the underground water that crosses through the coal deposit located in the Huşnicioara mines.
It is important to notice the fact that this disease affects only the rural space, most of the effective areas of the disease being concentrated around the urban centres like Drobeta Turnu-Severin, Baia de Aramă, Strehaia and Vânju Mare. The respective rural communities are considered to be truly vulnerable to the poor quality of underground waters. Given the fact that new cases of nephropathy are continuously discovered, one of the hypothesis is that the risk induced by the pollution of underground water layers is significant and that the human communities are highly vulnerable to this element.
The present study identifies the actual status regarding the symptoms and the extension of the disease, as well as the economical-social circumstances that favour the occurrence of the cases, representing a strong signal concerning the human communities vulnerable to the pollution of a natural resource that is indispensable to human life – water.

Keywords: *Balkan Endemic Nephropathy, social vulnerability, coal deposits, quality of underground water layers, rural communities, social isolation*

Rezumat

Vulnerabilitatea socială şi riscurile asociate Nefropatiei Endemice Balcanice în judeţul Mehedinţi. Nefropatia Endemică Balcanică (NEB) denumită popular şi „boala rinichilor uscaţi" a fost semnalată pentru prima dată în 1957 în satul mehedinţean Ergheviţa. Cu toate că fenomenul a fost studiat, în principal de medici, pe o perioadă de aproximativ 50 de ani, în acest interval numărul de cazuri de îmbolnăvire a crescut, iar cauza reală a apariţiei bolii nu a fost încă descoperită.
Principala sursă de îmbolnăvire este considerată a fi apa provenită din pânza freatică ce trece prin zăcământul de cărbune al minelor de la Huşnicioara.
De remarcat este faptul că această boală nu afectează decât mediul rural, majoritatea focarelor fiind grupate în jurul centrelor urbane precum Drobeta Turnu-Severin, Baia de Aramă, Strehaia şi Vânju Mare. Comunităţile rurale respective sunt considerate a fi cu adevărat vulnerabile la proasta calitate a apelor subterane. Având în vedere că noi cazuri de nefropatie sunt descoperite în continuare, se apreciază că riscul indus de poluarea apelor subterane este unul semnificativ, iar comunităţile umane prezintă vulnerabilitate ridicată la acest element.
În lucrarea de faţă se identifică stadiul actual al manifestării şi răspândirii maladiei, precum şi circumstanţele economico-sociale ce favorizează apariţia cazurilor de îmbolnăvire, constituind un puternic semnal de alarmă referitor la comunităţile umane vulnerabile la poluarea unei resurse naturale indispensabile vieţii – apa.

Cuvinte-cheie: *Nefropatie Endemică Balcanică, vulnerabilitate socială, depozite de cărbune, calitatea apelor subterane, comunităţi rurale, izolare socială*

INTRODUCTION

The Balkan Endemic Nephropathy was scientifically identified at the national level by Foarţă and Negoescu in 1957. Subsequently, hoping to discover the triggering causes, the researches concerning this endemic disease have enclosed a wide range of studies.

The epidemiological studies are the oldest ones and include the following aspects in the area: generating factors and diagnosis (Gluhovschi Ghe. et al., 2002), the causes and the nature of the disease (Lăzărescu R., 1966), the variation of the serial complement, as identification factor for BEN (Mustaţă N. et al., 1968), the etiological problems of BEN (Tatu C.A. et al., 1998), the epidemiology of BEN (Ceovic S. et al., 1992), the influence of the Ochratoxin A in corn and wheat on the occurrence of BEN (Puntaric D. et al., 2001) and the etiology of urothelial tumors (Ivic M., 1970).

The pathological studies are conducted at the national and international level and regard the following aspects: causes and symptoms of the diseases, the viral particularities of the disease

(Georgescu L. et al., 1970), the symptoms and the evolution of the disease (Gluhovschi Ghe., 1973), renal dysfunctions in families with cases of BEN (Arsenovic A. et al., 2005), the urothelial carcinoma associated with the etiology of BEN (Stefanovic V. et al., 2006) and the nephropatic study of the disease (Marc E De Broe, 2003).

The cytogenetic studies concerning BEN preoccupied more the medical specialists and included: the family as a factor in BEN (Zaharia C., 1968), chromosomes transformations in chronic cases of BEN (Tonea T.R. et al., 1967), chromosomes transformations at patients with BEN (Bruckner I. et al., 1971), biochemical transformations in cases of BEN (Gluhovschi Ghe., Sabo I., 1981), the mother-fetus risks for female patients with BEN (Gluhovschi Ghe. et al., 1966), the cytogenetic aspect of the disease (Toncheva D. et al., 1988) and the clinical aspects of the adults within families with cases of BEN (Dimitrov P. et al., 2006).

The geological and hydrogeological researches are recent as a preoccupation in cases of BEN and enclose various aspects, such as: the influence of the altered coal deposits upon the occurrence of BEN (Feder G. L. et al., 2002), the relation between the coal deposits and the etiology of BEN (Feder G. L., 1991), the vegetal associations which generated the Neogene coal (Ţicleanu N., 1984), correlations between the environment, geochemistry and etiolgy of BEN (Orem W.H. et al., 2002), the role of the fluorescent organic compounds in shallow ground water in BEN (Goldberg M.C. et al., 1994); the lecithin cholesterol acyltransferase enzyme and organic substances from coal in the areas with BEN (Orem W.H. et al., 2004), the contamination of the potable water that washes the Pliocene coal deposits (Voice T. C. et al., 2006) and the nephropathy, the role of the organic compounds derived from the Pliocene lignite and the etiology of BEN (Tatu C.A. et al., 2000).

Regarding the etiological factors, BEN is a chronic affection that develops in a latent stage, is hereditary and occurs predominantly in the rural space. Gh. Gluhovschi paid a special attention to the genetic, factors reporting, from the total number of patients under observations, a share of 25.7 percent of the cases when two or more members of the family developed the disease (Gluhovschi Ghe., 1973).

The geological studies regard the correlation between the presence of the Pliocene lignite layers and the geographical occurrence of the disease.

At the level of Mehedinţi County, most of the settlements that registered cases of BEN are located along the piedmont valleys and in the plains with altitudes lower than 250 meters (the area extended among Drobeta Turnu-Severin, Corcova, Strehaia, Bălăciţa and Batoţi settlements) (Fig. 1). Their geology is characterized by the presence of the old tertiary layers (clay, sand and Pliocene lignite) covered by Quaternary sediments (gravels, sands, clays and loess deposits).

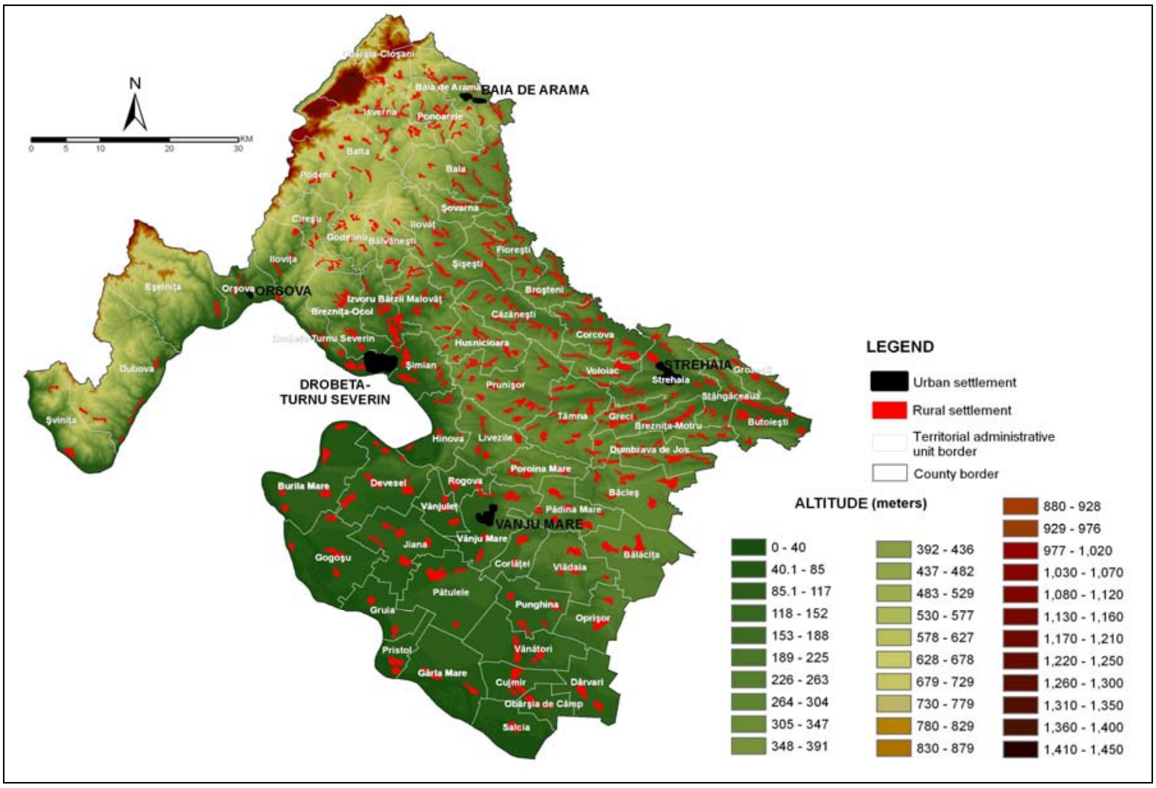

Fig. 1 The hypsometry of Mehedinţi County

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The occurrence of the paleo-species of *Nyssa-Taxodium*, *Myricaceae-Cyrillaceae* and *Sequoia* among which the most disseminated during the Tertiary was *Glyptostrobus europeus,* could have contributed to the enrichment of the organic compound specific to the Pliocene lignite within the endemic villages (Ţicleanu N., 1984).

The geology of the endemic regions helps to explain the high concentrations of aromatic compounds found in the lignite deposits located close to the surface (Fig. 2).

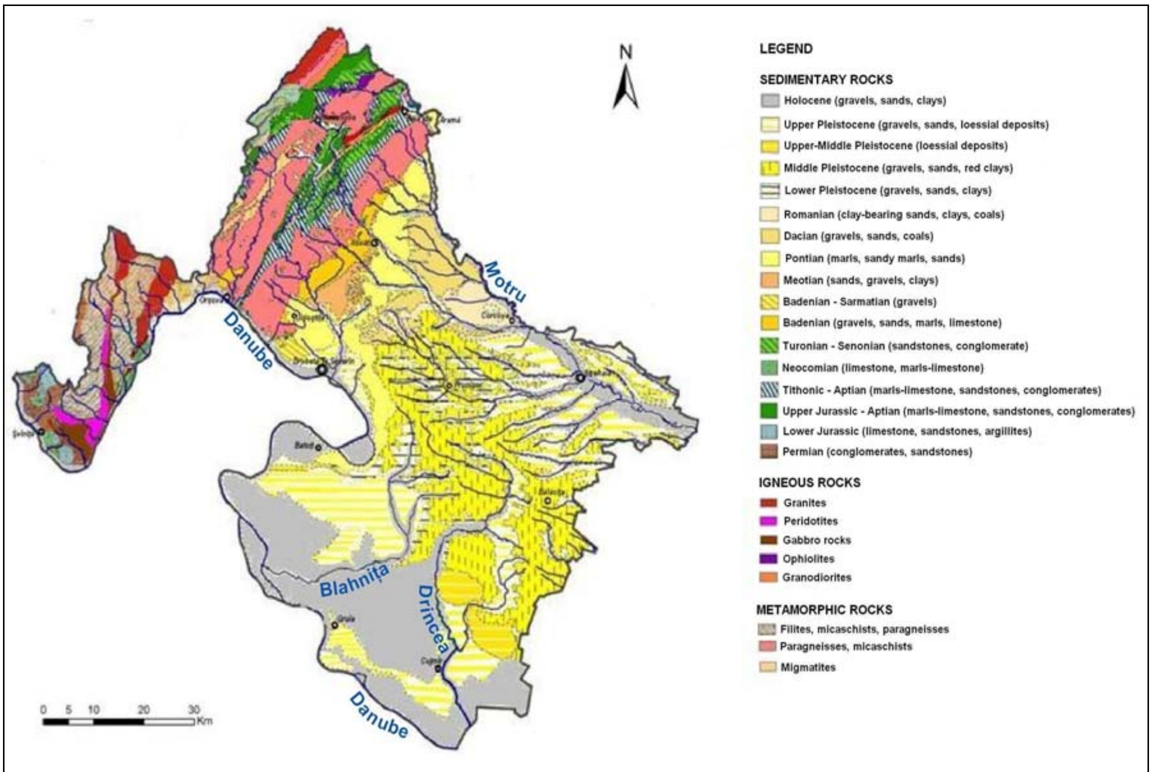

Fig. 2 The geology of Mehedinţi County

The Pliocene lignite deposits within the perimeter enclosed by the Motru, the Coşuştea, the Huşniţa and the Drincea rivers have been economically exploited in the mines from Pietriş, Huşnicioara Livezile, which are located immediately near the endemic settlements (Pietriş, Ergheviţa, Bistriţa, Livezile, Hinova, Tâmna, Prunişor and Huşnicioara).

Comparative studies regarding the geology and the hydrology of the endemic and non-endemic villages in Mehedinţi County had been performed by Feder G. L. and Orem W. H. in 2002. Thus, in 2002, Feder G. L. et al. tried to explain the endemic character of the Balkan nephropathy (the geographical restriction) in the studies concerning the "geochemical composition of the Pliocene lignite (pelicular organic composition) associated with the distribution areas of BEN and the hydrogeological environment from the affected spaces (rich in phenols and other aromatic structures which are initially derived from the lignite)". In one research conducted in 1991, the same authors support the hypothesis that "by washing the Pliocene lignite deposits and those of clayey lignite there result soluble organic compounds that are transported by the system of deep underground water layers supplying the underground water table from the wells people are using".

The existence of endemic and non-endemic villages located at only a few kilometres distance one from another may be the result of the variations in the concentration of toxic organic compounds within the wells (the underground water layer is maximum 15 meters deep). Thus, "the relative small concentrations of toxic organic compounds discovered in the potable water from the endemic villages can explain the occurrence of BEN pursuant a long period of exposure" (10 - 30 years or even longer) (Feder G. L. et al., 2002).

DATA AND METHODS

The natural environment of Mehedinţi County was analysed starting from the by hypsometric map (based on the digital terrain model SRTM at 30 meters), the geological map (the geological sheets scale 1:200,000 were georeferenced and processed) the hydrographical and demographic elements, which were put in connection with the areas of disease occurrence.

The demographic analysis at the level of the communes where cases of BEN were registered relies on processing, integration and interpretation methods applied to the statistical data from 2002 and 2009. This information regards the number of patients and doctors; the population on gender and age structure of the population groups; BEN outpatients under dialysis, gender and age structure of the population etc.

In estimating the population vulnerability in relation with BEN (Fig. 3), the first element is the physical exposure (facilities – medical cabinets, water supply, free transportation for dialysis) and the social one (the structure of the population on age groups and the social conditions), a fact which is going to be proved in the section of results. The third category, the economic exposure, is less evident for the analysed communes (economic activities – industrial platforms and dangerous industrial activities).

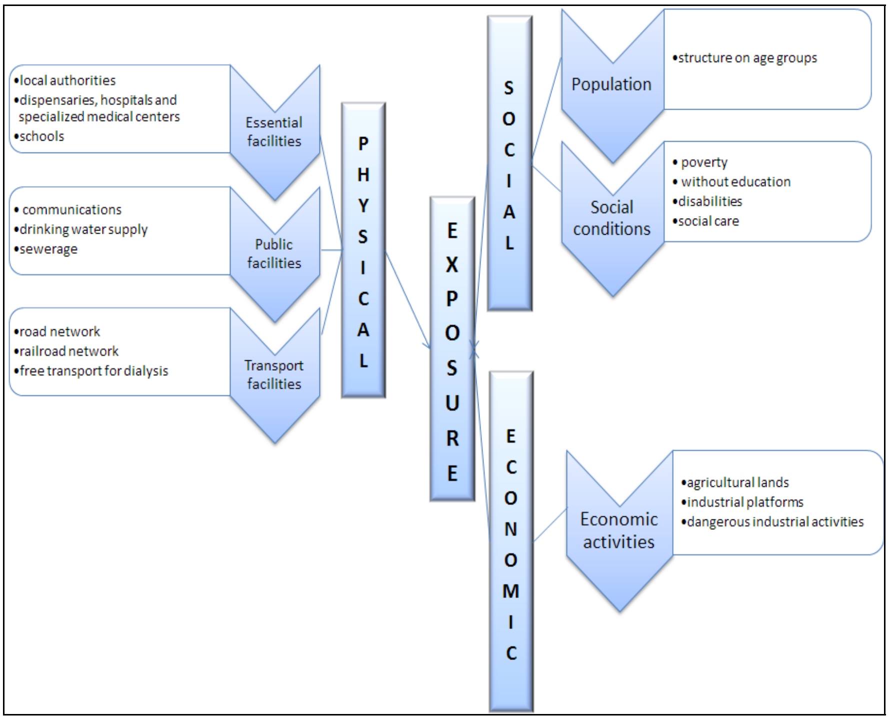

Fig. 3 Important elements in assessing the vulnerability in relation with BEN related vulnerability

In addition, a social survey was conducted during the field investigation in Rogova village (Rogova commune), Bistriţa village (Hinova commune) and Prunişor village (Prunişor commune) for a better emphasis of the demographic and social problems regarding the disease.

The analysis of the questionnaire applied and the 29 items that were used offered significant information concerning the subjects' opinions and the behaviours regarding BEN, but they pointed out especially the social needs to which the local authorities have to answer in order to reduce the population vulnerability to this disease.

RESULTS AND DISCUSSIONS

In order to clearly understand the demographic and social context in which the officially registered BEN cases appeared and evolved, the number of these instances is analyzed in relation with the population (total population, on age groups and sexes) and the number of doctors to which the total number of population is reported in each of the 22 territorial-administrative units taken into consideration.

The analysis considered the dynamics of these elements during the period 2002 – 2009.

The comparative analysis of the patients number and the communes affected by the Balkan Endemic Nephropathy in Mehedinţi County (Fig. 4 and Fig. 5) evidences a first significant aspect: while the reduction in the number of population and doctors is observed in the quasi-totality of the cases (one of the most notable exceptions being represented by Drobeta Turnu-Severin city, where the tendencies concerning the two elements are contradictory, the population increasing in number), the number of BEN patients under dialysis is rising continuously, reaching from 32 patients in 2002 to 4 patients in 2009. The greatest number of communes under

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analysis have a population between 2,000 and 4,500 inhabitants (10 TAUs in 2002 and 2009), to the opposite pole being the urban centres or the communes in their immediate area (Drobeta Turnu-Severin – 107,248 inhabitants in 2009, Strehaia – 11,726 inhabitants, Şimian – 9,998 inhabitants), with the highest values, and the communes from the central-southern part of the county, with the lowest values (Poroina Mare – 1,246 inhabitants in 2009, Rogova – 1,440 inhabitants, Corlăţel – 1,446 inhabitants etc.).

Generally, the number of the medical personnel follows the demographic share, but there are some notable exceptions.

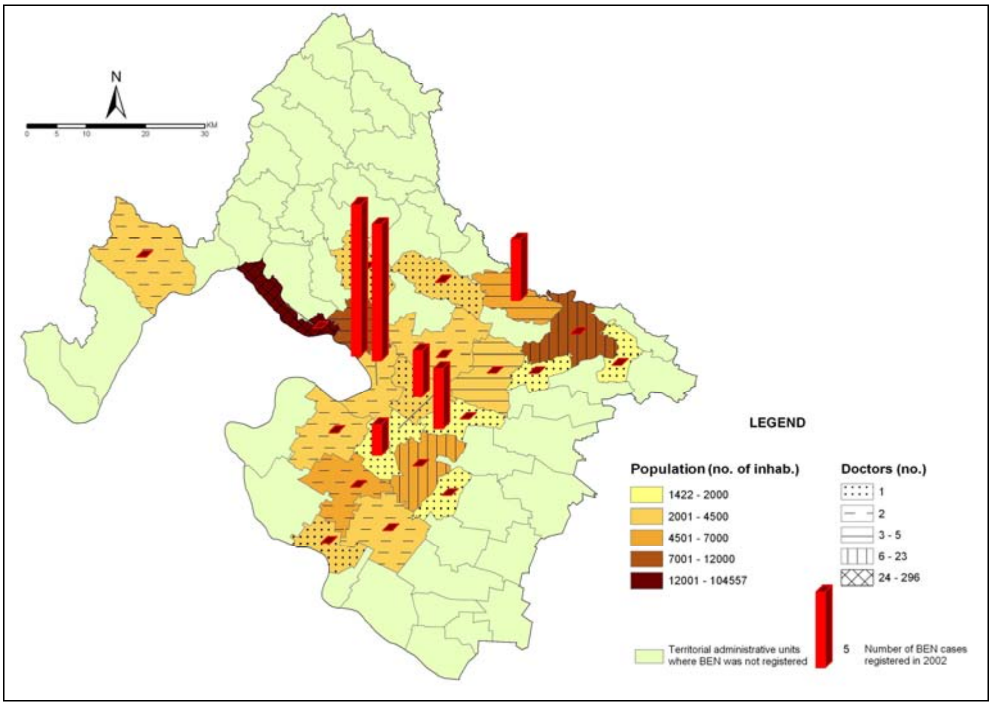

Fig. 4 The number of patients and doctors in the communes affected by the Balkan Endemic Nephropathy in Mehedinţi County (2002)

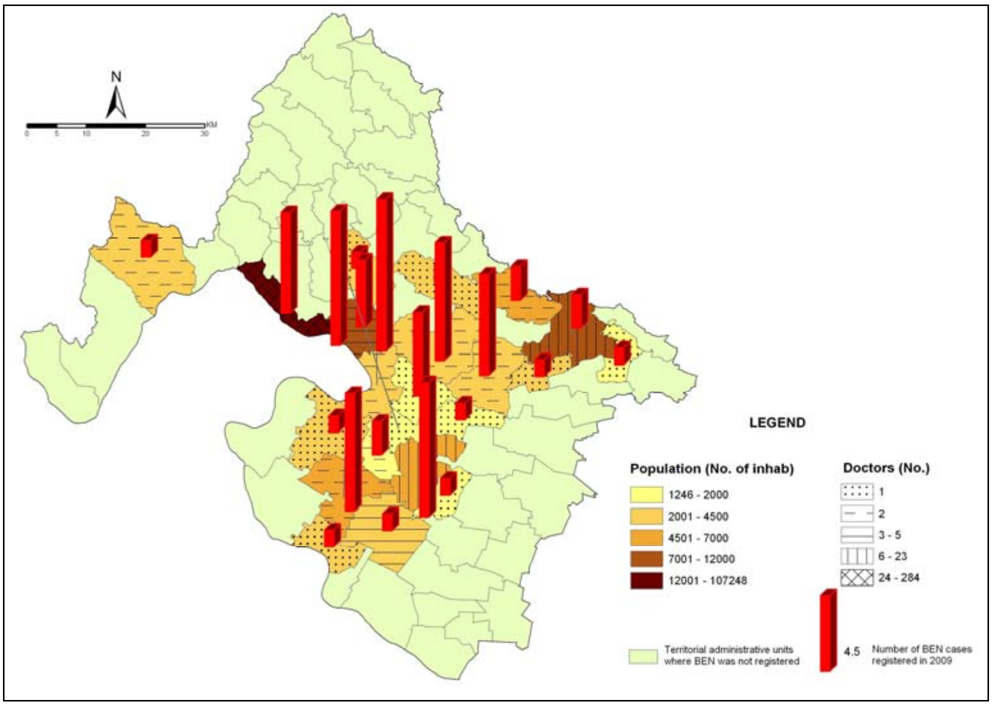

Fig. 5 The number of patients and doctors in the communes affected by the Balkan Endemic Nephropathy in Mehedinţi County (2009)

Thus, the Şimian commune, with a numerous population, benefits from the services of only 4 doctors. In the same time, territorial-administrative units with a similar demographic potential are strongly differentiated concerning the aspect of the medical personnel (for example, Vânju Mare – 6,406 inhabitants and 14 doctors in 2009 and Corcova commune – 6,084 inhabitants and 2 doctors, in the same year). It is notable the fact that the medical personnel is under-numbered in relation to the number of inhabitants, 10 of the 22 analysed communes benefiting from the services of only one doctor. On the other hand, the number of cases of BEN does not overlay, as localization, with the most populated communes. For example, certain nuclei where this disease was discovered are territorial-administrative units with a moderate number of inhabitants (Hinova – 9 persons under dialysis in 2009, reported to a total population of 2,824, Rogova – 8/1440, Jiana – 7/7486, Prunişor – 6/2213, etc.).

The comparative analysis at the level of the two years, 2002 and 2009, outlines the fact that beside the nuclei of occurrence existing in 2002 and maintained in 2009 (Hinova, Rogova, Livezile, Şimian, Corcova, Vânjuleţ), during this last year also other centres of BEN occurrence appeared (Vânju Mare, Jiana, Prunişor, Tâmna, Drobeta Turnu-Severin etc.).

The analysis of ***the gender structure of the population*** residing in the communes where BEN cases were registered in 2009 reveals the fact that the share of men and women is balanced, their number being almost equal in 85.72 percent of the 21 territorial administrative units. The exceptions are represented by Tâmna commune (with a high share of Roma), where the male gender accounts for 51 percent, while in the communes of Poroina Mare and Rogova the women are more numerous (Fig. 6).

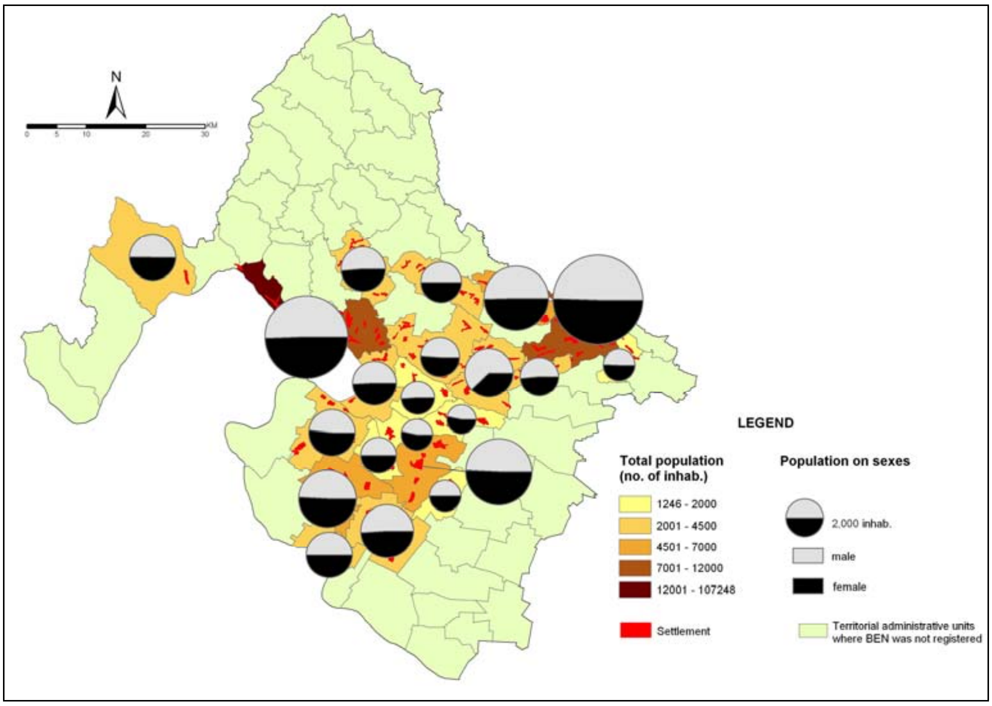

Fig. 6 Gender structure of the population residing in the communes affected by BEN within Mehedinţi County (2009)

In 2009, the gender repartition of the population affected by BEN showed that the disease is mostly encountered among women (55.40 percent of the total registered cases). Thus, in Rogova (87.50 percent), Jiana (57.14 percent), Tâmna (71.42 percent), Prunişor (66.60 percent) and Livezile communes, the women over 50 years of age are affected by the disease in the above-mentioned proportions. Nevertheless, there are some territorial administrative units where the part of the persons under dialysis because of BEN is higher among the male population: Drobeta Turnu-Severin, Vânju Mare and Hinova (Fig. 7). The part of one gender or of the other can be of 100 percent within the communes that account for a low number of BEN occurrences (under three). Such examples are offered by Eşelniţa, Strehaia, Devesel, Gruia and Pătulele, where only male persons are registered with BEN and are currently under palliative treatment, while in the communes of Malovăţ, Căzăneşti, Corcova, Stângăceaua, Greci, Poroina Mare and Corlăţel, 100 percent of the persons diagnosed with BEN are women. All cases of “dry kidneys” registered at the

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level of these communes, except for Corcova, were discovered after 2000. In that specific year, only four persons living in Corcova were under dialysis as a consequence of BEN, while in 2009 all mentioned communes accounted for at least one person diagnosed with this disease and following the treatment. Although from the statistical point of view, most of the BEN occurrences are officially registered among women, this aspect can be explained by the fact they are much more sensitive to the medical advices concerning the performance of detailed investigations that could establish the correct diagnostic and they are more willing to follow a treatment. Further analysis was conducted taking into account ***the age structure of the BEN outpatients under dialysis*** and it revealed that the greatest frequency of these cases is registered among the aged population between 60 and 80 years or beyond this age. Nevertheless, in 2010, in four of the communes affected by the occurrence of this disease (Gruia, Pătulele, Corlăţel and Eşelniţa – one case in each commune), the age of the outpatients is comprised between 30 and 40 years (Fig. 8).

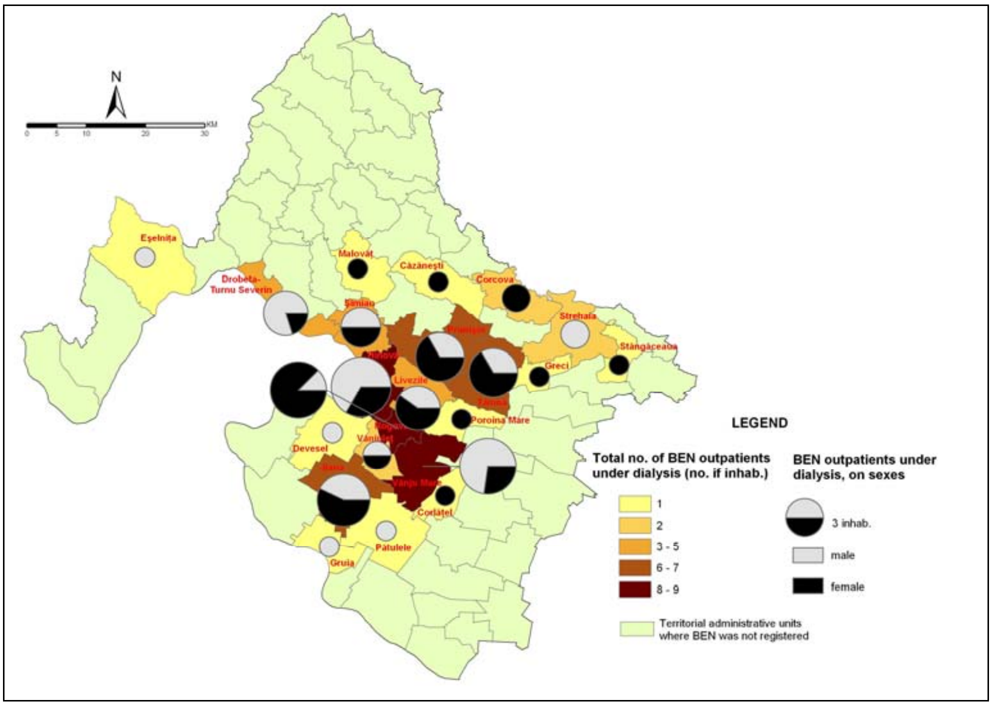

Fig. 7 Gender structure of the BEN outpatients under dialysis living in the affected communes, Mehedinţi County (2009)

The administrative units with the most numerous BEN official occurrence cases are: Hinova, with 9 instances of which 6 are registered in the village of Bistriţa and 3 in that of Hinova; Rogova, with 8 instances of which 7 in the homonym village and one in Poroiniţa, and Vânju Mare town, with 8 instances of which 3 in the urban core and the rest in the villages of Oreviţa Mare (4 cases) and Traian (1 case). The age of the persons affected by this disease and undergoing dialysis three times per week is comprised between 50 and 60 years in Hinova and Vânju Mare, the lower age limit descending to 40 years at the level of Rogova commune (Fig. 9). Regarding the situation of the occurrences in Vânju Mare and Rogova, it changed significantly since 2000, when no BEN case was registered in Vânju Mare, until 2009, when 8 cases were identified, while Rogova faced a duplication of the BEN occurrences during the above mentioned interval (4 outpatients in 2000 and 8 in 2009). The same dramatic change concerning the BEN registered cases is obvious at the level of Jiana, Prunişor, Tâmna rural administrative units and in Drobeta Turnu-Severin urban centre, where no person was officially diagnosed with BEN in 2000, while in 2009 the number of registered occurrences ranged between 5 and 7. This statistical change can be explained through the campaigns conducted by a medical and researching team that offered free analyses and consultations in all settlements located within the area of manifestation of the disease. Moreover, during the same campaign conducted in 2008 and 2009, there were taken samples of water that were subsequently analysed with the hope of tracing the causes of the illness. According to the 2009 statistical data, the three administrative units mentioned above concentrate most of the BEN occurrence cases, representing the maximum intensity core of the disease. Around these settlements, there are located Jiana, Prunişor and Tâmna communes, which account for 6 – 7 cases of BEN outpatients under treatment. Thus, there is to be noticed a decrease in the number of officially registered cases of BEN at the level of the stabile population as the distances from the core augment, 47.61 percent of the affected communes accounting for only one outpatient.

On the other hand, these are only the officially registered cases of BEN outpatients under palliative treatment, the real number of the persons with illness suspicions being much greater.

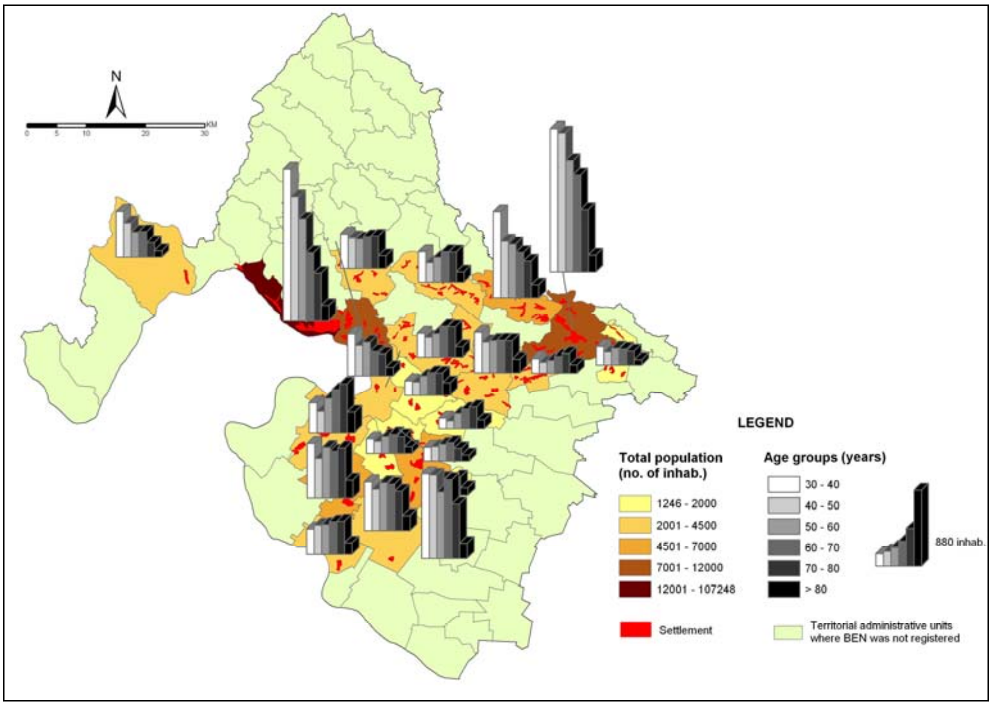

Fig. 8 Age structure of the population residing in the communes affected by BEN within Mehedinţi County (2009)

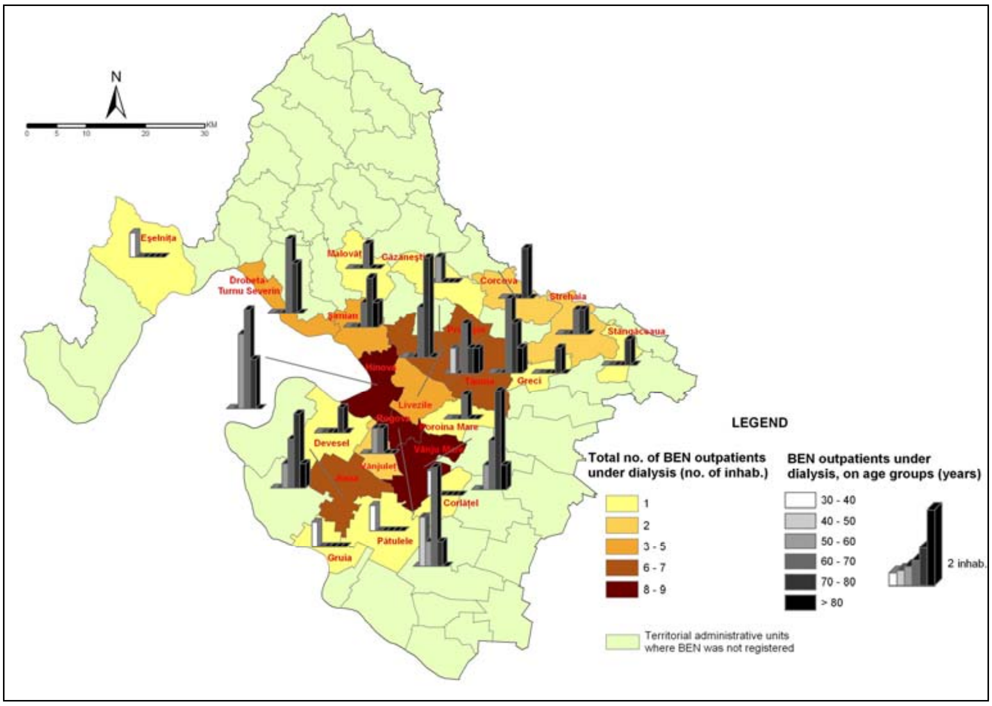

Fig. 9 Age structure of the BEN outpatients under dialysis living in the affected communes, Mehedinţi County (2009)

The above-mentioned conclusion also raises from the correlation of the statistical data analyses with ***the perception of the population on the Balkan Endemic Nephropathy***, which has been determined by means of a social survey.

The present research is based on the premise that within a region characterised by a significant number of BEN occurrences and in which the detailed information concerning the effects of fountain water consumption are not enough, the vulnerability of the population represents a very significant component of the general medical risk and especially of the risk related to the kidney diseases; thus, the detailed informing and the measures taken to reduce these particular risks are of great importance.

The study concerning the perception of the Balkan Endemic Nephropathy in the communes within Mehedinţi County was based on a questionnaire with 29 items; these elements tried to reveal the rural, social-economic and demographic context of the subjects, the level and the quality of BEN-related information, the opinions on the relation between the non-drinkable water consumption and the alteration of the personal life, the assessment of the willingness to seek special medical help and of the support possibilities for tracing down the disease etc.

This kind of research has a relative character, which is due, on the one hand, to the number of items used in the survey and, on the other hand, to the frequently unsubstantial relation between the subjects' opinions and their effective behaviour. Nevertheless, the analysis of the *face to face* survey in the villages within Mehedinţi County can offer initial information that is useful for the improvement of the measures taken by the authorities to support the decrease of the population's vulnerability to BEN, subsequently leading to an earlier tracing of the disease and to the possibility of medical support for more persons.

The social survey was conducted during the August – October, 2009 period, the population sample being represented by 315 persons residing in three of the villages that account for the highest number of BEN outpatients under dialysis: Rogova (Rogova commune) – 120 persons, Bistriţa (Hinova commune) – 120 persons and Prunişor (Prunişor commune) – 75 persons. The study attempted to ensure a balanced population sample from the viewpoint of their gender (44.4 percent male and 55.6 percent female) and of their age (28.5 percent – under 30 years of age, 41.3 – between 30 and 55 years and 30.2 percent - over 55 years). Regarding the educative level, the balance is clearly inclined towards the persons who only followed the elementary school, which are followed by those who finished ten classes, the last place being occupied by the higher education graduates (teachers, doctors, retired persons) that only account for 2.9 percent.

The results of the survey revealed the fact that the population does not have clear information concerning BEN or the quality of water sources (53 percent of the interviewed persons do not know if there have been realised analyses of the water within the communal wells or what were the results of such analyses), the risk of the disease being, nevertheless, felt in the framework of the local tradition that the water is not good and the residents are destined to die from "uraemia". Despite this, even after the appearance of the drinking-water network, a considerable share of the questioned persons admitted that they continue to consume water from the wells (36.5 percent). The medical problems are sometimes worsened by the social isolation of the families in which BEN cases are registered. This type of segregation is sometimes translated into the interruption of the relations with the descendents of families that registered "uraemia" cases. 84.1 percent of the interviewed persons responded that they do not have relatives with BEN or with other kidney conditions. However, a significant part of them admitted that they know certain persons (sometimes members of the same family) who suffer of this disease. Most of the subjects of this social survey (79 percent) declared that they would not change the place of residence even in the framework of the possible danger represented by the water in wells. One explanation of this situation lies in the strong bonds with their environment and with a certain life style, in the lack of money for another residential area, other reasons being the age of the respondents or the hope in certain alternatives that would reduce the risk of becoming ill.

CONCLUSION

The evolution of the Balkan Endemic Nephropathy is slow and the illness arrives at its clinical manifestation through decompensate chronic kidney insufficiency. At the level of the 2000 - 2002 period, the age of the ill persons was comprised between 30 and 50 years. In accordance with the latest data from 2009, the outpatients have between 30 and 80 years and even beyond this age (the most numerous are comprised between 60 and 80 years, 55 persons respectively). The statistical division on genders reveals that the women are the most affected (44 women and 32 men were registered and undertook dialysis at the end of 2009), while the repartition on living environments shows that the most affected areas are the rural ones and outpatients living in urban centres also originate in the affected rural communities.

Although the transportation and the palliative treatment at the dialysis centres in Drobeta Turnu-Severin are free of charges, because of the advanced age and of the lack of education, numerous persons affected by this illness refuse to see a doctor or to follow the treatment that could extend their lives. As the statistical data shows, in 2010, 86.49 percent of the registered outpatients reside in rural areas and only 13.51 percent live in the urban environment. Moreover, it is worth mentioning the fact that, regardless the age of the ill persons, they come to see a doctor and start the dialysis only in the final stage of the disease. The present study confirms the idea that BEN is a *family disease* (there were reported numerous instances in which members of the same family were ill), but one of the enigmas that continues to the present refers to the fact that there are affected rural settlements in the neighbourhood of others that are not touched by "uraemia". One of the identified weaknesses consists in the fact that the population is not well informed with regard to the disease and to the importance of the quality of potable water. At the same time, certain prejudices and old mentalities, as well as a feeling of shame lead to the social isolation of the families with BEN occurrences and to the retardation or refusal of the analyses and treatment.

ACKNOWLEDGEMENTS

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RESPONSIBLE TOURISM AND TOURISM ECOLOGY

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Abstract

Many efforts have already been made and several ideas have been promoted to solve the problems in the development of socially and economically underprivileged, peripheral areas. Most of the proposals suggest supporting rural tourism and its management based on local natural, cultural, agrarian etc. traditions and help them this way to catch up with the more developed regions of the country. According to our surveys, it can be stated that sustainable and responsible rural tourism development is unbelievable without the application of ecological thinking. Consequently tourism ecology, as theory and practice, naturally helps developing the tourism of rural areas based on local natural, social, and cultural resources. Sustenance of tourism is a double task: we have to provide long-term reservation and guarantee that entrepreneurs' input of capital will return and their firm's will better their economic etc. state in the same time. Sustainable tourism has to be endurable and economically executable on long term, but at the same time, it has to be socially and ethically fair in relations to local people. Nevertheless, it is also an expectation that actors of the system, i.e. tourists must continue an active and responsibly sustainable practice (responsible sustainable tourism).

Keywords: *responsible sustainable tourism, tourism ecology, rural tourism*

Rezumat

Turismul responsabil şi turismul ecologic. Au fost făcute multiple eforturi şi vehiculate numeroase idei pentru rezolvarea problemelor legate de dezvoltarea zonelor periferice, defavorizate din punct de vedere social şi economic. Cele mai multe dintre propuneri sugerează susţinerea turismului rural şi a managementului său pe baza tradiţiilor locale naturale, culturale, agrare etc. asigurându-se în acest fel suportul necesar pentru atenuarea diferenţelor comparative cu regiunile mai dezvoltate ale ţării. Conform sondajelor, se poate afirma că dezvoltarea unui turism rural durabil şi responsabil este de neconceput fără o gândire ecologică. În consecinţă, ecologia turismului, ca teorie şi pratica, ajută în mod firesc la dezvoltarea turismului în zonele rurale pe baza resurselor naturale, sociale şi culturale. Durabilitatea turismului are o dublă sarcină: trebuie să dăm garanţii pe termen lung antreprenorilor că infuzia de capital va fi recuperată şi starea economică a companiei se va îmbunătăţii în acelaşi timp. Turismul durabil trebuie să fie economic viabil pe termen lung, dar, în acelaşi timp, trebuie să asigure relaţii corecte din punct de vedere social şi etic pentru populaţia locală. Oricum, se aşteaptă ca actorii acestui sistem, de exemplu turiştii să continue să se implice activ şi responsabil (turism durabil responsabil).

Cuvinte-cheie: *turism durabil responsabil, ecologia turismului, turism rural*

FROM NATURAL AREA TOURISM TO ECOTOURISM

Natural area tourism

Natural area tourism represents a very wide category of the alternative forms of tourism (the ones that in many aspects differ from mass tourism) (*Michalkó 2004, 2007; Puczkó–Rátz 2005*). Natural area tourism includes all those tourists who left home for the natural ambient/areas/environment. Ecotourism, ski running, sailing, fishing, nature photography, animal and plant observation, hiking, and climbing are all parts of nature area tourism. Natural area tourism is an idea wider than ecotourism, because it includes all the leisure activities taking place in nature, but at the same time it is smaller in the sense that it is not necessarily value oriented, it does not concentrate on cognition of cultural values, and environmental aspects may also be less emphasized during the activities. The relationship of the types of natural area tourism (adventure tourism, nature based tourism, wildlife observation tourism etc.) to sustainability is really important and of course its relation to nature differs from area to area (in the nature, connected to nature, for the nature) (Fig. 1).

Ecotourism

When understanding ecotourism, we have to consider four important aspects: small groups (and system of personal services), basement on natural values, sustainable control, and criterions of education and definition. The popularization of ecotourism is undeniably true as well (Fig. 2).

By the end of the20th century, it became obvious that the direction tourism had been heading for (and still is) would cause the destruction of those natural elements that form the basis of these tourist products. Negative effects deriving from motion, staying and different forms of leisure activities lead to pollution and quantitative decrease of natural resources, to the endangerment of the unmolested and diverse wildlife, and in many places to the destruction of natural landscapes. Finally, areas once loved so much by tourists will lose their appeal. Thus, more and more among the actors of one of the most dynamically developing economic sector recognize the seriousness of the situation. Researches are started with the intention of finding solutions that may provide the basis for the long-term sustainable development of tourism. And they do it primarily because of the growing pressure from the demanding side (*http://www.kvvm.hu*).

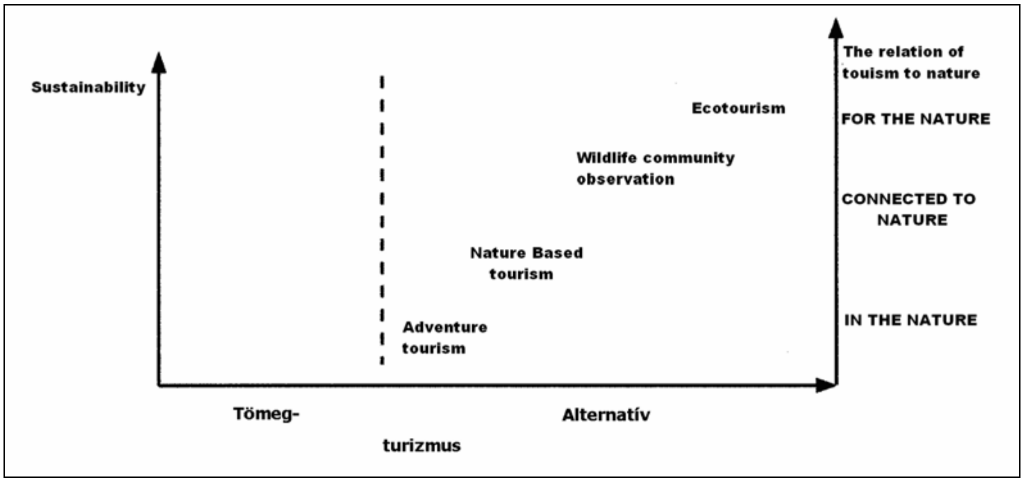

Fig. 1 The relation of Natural environment, alternative forms of tourism and sustainability, (Source: Newsome–Moore–Dowling 2002)

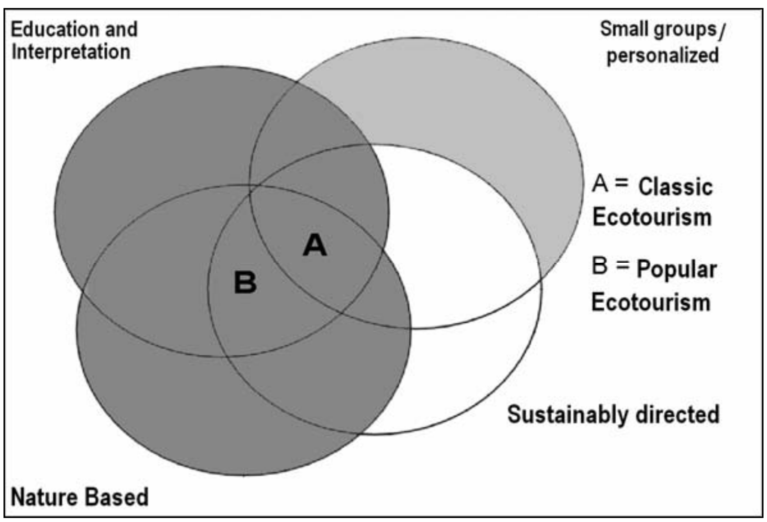

Fig. 2 Dimensions of ecotourism (Source: Weaver 2003)

There are surveys proving that for a huge part of tourists the undisturbed landscape, diversity in wildlife and clean, unpolluted environment have become the most important factors of attraction. As a result of this strengthening attitude of environmental responsibility, the number and rate of attendance of the world's natural parks and other protected natural areas is constantly increasing. It is a widely spread intention of the nature reservationists to make decision makers classify some of the countries areas with valuable wildlife and landscape as National Parks in order to maintain them for themselves and the coming generations. Growing interest and basic preservation functions if not well defended may lead to a significant conflict during maintenance and function. However, the creation of a kind of symbiosis is unavoidable because functioning of National Parks has an important role in laying down the basis for the social and economic changes that are necessary to attain attitudes of environmental responsibility. Apart from its impact on natural environment, we also have to consider the positive and negative effects it has regarding the population and community of the host territories. Development of tourism may contribute considerably to the economic development of a given area by creating workplaces etc. however a counter process occurs when its income is not reinvested into it. Mass appearance of tourists may disturb the everyday life of the local population; the encountering of different cultures may become a source of misunderstandings and contrasts. Thus, the idea of sustainable tourism requires the active contribution of the ones living on the hosting area and also to guarantee them the advantages of the developments. As it follows from the application of sustainable nature and rational landscape usage in the protected areas nature aspects of preservation have to be endorsed in accordance with other branches. In the course of this one has to meet many law limitations, restrictions that for example may have a disadvantageous effect on a national park and its population compared to non-protected areas and their population. Thus, it is understandable from their side that if they are not offered, ensured any proper compensation or resolution alternative they will encounter the interests of conservation and this way with their resistance they could make practice of conservation impossible. Conservation and demonstration, these two, seemingly irreconcilable oppositions, may be formed into a symbioses during the practical course of tourism. This way ecotourism may provide a complex resolution possibility for the managers of protected areas, so that they could control tourist circulation and apart from the establishments of conservation, local communities could also profit from the advantages of the developments (*http://www.kvvm.hu*, *Dávid–Jancsik–Rátz 2007*).

FROM SUSTAINABLE TO RESPONSIBLE TOURISM

Sustainability in Tourism

Sustainability of Tourism is a double task: one has to ensure the long-term preservation of charm and guarantee that those who invested in tourism will see their capital returning, their firm's results getting better. Sustainable tourism, on the long run, has to be ecologically sustainable, economically executable, but also socially and ethically fair regarding local population. Sustainable tourism development satisfies the necessities of present-day tourists and hosting areas, furthermore protects and expands any future possibilities. According to the concepts, it will make possible the managing of resources in a way that humanity may satisfy its economic, social, and aesthetic needs, it may preserve basic ecological movements, biological diversity, life-sustaining systems and the cultural integrity of different nations and ethnic groups at the same time. The connection among tourists, hosting communities, enterprises, attractions and nature is complex, interactive and symbiotic at the same time. It derives from the upper mentioned comes that sustainable management with the resources would lead to acceptable conservation and a better quality tourism. All in all, sustainable tourism may effectively enlarge and enrich the environment.

Tourism development may be considered sustainable if:

- it makes possible the renewal of natural resources by taking also into consideration the capacities of the natural environment of a given destination;
- it recognizes that local communities, habits, lifestyles are important segments of tourist products;
- it accepts that local population has to benefit proportionally from the positive economic effects of tourism;
- it respects tourism development related interests and desires of the population of the hosting area.

The concept of sustainability includes also:

- that the tourism sector itself is sustainable on the given area, i.e. The pace of its development does not imply unfavourable social or physical changes, thus it is still acceptable for the destination;
- tourism does not displace other economic activities that are also competing for the natural resources of limited availability

Principles of sustainable tourism development can be defined in various ways presented below.

For continuous future utilization, the natural, historical, and cultural etc. resources of tourism have to be preserved in a manner so that they benefit present societies as well. It is extremely important for the sector itself as it depends on tourist attractions, activities that are connected to natural environment, historical, and cultural heritage of the given area. Were these things be destroyed or not emphasized properly, tourism could not prosper.

When planning and managing tourism development no serious environmental or socio-economic problems could be caused. Decreasing energy consumption or waste-production and sustaining biodiversity could help us achieving this goal.

The general environmental quality of the tourist areas has to be sustained or where possible developed. Most of the tourists prefer visit places that are spectacular, clean, and not polluted. For the maintenance or development of proper conditions local management may ensure support and means. High level of environmental quality is also important for local population.

High satisfaction level of tourists has to be maintained in a way that tourist destinations could keep their popularity and market value. If not realized destinations could not keep their market and would stay as a viable destination.

Profit deriving from tourism should be prevailed in the whole society.

Sustainable tourism means a sort of increase or development that d does not exploit natural and constructed environment, but preserves the culture, inheritance, and artistic values of the local community.

Apart from these, we also have to take into consideration the realization of:
- integration of tourism into planning
- supporting local economy
- involving local communities
- communication between shareholders and community; involving local population to planning
- human resources training
- responsible tourist marketing and
- making tourism policy an organic part of the general politics of the society (*Dávid–Jancsik–Rátz 2007*).

Responsibility in Tourism

Responsibilities in the multi-actor tourism industry are divided so that the different "resource owners" are responsible for different segments. It makes the formation of guideline development, the maintenance of reliable quality level and the well-balanced communication much more difficult. The seriousness of the case having been recognized institutions all over the world were set up with the intention to relieve these problems (they are commonly referred as offices or tourism management organisations, however there are several other names to them) (*Dávid–Jancsik–Rátz 2007*). Cooperating with different partners they have to work on the task of developing responsible tourism so that life quality would develop as well (Fig. 3).

Responsible and sustainable tourism development

Because of the complexity of tourist motivating factors, it is clear that visitors arriving to given destinations have different behaviour or attitude towards that area (*Spenceley ed. 2008*). It would be ideal if tourists could participate in environmental protection meaning that they could be actively and responsibly sustainable (responsible sustainable tourism). Today it is still a vision, but we should not forget about the already existing practices people are trying out on different fields (environmental excursions, waste collecting excursions, ethical code of tourism).

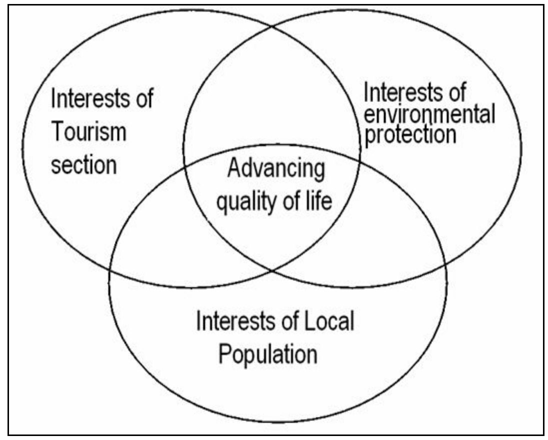

Fig. 3 The relationship of tourism, environment, and local society (Source: Inskeep 2000)

OF THE JUSTIFICATION AND NATURE OF TOURISM ECOLOGY

Several authors of international specialized literature have publications on the relationship of ecology and tourism (*Tyler–Dangerfield 1999, Grgona 2005*). Proceeding with their ideas and suggestions and taking elemental thesis of ecology and scientific approach of landscape ecology and settlement ecology as a basis, the phrase of tourism ecology could be introduced. The basis, correlations and investigational territories of tourism ecology are illustrated on the following figure (Fig. 4). Thus, tourism ecology is a tourism development theory and practice that naturally makes possible the efficient development of rural areas building upon natural and socio-cultural resources.

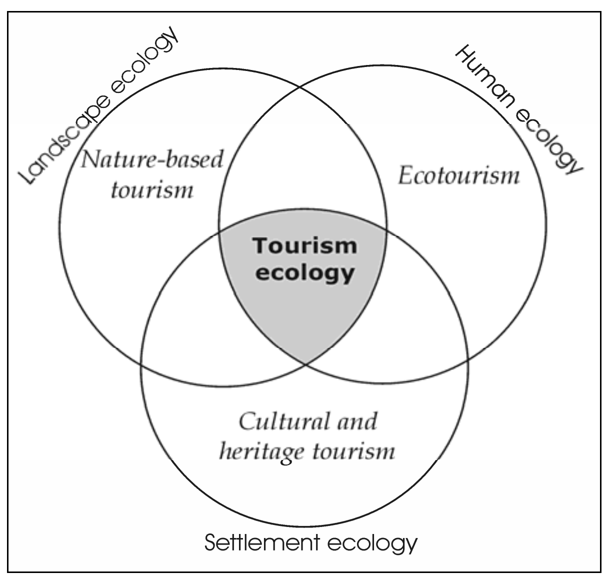

Fig. 4 Relationship of tourism ecology

(Sources: original self-made edition, Dávid 2009)

RURAL DEVELOPMENT, RURAL TOURISM, TOURISM ECOLOGY

In our interpretation, rural tourism is not a concrete form of tourism, but a set of sorts and categories of tourism. It provides the entirety of rural experience and means the adequately structured, natural, and tradition based diverse supply of unique and general elements. Tourism forms and categories that partly or entirely take part in it provide rural-like services in rural environment and rural-like host capacity either as a complex product or product element (*Fehér–Kóródi 2007*). For an easier overview we represented them to a summarizing chart (Fig. 5). The tourism ecology linkage is obvious: in the case of each form of tourism a close relation to natural and built environment is observable and it provides a basis for responsible sustainable rural tourism development.

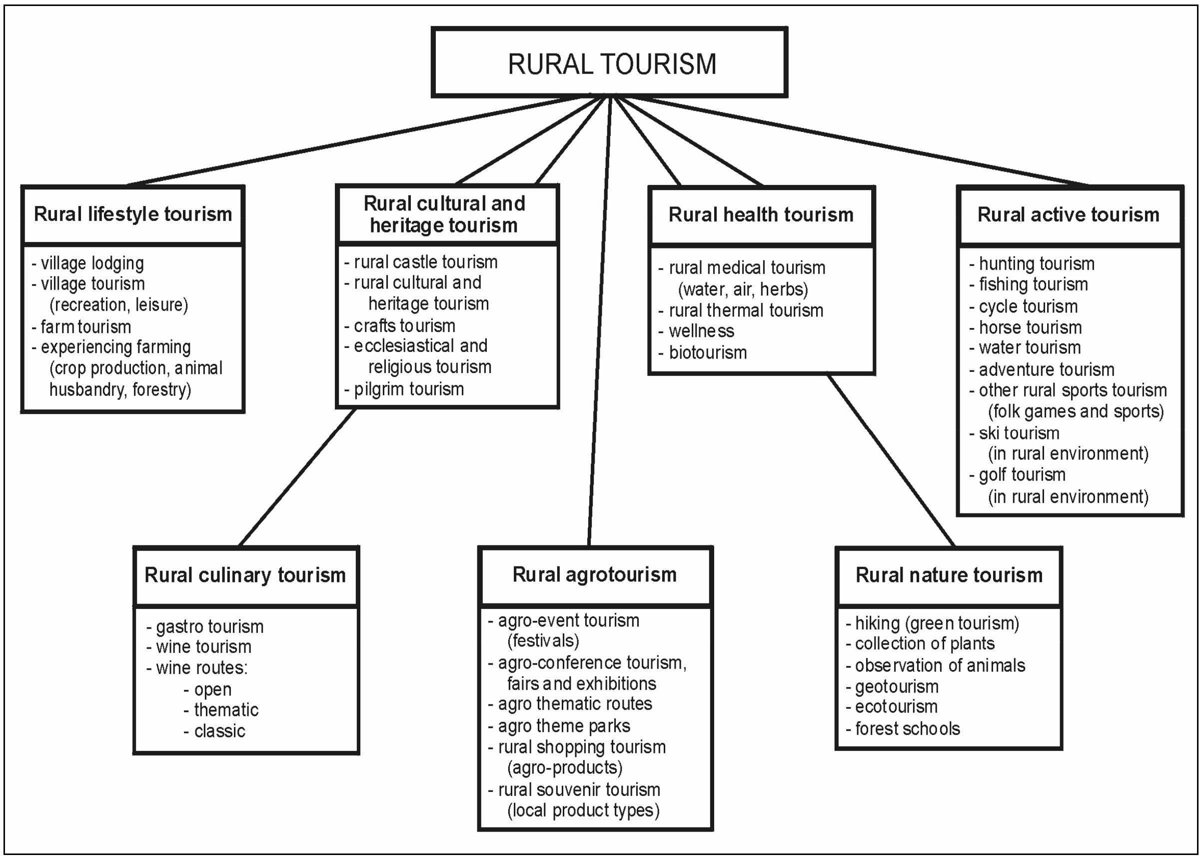

Fig. 5 Standardization of rural tourism (Source: Dávid–Tóth–Kelemen–Kincses 2007)

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