BABEȘ BOLYAI UNIVERSITY

THE FACULTY OF GEOGRAPHY

THE WATER RESOURCES WITHIN THE UPPER RIVER BASIN OF MUREȘ AND THEIR FLOW REGIME

PHD THESIS

SUMMARY

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KEY WORDS: river flow regime, water resources, upper river basin of Mureș

PART I

THE UPPER RIVER BASIN OF MUREȘ, INTRODUCTORY MATTERS

The first part of the thesis is divided into three chapters, the first chapter deals with the geographical location of the studied area and its territorial subordination elements, the second chapter deals with the river network organization within the upper sector of the Mureș river and the third chapter outlines the organization of the hydrometric and meteorological station networks.

1. The geographic location, boundaries and elements of territorial subordination

The analyzed territory is part of the central group of the Eastern Carpathians, stretching over an area of 2227 km2 corresponding to the upper basin of the Mureș river between its spring and the town of Deda.

The upper basin of the Mureș essentially grafted onto a mountain area partly covering areas Mountains Gurghiu, Călimani which are separated by the Mureș River through a gorge created between the localities of Toplița and Deda, the Harghita Mountains, the Giurgeu mountains and the Hăghimaș Mountains (Fig. 1) .

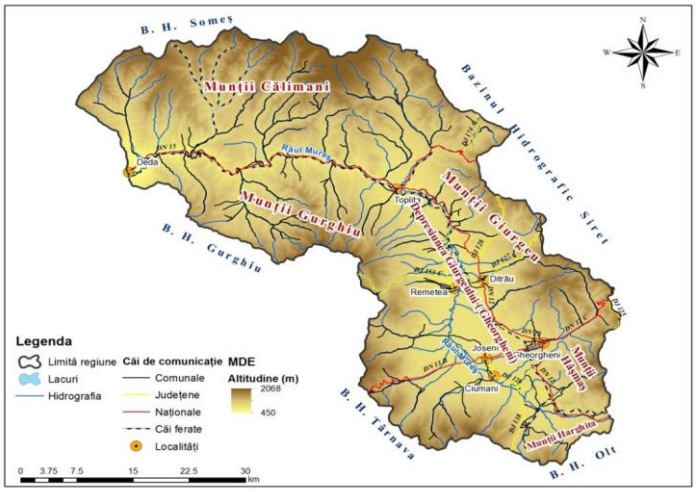

Fig 1. The delimitation of the upper river basin of Mureș

The studied area runs from the parallel of 46 ° 38 `11 `` and 56 `` 46 ° 56 'north latitude and the meridians of 25 ° 40` 08 `` and 24 ° 52 `31 `` eastern longitude, following a main orientation of North-West.

The Mureș river springs from the south-western slope of the mountains of Hăghimaș, at an altitude of approximately 850m. From there the Mureș river then carves through the depression area of Gheorgheni, following a general direction south-east to north-west up until Toplița, from where the river creates a gorge that spreads for 35 km up until the locality of Deda.

From a hydrographic perspective, the basin of the river Mureș adjoins with the Someș river basin on its northern part, to the east it borders the basin of the river Siret, to the south-east it is limited by the Olt basin, and to the south-west by the Târnave basin, which are tributaries of the Mureș river in its middle course same as the Gurghiu basin that limits the upper river basin of Mureș on its west side (Fig. 1).

The Northern boundary of the basin of the river Mureș corresponds to the maximum altitude that separates the upper basin of Mureș from the tributaries of the river Somes as the watershed is grafterd along the main peaks of the mountains Călimani: the Bistricioru Peak (1960m) the Pietrosu peak (2102m) the Călimani peak (2013m) the Reținș peak (2021m) and the Borsec ghat (1105m).

The eastern boundary of the uuper river basin of the Mureș separates the basin from the neighbourin one, Siret along the line that is marked in relief by the massif mountain peaks belonging to Giurgeu: Pietrosu peak (1507m), the Black Peak (1567m).

The west watershed separates the upper sector of the river Mureş from its tributaries in the middle sector, the basins of Gurghiu, Niraj and Târnave. The section consists of the Amza peak (1694m) – the volcanic caldera Şumuleu, the volcanic caldera of Saca-Tătarca (the Buckwheat Peak, 1689m) – the Old-Woman peak (1634m) – the volcanic caldera of Fâncel - Lăpuşna (Fâncel Peak, 1684m).

2. The river basin organization within the upper river sector of Mureș

The hydrographic network of the upper river basin of Mureș, from its spring until the settlement of Deda, consists of 42 tributaries of which 23 tributaries on the left and 19 right tributaries, which implies an asymmetric basin slightly more developed on the left side.

Although, within the Depression of Gheorgheni, before the locality of Toplița, the Mureș river receives half of its tributaries in the upper basin, their smaller basin area implies a reduced intake in the Mureș river runoff formation as compared to the contribution made by the tributaries of the Mureș river within the gorge area.

3. The organization of the hydrometric and meteorological networks within the upper river basin of Mureș

In this study, the data was provided by eight gauging stations (of which four stations located on the Mureş river and four stations located on its tributaries) and 4 meteorological stations (Fig. 3).

Considering the period of establishment of the gauging stations (Table 1) we have agreed on a joint study period between the years 1986-2010. The reason for choosing this period was the establishment of the station of Toplița upon the river Mureș not until 1986.

In parallel to this situation there are four hydrometric stations that can be analyzed over a longer common period, namely 1970-2010. These stations are the Suseni station upon the Mureș river, founded in 1949, the station of Stânceni also upon the Mureș river and founded in 1949, the station of Toplița upon the Topliţa river founded in 1952 and the station of Răstoliţa established on the Răstoliţa river in 1949.

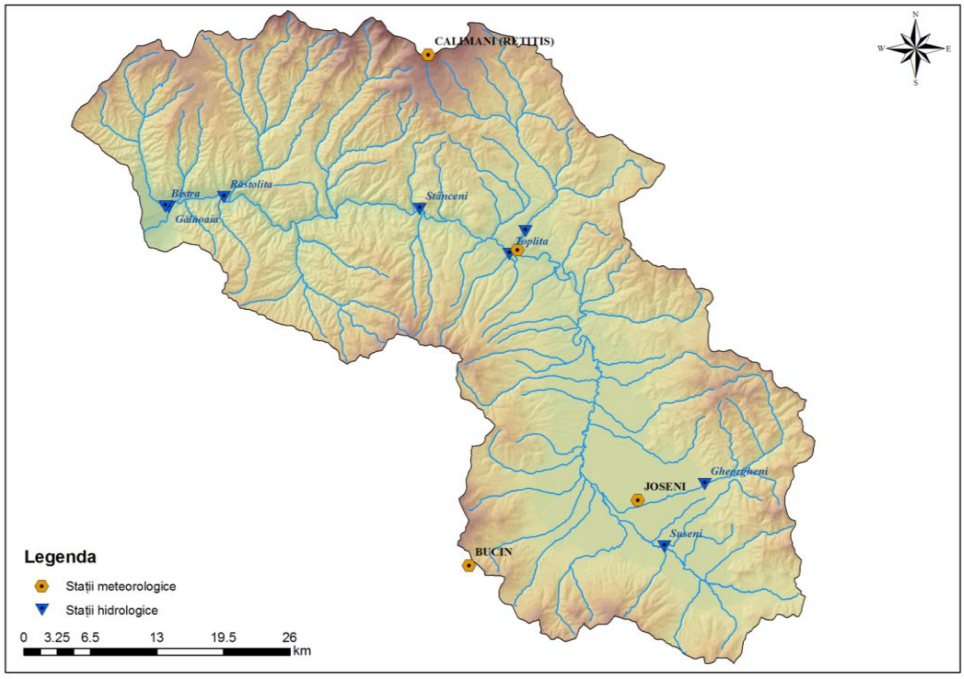

Fig 2. The distribution of the main hydrometric and meteorological stations in the upper basin of Mureș

Table 1 Main hydrometric stations in the upper Mureş

River	Station	H point (m)	H med basin (m)	F station (km^2)	L (km)	Year of establishment
Mureș	Suseni	748	987	160	19	1949
Mureș	Toplița	654	935	1071	77	1986
Mureș	Stânceni	618	967	1532	98	1949
Mureș	Gălăoaia	521	988	2135	127	1982
Belcina	Gheorgheni	800	1.115	94	33	1984
Toplița	Toplița	657	1.149	215	29	1952
Răstolița	Răstolița	513	1174	163	21	1949
Bistra	Bistra	450	1.104	92	26	1973

H point = section elevation, H med basin - average basin altitude, F station = area corresponding hydrometric station, L - the total length of the stream

The meteorological stations located in the studied area and used to characterize the climate of the area are Joseni and Toplița located in the valley and depression areas and the meteorological stations located on the heights: Bucin and Reținș. The data from these stations

refer to the monthly average temperatures, while snow cover data were obtained from stations Joseni Topliţa and Bucin on pentad periods.

PART II

THE EVALUATION AND SPATIAL DISTRIBUTION OF THE WATER RESOURCES IN THE UPPER RIVER BASIN OF MUREŞ

The second part of the thesis is divided into five chapters addressing research elements involved in the formation and distribution of surface water resources in the upper basin of the Mureş and evaluation of water resources in this area.

4. The research history on the assessment of water resources of rivers

The first chapter of this part refers to the history of water resources research at both national and international and area.

On the international level, the theme of water resources has been addressed by many authors including Lvovitch M.I. (1938, 1945, 1959, 1960, 1963, 1964, 1969) Ambroise, B., (1998) Bravard J.P. and Petit F, Jones (2000), Lambert, R. (1996).

On a national base, the milestone in the study of water resources came with the seventh decade of the twentieth century, when the Institute of Geography approached a new direction in the research of water resources namely a hydrographical one reflected by the development of studies (P. Gâştescu et al. 1967 1970.1976) and hydrographical maps at scale 1: 1000000 (overview map) and 1:200,000 (on paper), useful in watershed planning activities.

The hydrological research in Romania tackles among the issues studied in the last century areas like specific average flow (C. Diaconu et al. 1954), the hydrological balance (D. Lazarescu, I. Panait, 1957), river network density (T. Morariu et al 1956, I Ujvari, 1956), alimentation sources of the rivers (I. Ujvari, 1957 D. Lazarescu, and until 1957).

5. Methodological issues concerning the study of water resources

In this study we used a range of methods and techniques work encompassing both classical and modern methods.

Among the methods of systematizing knowledge there have been used the geographical classification, thus achieving a grouping of the water resources based on various criteria such as the altitude, the relief units or the river basins.

Among the techniques implemented to achieve this study one can include the direct observation and indirect geographical description, the processing data streams, and the geographic survey.

The basis for characterizing the impact of climatic conditions on the formation and distribution of water resources in the basin Mureș was the statistical analysis of data streams representing quantitative parameters:

- the average annual rainfall recorded at weather stations in the region analyzed for the period 1986-2010
- the maximum rainfall recorded within 24 hours at the rainfall stations in the region in the period 1986-2010
- the duration and snow depth in the region during the period 1986-2010
- the monthly and annual average temperatures for the period 1986-2010
- the average annual flow, the maximum annual flow, annual minimum flows recorded at 8 gauging stations in the region during the period 1986-2010

The statistical analysis and mapping were conducted using computer techniques such as the program Corine Landcover 2008.

Graphical representations of the possibilities offered by Excel were also used in developing the present paper such as column charts, strip charts, section diagrams, historiograms.

6. The conditions that influence the formation and allocation of water resources in the upper basin of the river Mureș

Both the formation and distribution of surface water resources in the upper basin of the Mureș are subject to local conditions of of geological, geomorphological (altitude, slope, slope orientation, the relief), climate, vegetation and human interaction type.

6.1. The role of the geological conditions in water resources allocation

From the geological point of view, the relief carved by the Mureș river and its tributaries in the upper sector develops a mosaic of rocks belonging both to the crystalline and volcanic origins, as we can encounter syenite, basalt or andesitic pyroclastics (Fig 3).

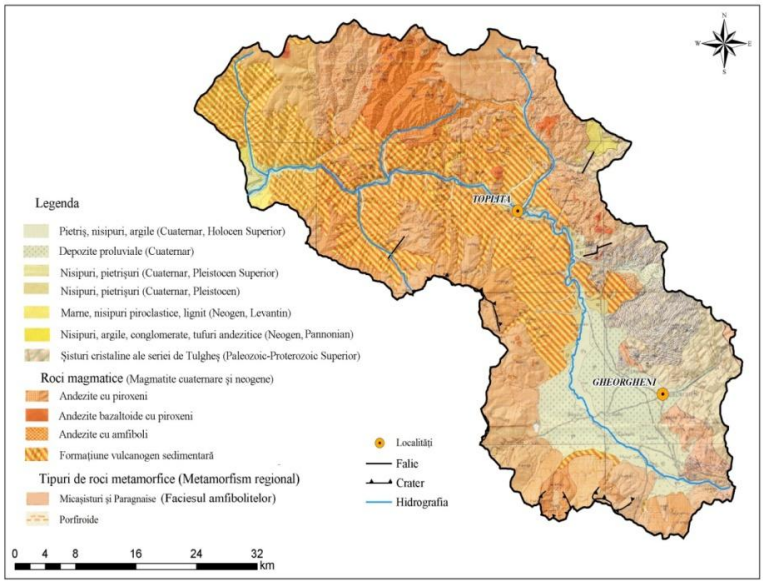

Fig. 3 The Geological map of the upper basin of the Mureș, after the Romanian Geological Map, 1:200,000

The role of geological substrate is shown in the terms elaborated by I. Zavoianu (2005) in a classification developed on the principle of rock permeability. Thus we describe the studied area as one characterized by aquifer and acvilude rocks in the depression area, causing some areas of swamp and rich underground alimentation of the springs, while the mountainous frame consists mainly of acvifug rocks, resulting in a concentration of runoff on slopes.

6.2. The role of the geomorphological conditions in the formation and distribution of water resources in the basin of the Mureș

6.2.1. The altitude

The role of the altitude in the distribution of the water resources in the upper basin of the Mureș can be emphasized by studying the river network organization in this sector. Following general laws, the water catchment areas in their form early, poorly organized, are usually present at high altitudes, and as the altitude decreases the tributary rivers in the region will receive tributaries of their own that will fill their river basin (fig 4).

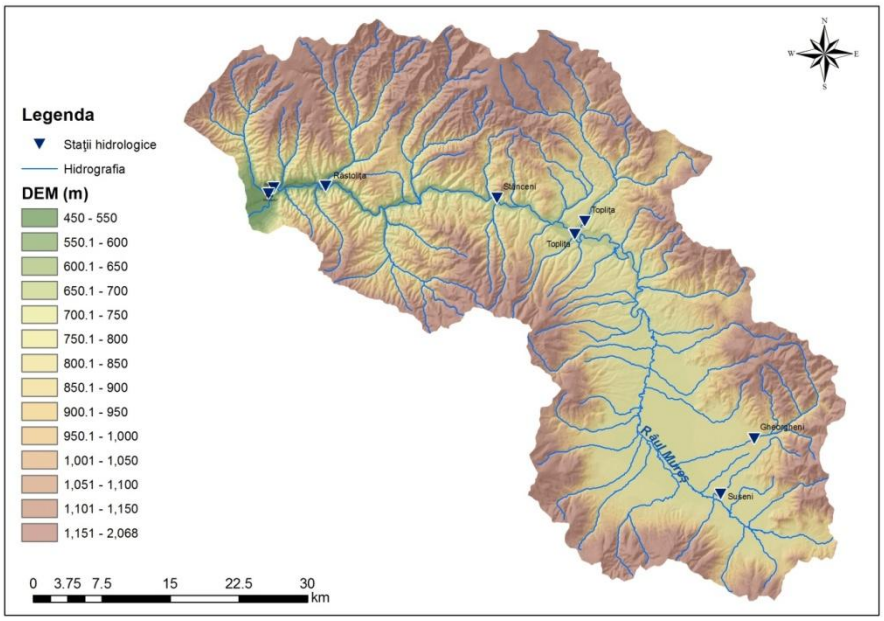

Fig. 4 The hypsometric map of the upper basin of the river Mureș

In the upper basin of the Mureș beyond the altitude of 1500m, as shown by the weather stations of Bucin in the Gurghiu Mountains and Retitis in the Călimani Mountains, snow is preserved on the ground for eight months a year, which determines the alimentation of the rivers situated at this altitude for more than half of year to be dependant only on this source. The streams that fall into this typology arise from high altitudes in the Călimani mountains, namely Topliţa and its tributaries: Pârâul Porcului, Voivodeasa, Secu, the tributary of Ilva: Pietrosul, the

tributaries of Răstoliţa: Pârâul de Mijloc and the tributaries of Mureș from the Gurghiu Mountains: Borzonțul Mic, Șumuleul Mare și Șumuleul Mic.

6.2.2. Slopes

Over half of the mountain slopes that make up this area (57%) are characterized by slope gradient of 10-20 degrees and 19% of the territory is characterized by higher slopes of 20-30° which causes a rapid concentration of the water on the grooves already formed on slopes and a high speed water transport especially within the subasins (fig 5).

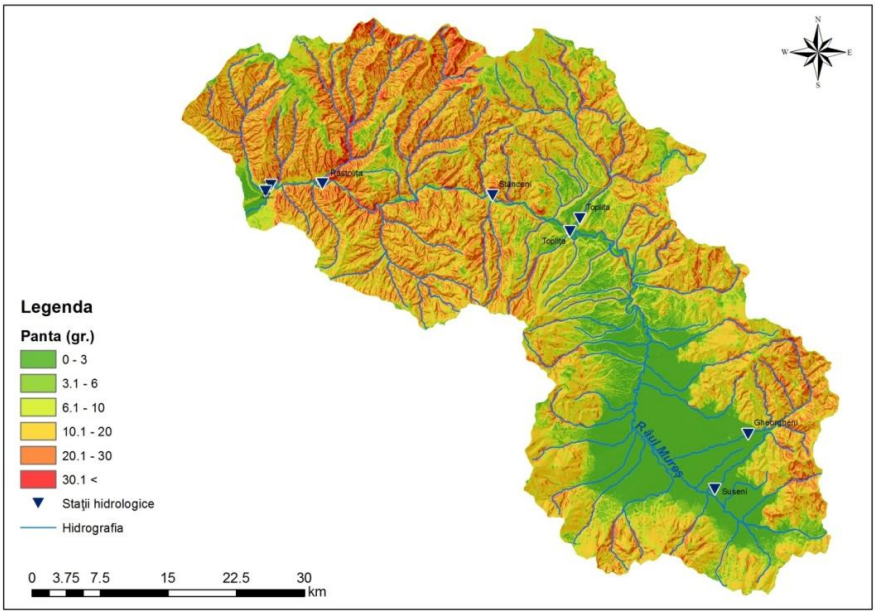

Fig. 5 Slope map within the upper river basin of Mureș

6.2.3.The slope orientation

The orientation of the slopes in the upper basin of the Mureș is very diverse, but one is able to identify a broadly oriented basin in the SE-NW. The slope orientation categories are at similar values (table 2).

The slope orientation plays an indirect role in the formation and distribution of water resources in the upper basin of the Mureș, affecting primarily the climatic conditions which in turn influences the wealth of water resources.

Table 2 The orientation of slopes within the upper river basin of Mureș

Orientation (%)	N	NE	E	SE	S	SW	W	NW
Bistra	6.52	7.31	12.49	16.23	14.69	13.52	15.08	13.76
Răstolița	6.55	9.76	14.89	15.88	12.96	14.95	15.05	9.94
Tolița	6.90	8.90	13.80	18.70	16.67	13.57	11.38	9.97
Belcina	9.63	9.23	10.34	12.04	12.73	15.73	14.30	13.16
B. S. Mureșului	11.05	12.07	13.44	12.87	11.14	12.12	13.07	12.27

6.3. The role of climatic conditions in the formation and distribution of water resources in the basin of the Mureș

In this chapter we have analyzed the climatic conditions influencing the formation and distribution of water resources in the upper basin of the Mureș river. These factors are the distribution of temperature on a monthly, seasonal annual and multiannual scale, also temperature trends in their multi-level for the period 1986-2010, the amount of rainfall in the basin and their variation at monthly seasonal, annual and multiannual (Figure 8) and the main parameters of the snow.

6.3.1. The air temperature

The climate is a typical mountain one, the characterized by lower temperatures at high altitude as compared to the depression and gorge area (fig 6).

The mean annual temperature (Fig. 6) varies between -1 ° C in the high Caliman, 2-4 ° C on the slopes of the Harghita Gurghiu and Hăghimaş mountains and values from 4-8 ° C in the lowland Gheorgheni and the corridor along the Mureș.

The monthly air temperature regime in this area displays a maximum temperature reached during the months of July-August and ranging from 14 ° C to Bucin to 16 ° C at Joseni and 16-17 ° C at Topliţa.

At the opposite end there are the months of December and January when the average monthly temperatures range from -4 to -5 ° C. For the higher mountain area the negative

temperature period is extended, as these values were recorded in January and February and December.

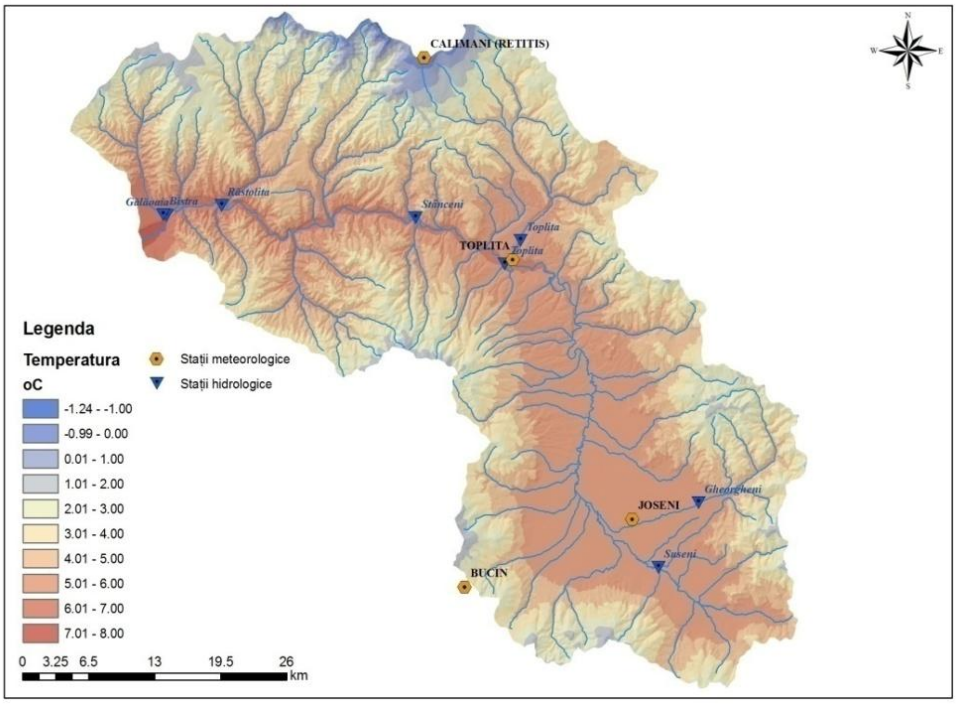

Fig. 6 The distribution of the average annual temperatures during 1986 to 2010 in the upper basin of the Mureș river

6.3.2. Rainfall

Based on the collected data, one can highlight three areas that validate the relationship between the average annual rainfall and the altitude level. Based on these areas, one was able to elaborate the annual average rainfall distribution map for the upper river basin of Mureș and divide it into three areas, namely: the Mureș spring up until the central part of the depression of Gheorgheni where there is a multi-annual rainfall amount 400-600mm/mp / year, an area of contact between the gorge and northern depression of Gheorgheni where the rainfall quantity increases to 600-800mm/mp/an and the gorge sector characterized by a rainfall amount of 800-1200mm/mp/an.

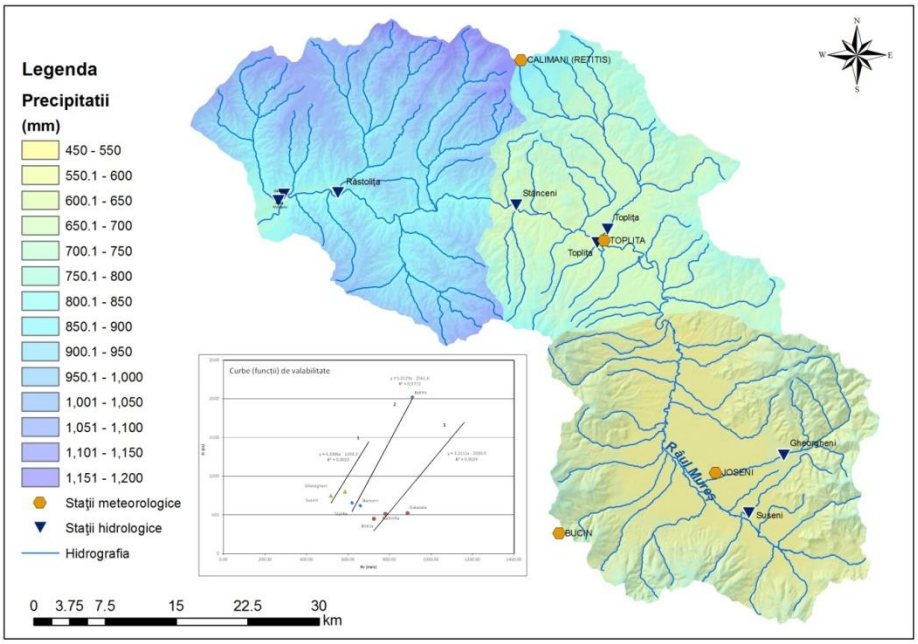

Fig. 7 The average annual rainfall in the upper basin of the river Mureș

6.3.3. Snow

The duration of the snow cover depends on the amount of solid precipitation and to maintain the soil temperature at 0° C. With the first decade of October at the Bucin meteorological station (Figure 8) and by the second decade of October within the territory characterized by the Joseni meteorological station (Figure 9) the submission of snow is highly possible. The exception to this situation ae the eastern slopes of the valleys located at elevations lower than the average region where the first snow cover the ground in November (as the weather station Toplița confirms, fig 10).

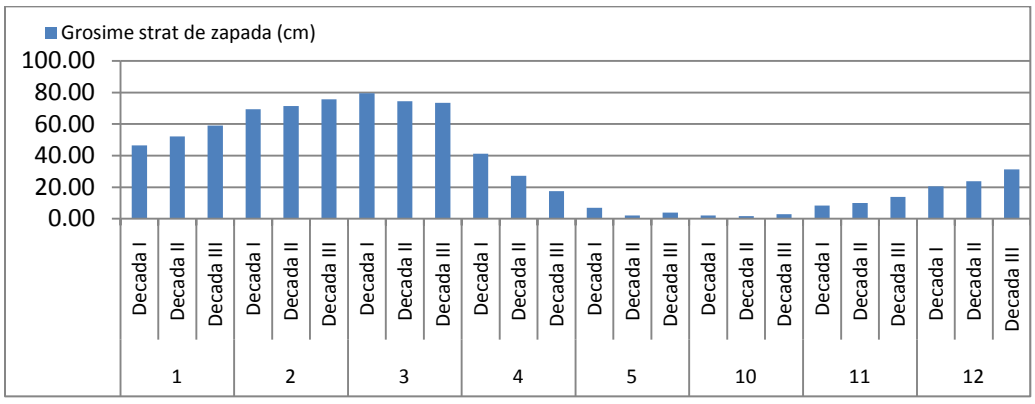

Fig. 8 The evolution of the average thickness of the snow in a year at the Bucin station

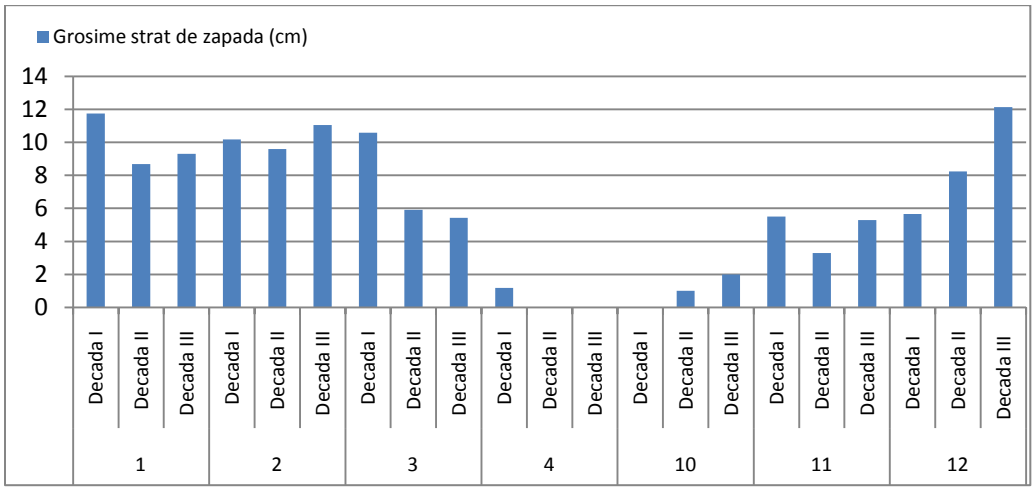

Fig. 9 The evolution of the average thickness of the snow in a year at the Joseni station

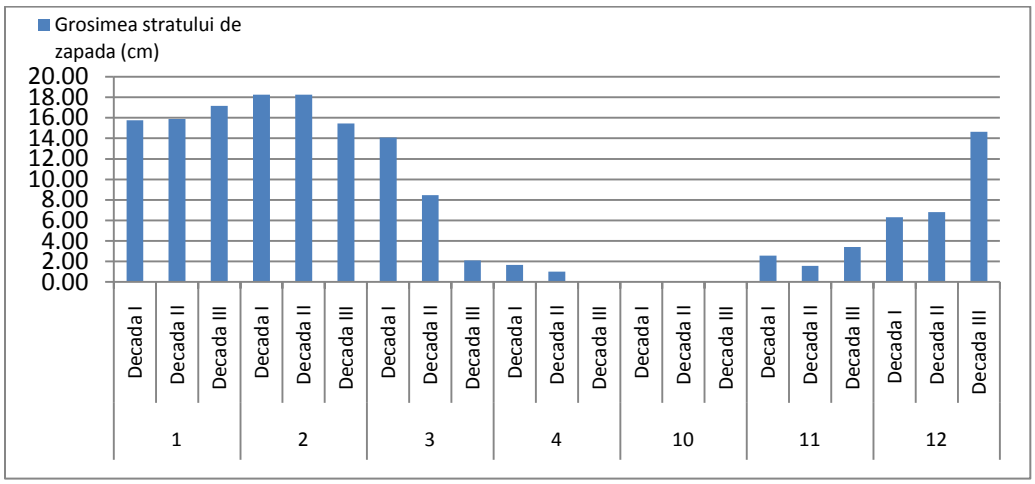

Fig. 10 The evolution of the average thickness of the snow in a year at the Topliţa station

6.4. The influence of soil conditions on the formation and distribution of water resources

This chapter deals with the influence of soil on water resources distribution and hence on river flow regime in this sector which is manifested by its characteristics: particle size, structure, degree of compaction. Most of the study area is covered by Cambisols (30%) and umbrisols (36%) given the large expansion of mountain frame made of compact rocks.

The low permeability soils that characterize the mountain slopes in the area, is due to the high degree of soil water saturation, the amount of water being maintained for a long period with increasing altitude and causing a food rich groundwater.

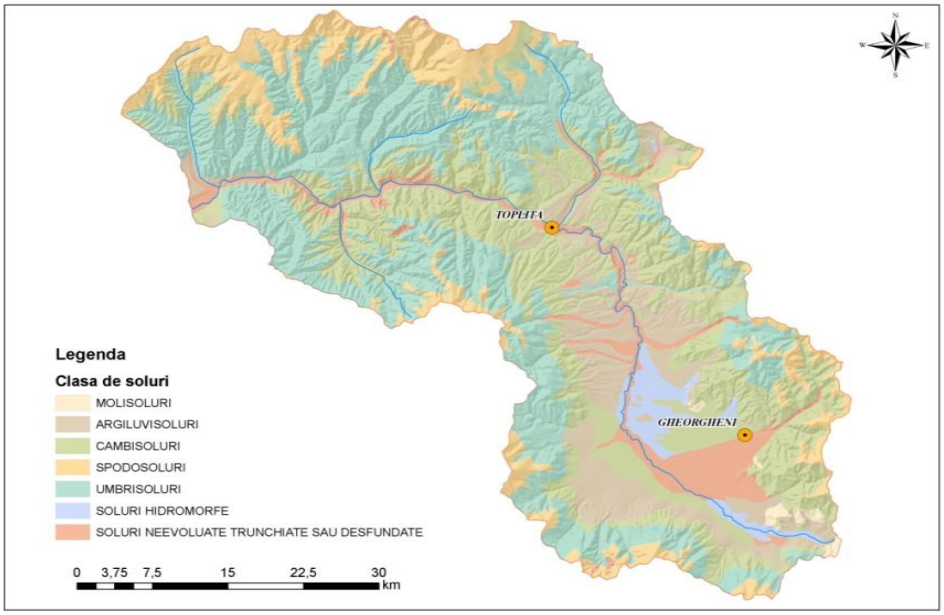

Fig. 11 The soil map in the upper basin of the Mureş (after the Romanian soil maps, 1:200,000)

6.5. Vegetation and land use influence on water resources distribution

This chapter deals with vegetation as a factor contributing to the genesis of structures for ground longer loose its influence reflected in soil resistance to erosion action of external agents.

The forest is the most visible indicator of seasonal change in this area which it is subject. With the installation of the thermal positive throughout the warm season vegetation is responsible for withholding a proper amount of water and adjusting the flow in the forested river basins.

The anthropogenic influence on the vegetation within the studied area has in turn impacts on the water resources. Under the influence of anthropogenic activity in the region there are irrigated lands for a higher agricultural production, and some swampy areas have been drained to obtain and more cultivable land in an area that is not naturally conducive to agriculture on a large scale.

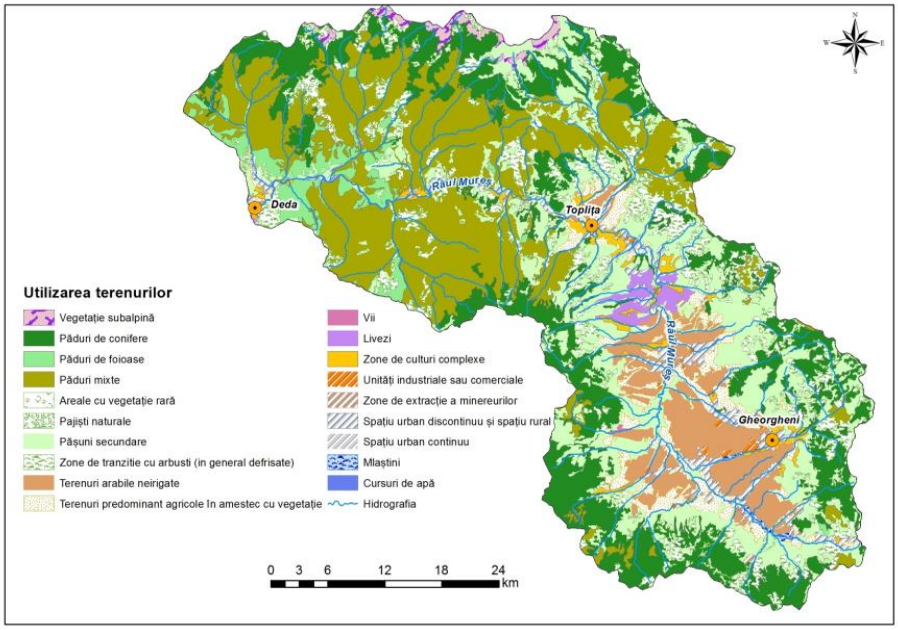

Fig 12 The vegetation and land use map in the upper basin of the Mureş (based on data from the Corrine database)

7. The multiannual average flow of the rivers and the upper basin of Mureş and the water balance

7.1. The annual average river runoff in the upper basin of the Mureş

The average flow is the main indicator of the wealth of water resources in the upper basin of Mureşuluişi was determined as the arithmetic average of the daily flows, monthly and yearly for peiroadele 1950-2010, 1970-2010 and 1986-2010 (table 3).

The reason for studying the flow of rivers with the aid of three continued periods consists of the need for a data string long enough to be representative of the study area, and thus we have appealed to the period 1950-2010 but since during this period there have functioned only three of the eight stations under study we also used a period common to the eight operating gauging stations in the basin from 1986 to 2010 respectively.

Table 3 The average rivers flow for the periods 1950-2008, 1970-2008 and 1986-2010 at the hydrometric stations in the upper basin of the Mureș

River	Hidrometric station	1950-2000			1970-2008			1986-2010		
		Q (m^3/s)	q ($l/s.km^2$)	Y (mm)	Q (m^3/s)	q ($l/s.km^2$)	Y (mm)	$Q_{med..}$ (m^3/s)	q ($l/s.km^2$)	Y (mm)
Belcina	Gheorgheni	-	-	-	1.018	10.829	341.8	1.013	10.766	340.1
Topliţa	Topliţa	2.896	13.469	425.1	2.968	13.804	435.7	2.893	13.455	424.7
Răstoliţa	Răstoliţa	3.478	21.337	673.4	3.467	21.27	671.3	3.289	20.178	636.8
Bistra	Bistra	-	-	-	-	-	-	2.377	25.837	815.4
Mureș	Suseni	-	-	-	1.089	6.681	214.8	0.963	6.018	189.9
Mureș	Topliţa	-	-	-	8.513	7.269	229.4	6.717	5.736	181
Mureș	Stânceni	13.552	8.846	279.2	14.727	9.613	303.4	14.143	9.231	291.3
Mureș	Gălăoaia	-	-	-	-	-	-	23.665	11.084	349.8

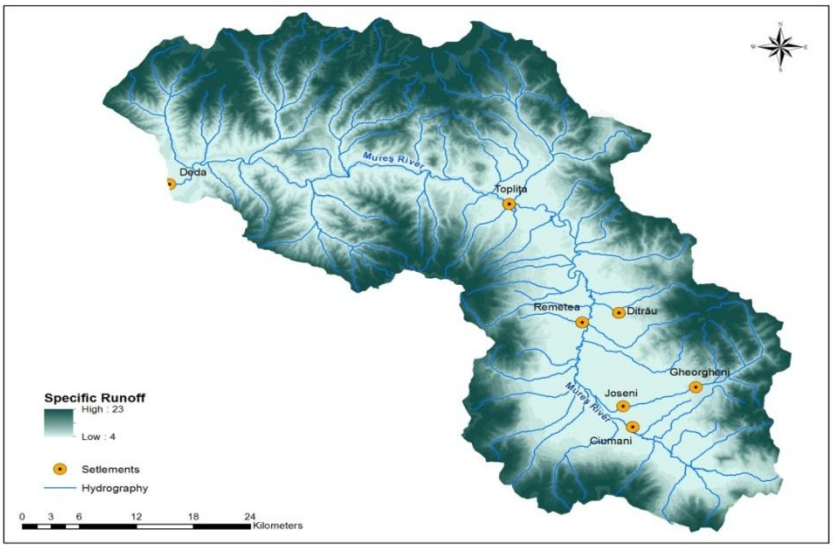

Fig 13 Map of the specific flow environments in the upper basin of the Mureș (after Sorocovschi V, Cs Horvath, 2011)

The modes of expressing the water richness within the area are the average flow, the medium flow, the volume flow, the specific flow, the elapsed layer coefficient method and the flow coefficients.

Over the course of the river Mureș the specific average flow (Figure 13) in the range from 1986 to 2010 (Table 2) ranges from a difference similar values hills, plateau level (q = 2-7

l/s/km2) or 5.736/s/km2 (river Mureș Ghoegheni depression, Suseni station) and typical values mountain area (q = 7-20 l/s/km2) or 11.084 l/s/km2 for Mureș river gorge at station Gălăoaia.

The highest value of specific runoff is typical high mountain area (q> 20 l/s/km2) and recorded in the basin Bistra (q = 25.837 l/s/km2) (Table 3).

The same chapter examines the trends in average annual flow in the upper Mureş by the aid of the graphs that show a general upward trend of the parameter.

7.2. The water balance in the upper river basin of the Mureș

This chapter presents the main water balance of the upper Mureș on a subasins level respectively the Belcina river basin, the Topliţa river basin, the Răstoliţa river basin and the Bistra river basin.

The amount of precipitation that consists in "inputs" in the upper basin of the Mureș system vary by basin area.

Data for sheet flow components vary according to the geographical location and the main river tributaries Mureşului. Thus, an intense evaporation characterizes the river basin of Belcina where only 27% of the water from rainfall forms the runoff, the rest evaporates or seeps through as half the river basin is developed in the depression Gheorgheni, an area characterized by low amplitude slope categories and through a permeable substrate and as such by frequent swamp areas. Compared with this, the output of the gorge area in the river basin of Bistra the amount of rainfall is large and is evaporated to a smaller volume.

8. The evaluation and spatial distribution of the water resources in the upper river basin of Mureș

8.1. The evaluation of water resources of the rivers in the upper sector of Mureș

The identified areas that validate the relation q = f (Hm) allowed the evaluation of the average annual runoff on three levels: on an altitude level, on a geographical units level, and on a level that resides on the main tributary rivers Mureș in this sector.

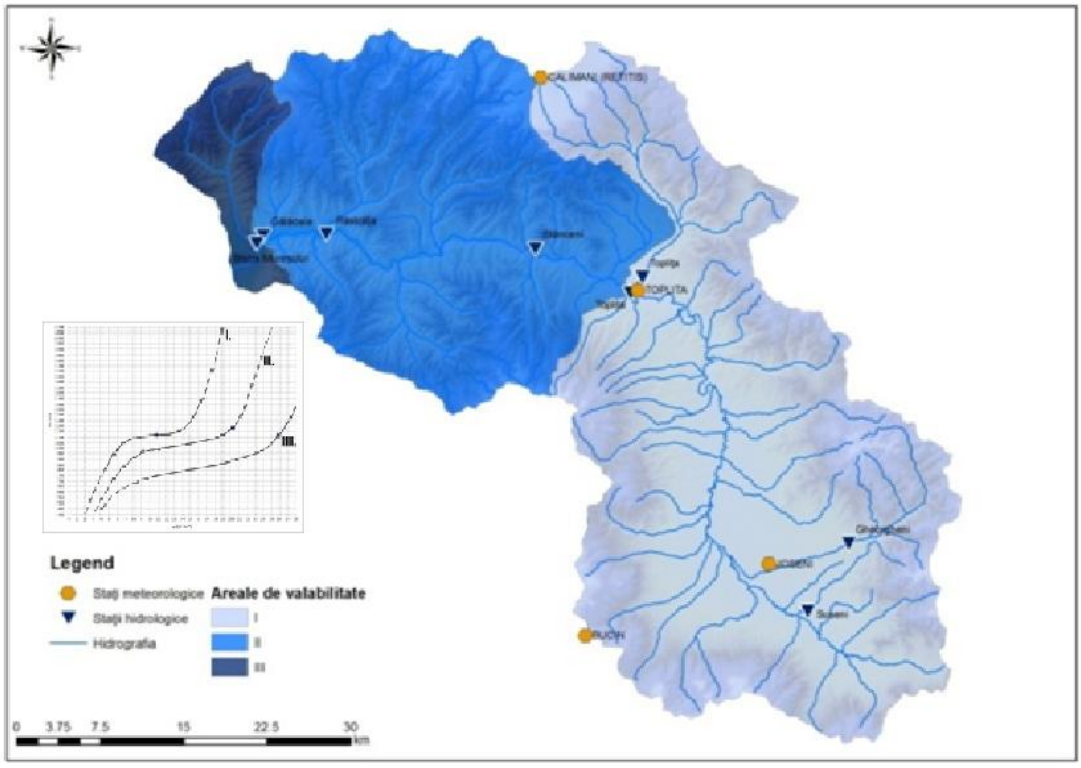

Figure 14 Areas of validity of the relationship q = f (Hm) (Sorocovschi V, Cs Horvath, 2011)

The correlation made between specific environments and leakage values mean catchment altitude control stations studied in the identification of three curves of validity of the relationship q = f (Hm) (Fig 14).

The identified correlation curves correspond in territory to areas in which the increase in average runoff in relation to altitude is done differently.

8.2. Spatial distribution of the water resources of rivers

The spatial distribution of flow was examined on three levels: on the steps of altitude river basins (over 10 km2) and geographic subunits.

8.2.1. The distribution of water resources on steps of altitude

This chapter deals with water resources and their distribution on the steps of altitude in the upper basin of the Mureș.

The high water flows in the range 700-1500m altitude, with a maximum altitude reached at 1200 to 1300 this area is characterized by steep slopes while being quite low in terms of altitude in order to allow the river network to emerge.

The average specific runoff increases both in relation to the altitude and the three intervals of validity q = f (Hm), the highest values the relationship q = f (Hm) being recorded in the third area of validity.

8.2.2. The distribution of water resources on physical-geographical units

This section refers to the distribution of the water resources on geographical units within the upper basin of the Mureș, where, depending on the covered area and moisture, runoff potential environments differ from a geographical unit to another.

Of the total volume of water carried by in the river Mureș in its upper basin, almost half springs from the Căliman Mountains (47%), where the flow gradients reach high values. Following this share are the Gurghiu Mountains that participate with 25% to the average assessed due to the significant area held by this unit within the studied region.

8.2.3. The distribution of water resources in river basins

Analyzing the distribution of water resources in river basins in the upper sector of the Mureș we can say that the total flow collected from the study area was estimated at 11.46 m3 / s, of which nearly two-thirds comes from the territories adjacent to the upper basin of the Mureș, downstream Toplița.

Tributaries surfaces developed in areas with large pools of runoff lift gradients account for consideration of the volume of water transportations of Mureș (Răstolița 12% Toplița 9.6%, 9.47% Bistra, Ilva 9.33%).

PART III

THE FLOW REGIME OF THE RIVERS IN THE UPPER RIVER BASIN OF MUREȘ

The third part of this paper focuses on the flow regime in the upper basin of the Mureș river.

In the introduction to this part of the research we have dealt with history flow regime and the national and methodological issues underlying the research undertaken.

9. Istoricul cercetărilor şi aspectele metodologice privind regimul de scurgere al râurilor

9.1. History research of river flow regime

Nationally, the works devoted to the river flow regime with emphasis on the types of regime of rivers, their food sources and their characterization remain those of I. Ujvari, D. Lazarescu and up, 1957, Găştescu (1979, 2003), I Pișotă and Liliana Zaharia (2003).

Mures Upper Basin was covered in an article prepared in 1944 by I. Gugiuman it addressing the general theme of the hydrological regime of Mures and later in his summary Mures catchment hydrological developed in 1963, which address topics such as daily flow regime and regime phases for maximum flow and minimum periods stations set up at that time in the upper basin of the Mures: Suseni, Remetea Topliţa and Stânceni on the Mures River Răstoliţa Răstoliţa.

9.2. Methodological aspects of the study of river flow regime

A first step in the study of the surface water involves making a series of measurements on the water, these measurements will then be processed and the resulting material to be used to develop summaries and hydrological forecasts to ensure a working basis for design and then use hydraulic works and the organization and planning.

Strings and analyzed data needed to develop the study on flow regime in the upper basin of the Mures river are:

- Daily precipitation recorded at weather stations in the region analyzed for the period 1986-2010

- Maximum rainfall recorded within 24 hours, rainfall stations in the region in the period 1986-2010

- Duration and snow depth in the region during the period 1986-2010

- Monthly and annual average temperatures for the period 1986-2010

- Annual average flow, maximum annual flow, annual minimum flows recorded at 8 gauging stations in the region during the period 1986-2010

- Daily flows recorded in years with minimal leakage, average and maximum hydrographic stations in the region

- The first two annual floods representative at the eight stations under study between 1986-2010

The database was not limited to the hydrological and meteorological data, as they are complemented by cartographic documents, bibliographic materials, and information from field trips, during which personal observations were made.

10. The sources of alimentation of the rivers in the upper sector of Mureș

Sources feeding the rivers, prompting their dynamics on a diurnal, monthly, seasonal, annual and multi-annual level are the most diverse being consisting of groundwater (aquifers) and surface supplies (snow and water from precipitation). The share contributed by these sources to leak formation depends on the geographic factors that have been discussed in the previous chapters: the geological, geomorphological, edaphic, climatic and vegetation factors.

The high mountain region surface supply is dominated by snow (Zs> 50%), while the lower, valley supply consists of both rain and snow (Zs <50%).

In general, groundwater supply holds up to 30-35% of the annual runoff in the study area, resulting in its classification in the categories groundwater supply areas with moderate (Stânceni, Răstoliţa) and rich in Gheorgheni depression area (station Suseni).

The study area is characterized by the nivo-pluvial (zp-s) alimentation type in the Călimani mountains, especially for the rivers whose basins are located at an altitude of 1400-1800m and pluvio-nival (pz-s) with moderate groundwater supply that characterizes a good part of mountain and lowland habitat in the range 400 and 1600m altitude.

11. The rivers flow regime within the upper sector of Mureș

11.1. The daily flow regime

In order to characterize the daily flow regime we have chosen the method of case study for Gălăoaia station located in the gorge Mureș, on the river Mureș. Studying at the multiannual average flow (period 1986-2010) emerged three years representative that 2010 year maximum flow, average outlet 2004 year and 2000 year with minimal leakage.

For each year analysis were developed three basic graphs constituting of the daily rainfall, daily flow hydrograph and the snow depth graph.

The flow phases were divided into two categories namely maximum scrgere periods represented by high waters and floods that occur mainly in spring and minimum drain periods, often represented by the shallows of winter.

11.2. The monthly flow regime

Distribution of monthly regime during the upper basin of the Mureș river reveals a peak period in April (period dominated by floods and high waters) and the lowest recorded during the month of January (winter low water period).

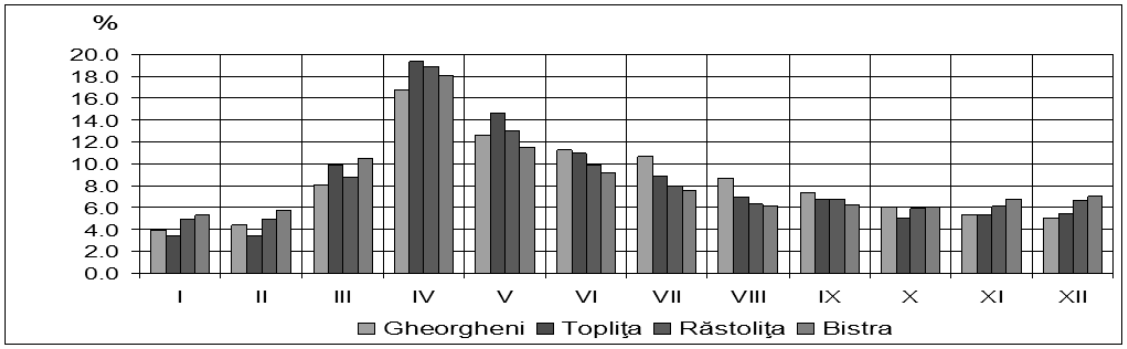

Fig 15 The monthly runoff regime of the Mureș main tributaries in the upper sector

The lowest percentage value for January-February characterizes Topliţa basin (3.74%), and most characteristic river Bistra (5.30%).

Among the sector Mureș upper tributaries, the most important contribution to the total flow is achieved during the month of April in Topliţa basin, (19.35%) and the main course, it can be identified in particular Stânceni stations (19, 73%) şiTopliţa (19.65%), which performs a similar share in this peak period.

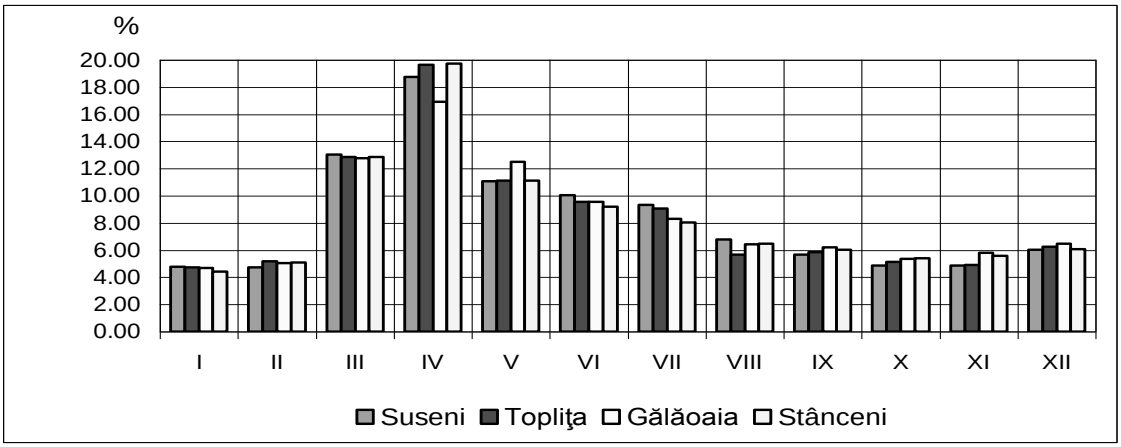

Fig 16 The monthly runoff regime of the river Mureș in its upper sector

Percentage values calculated for this period are allocated surplus Gălăoaia station on the river Mureş, this role being felt regularized attenuated runoff in the catchment scale, (16-17%) (Figure 16).

11.3. The seasonal flow regime

The percentage analysis of the spill spread over four seasons makes possible a first characterization of the flow regime, and a first step in the knowledge evolution of water flow. Upper basin of the Mureș River Basin fall within the typology mountainous with altitudes exceeding 800 m and whose drain is performed mainly in the warm season of the year (Figure 17).

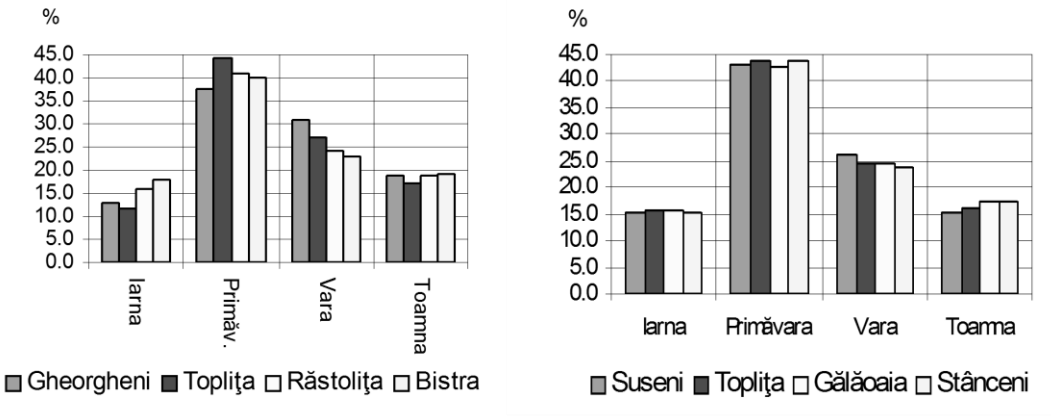

Fig 17 The seasonal flow regime of the main rivers of the upper basin of the Mureș

On an annual basis, the more concentrated the flow of the river spring while on the other hand, during the winter season river flow as low registered in the region.

This chapter deals with variance anotimpuale flow, highlighting the smallest flow anotimpuale respectively anotimpuale of the largest flow recorded at the main gauging stations in the region.

By statistical analysis of a series of 25 one can observe a growing trend characterizing rivers flow mainly during winter seasons, summer and autumn, while spring stagnate the last point on the Mureș hydrometric this sector: Gălăoaia.

12. The anthropic influence on the average flow in the upper basin of the Mureș

Anthropogenic influence on the average annual runoff in the upper basin of the Mureș river is one reduced their flow regime is not strong anthropogenic change in the study period.

Anthropogenic influence on the flow regime of rivers can be seen as taking place mainly in urban areas, Topliţa Gheorgheni and works through regulation and embankment which runs courses on several sections, especially in the gorge.

The area immediately around the spring Mureş, Suseni hydrometric station, the river flow do not differ between natural and measured, so we can say that on this stretch of 10 km between source and station drain is made as natural, unaffected.

In the gorge, Mureș has a flow regime influenced surplus (Q meas> Q nat) in right Topliţa hydrometric station (the entrance to the gorge), and slightly irregular in hydrometric station right Stânceni, (inside the gorge area).

Changes in the natural flow of the rivers in this area can be seen as particularly Mures River station located right Topliţa (Fig 18) and its tributaries in the main basin (Fig. 19).

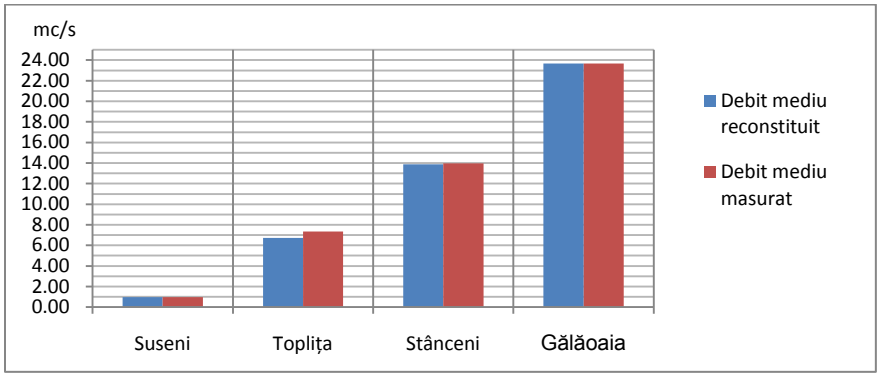

Fig 18. The natural and influenced flow measured on the river Mureș in its upper sector

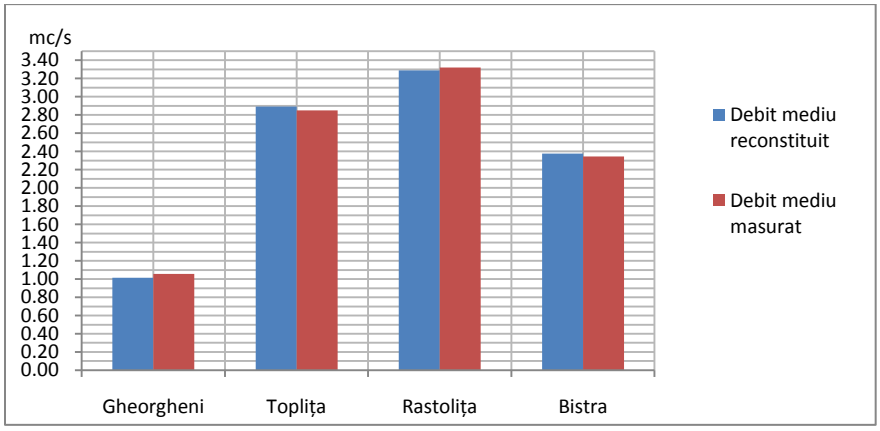

Fig 19. Fig 18. The natural and influenced flow measured on the main tributaries of the river Mureș in its upper sector

CONCLUSIONS

The upper river basin of Mureș from its spring until the settlement of Deda, consists of 42 tributaries of which 23 tributaries of the left and 19 right tributary, which implies an asymmetric basin slightly more developed on the left side. The study was designed on the basis of data from hydrometric stations oferitre: Suseni, Topliţa Stânceni, Gălăoaia Mureș River while tributaries to characterize the dynamics provided data on Belcina Gheorgheni hydrometric stations, Topliţa River Topliţa Bistra Bistra River Răstoliţa Răstoliţa River. Hydrometric station network is complemented by meteorological stations: Bucin, Retitis, Joseni Topliţa.

The factors influencing the distribution and flow regime of the rivers in this area factors that in turn, influence each other, are the geological, geomorphological, soil, climatic and vegetation cover as well as the human factor.

The geomorphological factor plays an important role in managing the climatic factors as well as others (soil, vegetation) determining through altitude and slope and slope orientation a natural setting for the wealth of water resources that can be found here.

Sources feeding the upper basin rivers Mureș have a surface and underground nature.

The main food sources of the rivers are the surface water from rain, melting snow and glaciers. Share with attending these sources depends on the latitude and altitude of the studied catchment and local geomorphological elements such as altitude of the basin, and the slopes within.

Groundwater supply is from ground water and depth. The role of these sources, especially the ground is very important during the winter when the water is stored on the land surface as snow, and in summer when evapotranspiration is high. The weight of underground power depends on the depth of water are ground, the permeability of the deposit and the amount of precipitation of that feed the aquifer.

In general, groundwater supply holds up to 30-35% of the annual runoff in the study area, resulting in its classification in the categories groundwater supply areas with moderate (Stânceni, Răstoliţa) and rich in Gheorgheni depression area (station Suseni).

A good part of the study area falls in the categories of food nivo-pluvial. Due to negative temperatures is one Nival power in the winter when snow remains on the land surface for intervals of 5-8 months per year according to altitude and mixed for nivo-pluvial intervals between 5-6 months per year, all in relation to altitude.

Widespread development of Mureș basin from spring until the exit of the gorge is outlined and multiannual average flow increase over the Mureș River 127 km traveled from the source, where the station right Suseni Mureș River recorded on average period 1986-2010, an annual average flow of 0.963 m / s to the last station on the Mureș River in the upper, Gălăoaia where Mureș record 23.665 m^3 / s

General tendency of the average flow in the upper basin of the Mureș in the period 1986-2010 is one of growth, consistent with the trend of increasing mean annual precipitation.

Water resource assessment was based Mureș identification validity of three curves that generated dividing surface in three areas of life. The analysis of the water balance in the area we can conclude that the richest surface water resources are found in the gorge Mureș, ie in the Bistrica Gălăoaia, where the influence of the relief area, western air masses loaded rainfall, are forced to concentrate in a narrow area and take an upward direction.

Analyzing the daily flow regime in the upper basin of the Mureș we can say that it is characterized as periods of high leakage, as evidenced by periods of high waters and floods, common in the spring season and during periods with low leakage that characterize rivers of this area in winter mainly in the range monthly from December to January as a result of negative thermal regime resulting in a large amount of water storage in solid form and block courses.

The human impact on the average annual runoff in the upper basin of the Mureș river is low, their drainage system is not heavily modified anthropogenic, in the study period.

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