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RESEARCH ON THE ENVIRONMENTAL QUALITY IN VÂLSAN RIVER BASED ON THE MACROZOOBENTHIC ANALYSIS

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Abstract
Vâlsan River is the only ecosystem in the world populated with Romanichthys valsanicola (asprete), a tertiary relict, with a very limited area of distribution, included in the Red List of U.I.C.N –Resolution D-46 of the CE, as critically endangerd species. Currently, Vâlsan River undergoes a cumulative effect of disturbances upstream, due to hydraulic improvements or human activity. It also affects the water quality and quantity, which requires taking emergency measures to mitigate it. This paper synthesizes and processes personal data on the structure of benthic zoocenosis of Vâlsan River during 2001-2015, aiming at setting the environmental status and water quality, especially through analysis of Ephemeroptera fauna.

Keywords: Vâlsan River, macrozoobenhtos, Romanichthys, asprete

1. INTRODUCTION

In the European Union, of which Romania is part, the concern for the water quality has been and remains a very topical issue. The strategies and policies in water management materialized through the adoption by the European Parliament (23th October 2000) of the Framework Directive "Water" 2000/60 / EC, implemented on 22nd December 2000 when published in the Official Journal of the European Union. The aim of these strategies is the balanced management of water resources and ecosystem protection, with the main objective to achieve a "good state" of surface water and groundwater.

The main instrument to implement the Framework Directive 2000/60 / EU in Romania is the River Management Plan (RMP) whose target was to obtain a "good state" of water in 2015. This was to ensure the same standard of living in terms of water for all citizens, and had to be within the Romanian National Plan for Water Management, part of the Danube River Management Plan.

In recent years, the study of benthic invertebrates has become particularly important, along with the study of other components of water biocenosis in terms of applying it to the Water Framework Directive 2000/60 / EC in Romania. This provides implementation of a National Programme to monitor the water quality in Romania, with macrozoobenthos as one of the basic elements in determining the quality of running waters.

The presence or absence of benthic invertebrate groups, their density and abundance, structure and diversity of zoocenosis provide important information to biomonitor the water ecosystem. The present work synthesizes and processes personal data on the structure of benthic zoocenosis of

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Vâlsan River during 2001-2015, aiming at setting the water quality, especially through analysis of Ephemeroptera fauna.

2. MATERIALS AND METHODS

Based on the physical geographical and climatic characteristics, water regime, physical and chemical characteristics of water, and also factors of human impact, Vâlsan River can be divided into several sectors with specific morphostructural and functional aspects, within which is necessary to analyze the structure and dynamics of biocenoses to complete the hydrobiological picture of Vâlsan River. Given the heterogeneity of biotope structure and the human impact on the river there were formed 8 stations along the watercourse for benthic and bioderma sampling (fig. IV.1), as follows:

Station 1 - Alunu - characteristic of the upstream lake, 1 km far from it ($45^0$25'3030"N, 24^0'147"E). It is standard in comparison to stations downstream of the dam to highlight the impact of hydraulic improvements on the river;

Station 2 - Poieni Vâlsan - characteristic of the reservoir Cheile Vâlsan, 1 km downstream ($45^0$22'2175"N, $24^0$43'4789"E) which aimed to determine both the impact of hydraulic improvements on the river biocenothic structures and the effects of seasonal tourism;

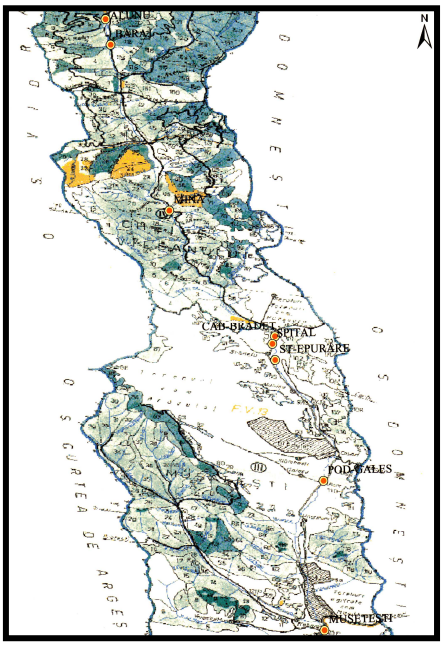

Figure 1. Locating sampling stations

Station 3. Mina veche – characteristic of Cheile Vâlsanului sector, located next to the mine ($45^0$21'4785"N, $24^0$43'6753"E);

Station 4 – Cabana Brădet – located about 1 km far from the exit of Cheile Vâlsanului ($45^0$18'9215"N, $24^0$45'7795"E), this area represents the upper limit of asprete spreading area. It highlights the impact of tourism in this area and wastewater discharge from the chalets;

Station 5 – Upstream of the wastewater discharge from Brădet Sanatorium ($45^0$18'4523"N, $24^0$45'7779"E)**.**

Station 6 - Downstream of the wastewater discharge from Brădet Sanatorium*; it highlights the impact of wastewater discharge on the structure of biocenosis in Vâlsan River;* ***Station 7 – Pod Galeş*** *- located at the lower end of Brădet-Galeş sector, and the spreading area of asprete* ($45^0$16'0219"N, $24^0$46'7205"E). *The human impact is mainly specific to the riverside households;* **Station 8 – Pod Muşeteşti** - characteristic of Muşeteşti-Mălureni sector ($45^0$13'0565"N, $24^0$46'6967"E), a densely populated area with houses on the river bank and landfills next to the watercourse.

Benthos samples were taken using a modified Surber Sampler benthic grid. Each station provided 10 quantitative samples from the river banks and the centre of the river, thus covering all biotope mosaic. Qualitative samples were also added across the river from its source to its mouth. Frequency, relative abundance of species, Shannon-Wiener diversity index (according to Botnariuc and Vădineanu, 1982) and equitability were calculated for Ephemeroptera in particular. Based on Ephemeroptera fauna, there was calculated the saprobity index (according to Pantle and Buck, 1955) for each river sector in order to characterize the quality of Vâlsan River.

3. RESULTS AND DISCUSSIONS

Qualitative analysis

In terms of qualitative structure, the macrozoobenthos of Vâlsan River includes representatives of all groups of invertebrates characteristic of rivers, namely: turbellaria, oligochaeta, hirudiniformes,

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amphipoda, dragonflies, ephemeroptera, plecoptera, trichoptera, black flies, blepharoceridae, chironomidae and other less important groups present sporadically and incidentally in qualitative samples (table 1). A brief analysis in terms of systematic bodies identified highlights the following aspects: *Turbellaria* were rarely identified being represented by *Crenobia alpina* and *Dugesia gonocephala* in the upstream sector of the lake, and *Dendrocoelium lacteum* in Brădet generally in the qualitative samples and very rarely in the quantitative ones. *Oligochaeta* are scarce along the river, being identified sporadically in some samples upstream of the lake, downstream of the dam in Poienile Vâlsan and Mina Veche and once in the lower course of the river, in Pod Galeş and Muşeteşti. A low number of qualitative samples were also identified at the confluence of Argeş River.

Table1. Benthic invertebrates fauna structure – Vâlsan River

SPECIES	ALUNU	POIENI	MINĂ	CABANĂ	AMONTE	AVAL	GALEŞ	MUŞETEŞTI	CONFLUENŢĂ
TURBELARIATA									
Crenobia alpina	+	-	-	-	-	-	-	-	-
Dendrocoelium lacteum		-	-	+	-	-	-	-	-
Dugesia gonocephala	+	-	-	-	-	-	-	-	-
OLIGOCHAETA	+	+	+	-	-	-	+	+	+
HIRUDINEA									
Erpobdella octoculata	-	-	-	-	-	-	-	-	+
AMPHIPODA									
Gammarus balcanicus	+	+	+	+	+	+	-	-	-
ODONATA	-	-	-	-	-	-	-	-	+
EPHEMEROPTERA									
Baëtis alpinus	+	+	+	+	+	+	-	-	-
Baëtis lutheri	+	+	+	+	+	+	+	+	-
Baëtis muticus	-	-	+	+	+	+	+	+	-
Baëtis rhodani	-	+	+	+	+	+	+	+	-
Baëtis scambus	-	+	+	+	+	+	+	+	-
Baëtis vernus	-	+	+	+	+	+	+	+	-
Caenis macrura	-	-	-	+	+	+	+	+	-
Ecdyonurus dispar	+	+	+	+	+	+	+	+	-
Ecdyonurus torrentis	-	+	+	+	+	+	+	-	-
Ecdyonurus venosus	-	+	+	+	+	+	+	+	-
Epeorus sp.	+	+	+	+	+	+	+	-	-
Ephemera danica	-	-	-	+	+	-	-	-	-
Ephemerella ignita	+	+	+	+	+	+	+	+	-
Habrophlebia fusca	-	-	-	-	+	-	-	-	-
Paraleptophlebia submarginata	+	+	+	+	+	+	+	-	-
Rhithrogena semicolorata	+	+	+	+	+	+	+	+	-
PLECOPTERA									-
Chloroperla tripunctata	-	-	-	-	+	+	+	+	-
Isoperla grammatica	-	-	-	-	+	+	+	+	-
Isoperla rivulorum	+	+	+	+	-	-	-	-	-
Isoptena serricornis	-	-	-	+	+	+	+	+	-
Leuctra hippopus	+	+	+	+	+	+	+	+	-
Leuctra sp.	+	+	+	+	+	+	+	+	

The species identified among hirudiniformes was - *Erpobdella octoculata* – present only in qualitative samples at the confluence of Vâlsan with Argeş Rivers, which shows a high degradation of quality under the cumulative influence of anthropogenic factors on the river, being an indicator for α-mezosaprobic waters. Amphipoda, represented by *Gammarus balcanicus* are present in the upper course of the river, upstream of the dam and downstream of Brădet area, but their number and frequency remain consistently low. The dragonflies have been rarely identified in the qualitative samples at the confluence with Arges River, where biotope conditions permit their development, and the water flow rate is much lower.

Given that most of the river course is in the mountains and foothills, it is certain that its benthic biocoenosis is dominated by litoreophila from the group of ephemeroptera, plecoptera and trichoptera, to which black flies and chironomidae are added, especially in the lower course of the river. *Plecoptera* have a relatively large number of representatives, including *Nemoura cinerea, Nemurella pictetii, Protonemura intricata* and *Leuctra hippopus.* They have a ubiquitous nature, throughout the river. Overall, both the number of species and number density of this group mark a progressive decrease from upstream to downstream, which are specific to the rhitron, with the highest diversity in the upstream reservoir. *Protonemura praecox, Perla bipunctata, Perla grandis, Isoperla rivulorum* and *Siphonoperla torrentium* are present exclusively in the upstream stations to Brădet no longer identified in the middle and lower course. They are stenobionte species, sensitive to changes in biotope, and water quality. On the contrary, *Isoptena serricornis, Chloroperla tripunctata* and *Isoperla grammatica* were identified

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especially in the middle and lower course of the river, with much lower frequencies and densities. Trichoptera have a relatively uniform distribution, a diversity comparable to the other two, but the number density is relatively low. The highest specific diversity was recorded in the upstream sector of the lake where there were identified a number of species no longer found downstream, which shows that hydrotechnical improvements have brought about significant changes in the structure of this genus. Such is the case of the species *Sericostoma personatum, Sericostoma timidum, Brachycentrus montanum, Philopotamus montanum* and *Hydropsyche angustipenis* which were replaced downstream by *Rhyacophila septentrionis, Rhyacophila nubila, Rhyacophila sp., Hydropsyche pellucidula, Hydropsyche sp., Stenophylax stellatus,* meant to completely disappear in the downstream sector of Muşeteşti to the inflow. Black flies are rare with low density of the samples upstream of Vâlsan River being represented by *Prosimulium hirtipes.* These species were replaced downstream by *Simulium reptans* and *Simulium venustum* with low densities throughout the research. *Simulium angustipenis* and *Simulium ornatum* were added downstream of Galeş to its inflow. Chironomidae are absent or present in very small number upstream of the dam, just like in Cheile Vâlsan, being underrepresented downstream of the dam in Poienile Vâlsan. Their diversity and density rise progressively from Brădet to the river inflow. The prevaining species indicating water quality are *Ablabesmya monilis*, *Ablabesmya longistyla* and *Cricotopus bicinctus* with very high densities in the lower course. Species *Blepharicera fasciata* and *Liponeura sp.* should also be mentioned, even if they are less present in the qualitative samples identified only sporadically upstream of Brădet.

ECOLOGIC ZONING OF VÂLSAN RIVER BASED ON EPHEMEROPTERA

The research on macrozoobenthos in Vâlsan River paid special attention to Ephemeroptera populations, taking into account their environmental peculiarities as indicators of water quality. After the processing, 16 species have been identified in Vâlsan River: *Baëtis alpinus, Baëtis lutheri, Baëtis muticus, Baëtis rhodani, Baëtis scambus, Baëtis vernus, Ecdyonurus dispar, Ecdyonurus torrentis, Ecdyonurus venosus, Epeorus sp., Rhithrogena semicolorata, Paraleptophlebia submarginata, Habrophlebia fusca, Ephemera danica, Ephemerella ignita, Caenis macrura.* Most species belong to baetidae (6 species belong to Baëtis), followed by 5-taxon heptageniidae, including 3 *Ecdyonurus* species, one *Rhithrogena* species, and other representatives of *Epeorus* species. In terms of the specific structure of Ephemeroptera fauna, 15 taxa (figure 2) have been identified in Cabana Brădet station and upstream inflow, throughout the research period. 14 species, except for *Ephemera danica*, were present in the upstream inflow and other 13 species were identified in Poieni Vâlsan, Mina Veche and Pod Galeş. The fewest species (6) were found in Alunu station, which is the most upstream point of the research area.

The ***relative frequency of species*** is an important indicator to characterize biocenosis. Species *Baëtis alpinus* and *Rhithrogena semicolorata* have a frequency of 100% in Alunu – Mina Veche sector (figure 3).

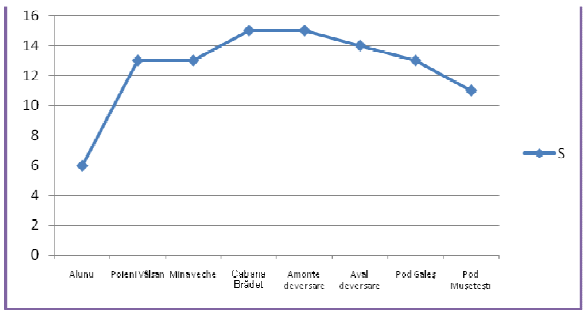

Figure 2. Number of taxa identified in each sampling station in Vâlsan River

These are added to *Baëtis lutheri* Poieni Vâlsan – upstream inflow station with the same frequency. The frequency of *Baëtis Rhodan* increases from upstream to downstream, reaching 100% (figure 4) in the

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last three stations. The lowest frequencies were met in *Ephemera danica* (maximum 25% upstream inflow), as well as in *Caenis macrura* in the inflow area. *Epeorus* genus has high frequency in the upstream stations, with a maximum of nearly 60% in Poieni Vâlsan and Mina Veche stations.

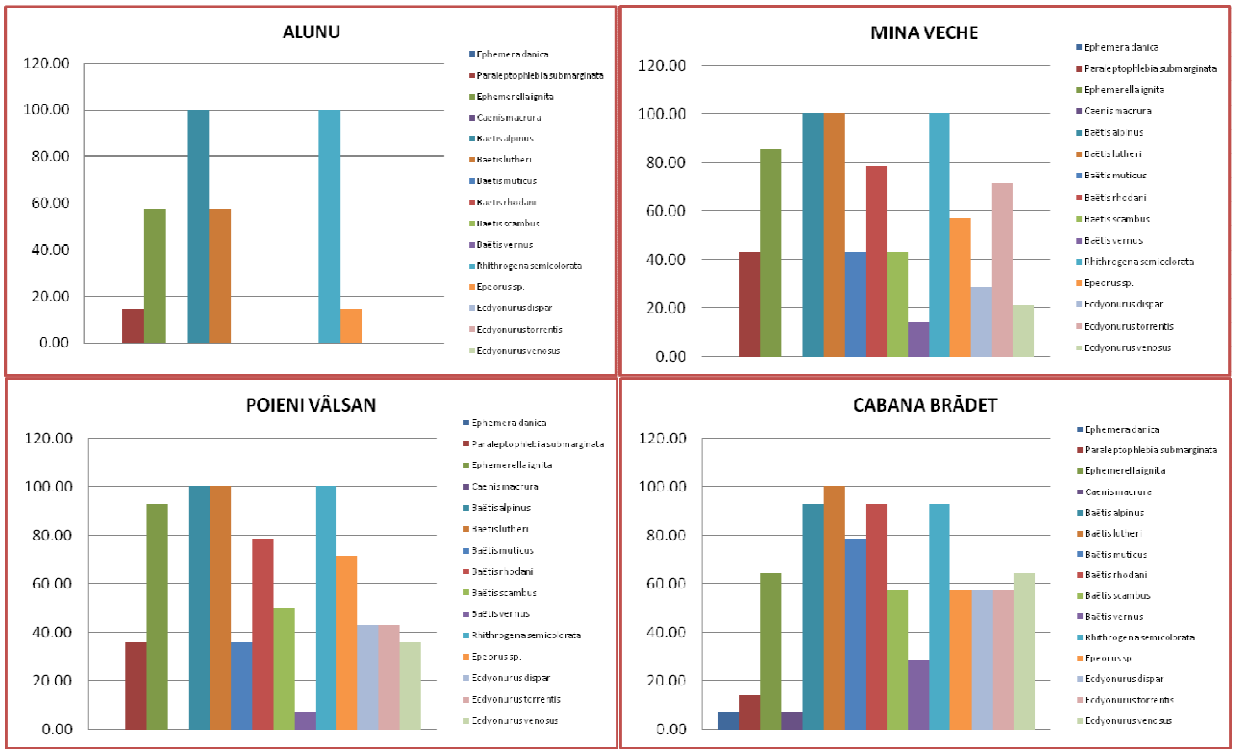

Figure 3. Frequency (%) of Ephemeroptera species in the sampling station Alunu – Cabana Brădet

The relative abundance of species in each sampling station reveals important aspects of Ephemeroptera fauna and gives clear indications about the ecological zoning of the river (figure 5-6). The prevailing species in Alunu station is *Baëtis alpinus* with a relative abundance of 57.44%, followed by *Rhithrogena semicolorata* (34.66%). The other species identified have a relative abundance below 7%. *Baëtis lutheri* is also present with a low relative abundance of only 6.13%.

The relative abundance of *Baëtis lutheri* in Poieni Vâlsan station increases substantially reaching 22.90%, very close to that of *Baëtis alpinus* - 23.11% and *Rhithrogena semicolorata* - 29.46% All three species are prevailing. *Ephemerella ignita* is added with an abundance of 9.24%. *Rhithrogena semicolorata* (36.7%), *Baëtis alpinus* (27.15%) and *Baëtis lutheri* (15.29%) prevail in Mina Veche.

The biotope mosaic in Brădet station reveals the diversity of Ephemeroptera fauna. The prevailing species *Rhithrogena semicolorata* has a relative abundance of 46.15%, the highest recorded downstream of Poieni sector. *Baëtis lutheri* (17.72%) and *Baëtis rhodani* (15.77%) have close abundances (17.72% and 15.77%). The other species have much lower abundances below 2%.

The comparison between the two stations upstream and downstream of wastewater discharge from Brădet Sanatorium shows that there are not surprisingly high differences. The highest relative abundance for both stations was recorded by *Rhithrogena semicolorata* (32.95% and 33.83 %), along with all the other baetidae mentioned above.

The biotope of the station upstream is characterized by extensive areas of clay with sand and detritus accumulation on of the river bank. This is reflected in the structure of biocenosis through the great abundance of *Baëtis muticus* (oligosaprobes) – 14.97%. The two stations lie between metarhitron and hyporhitron, a heavily trafficked area. Moreover, these features of the biotope maintain broadly to the inflow of Vâlsan River into Argeş.

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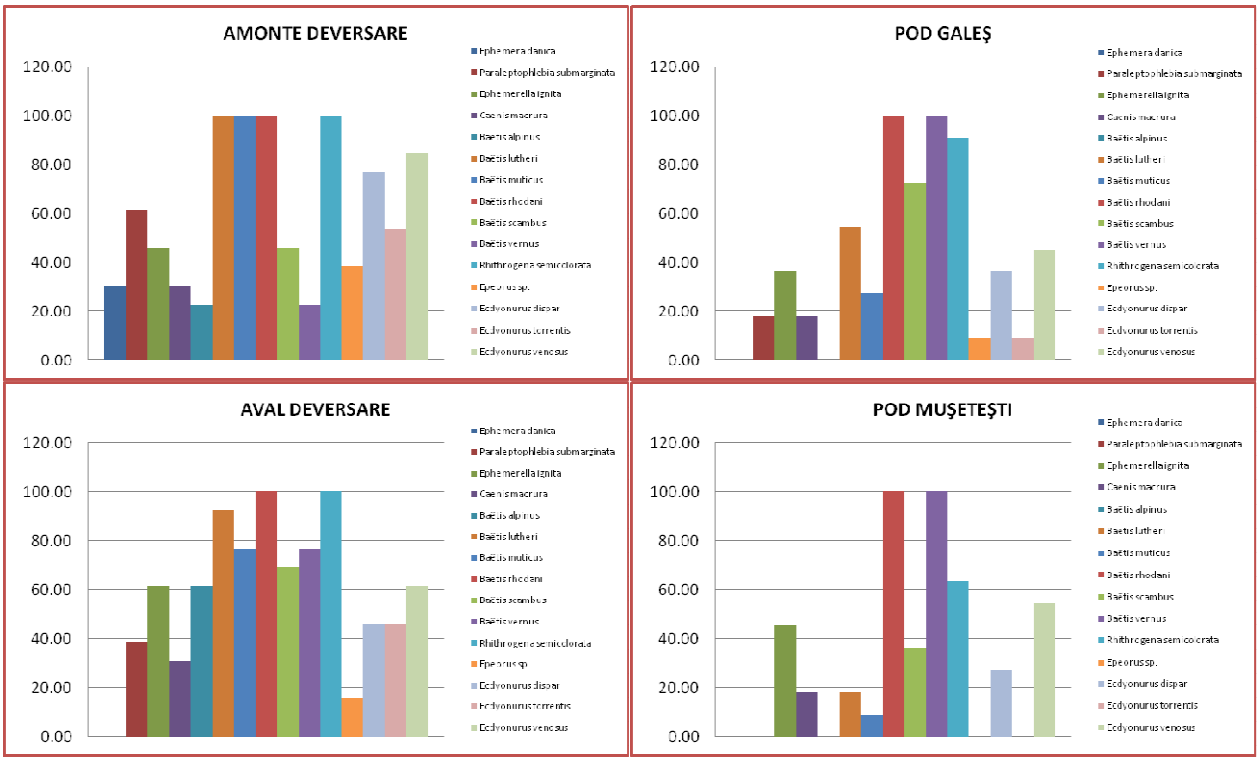

Figure 4. Frequency (%) of Ephemeroptera species in the sampling station upstream inflow– Pod Muşeteşti

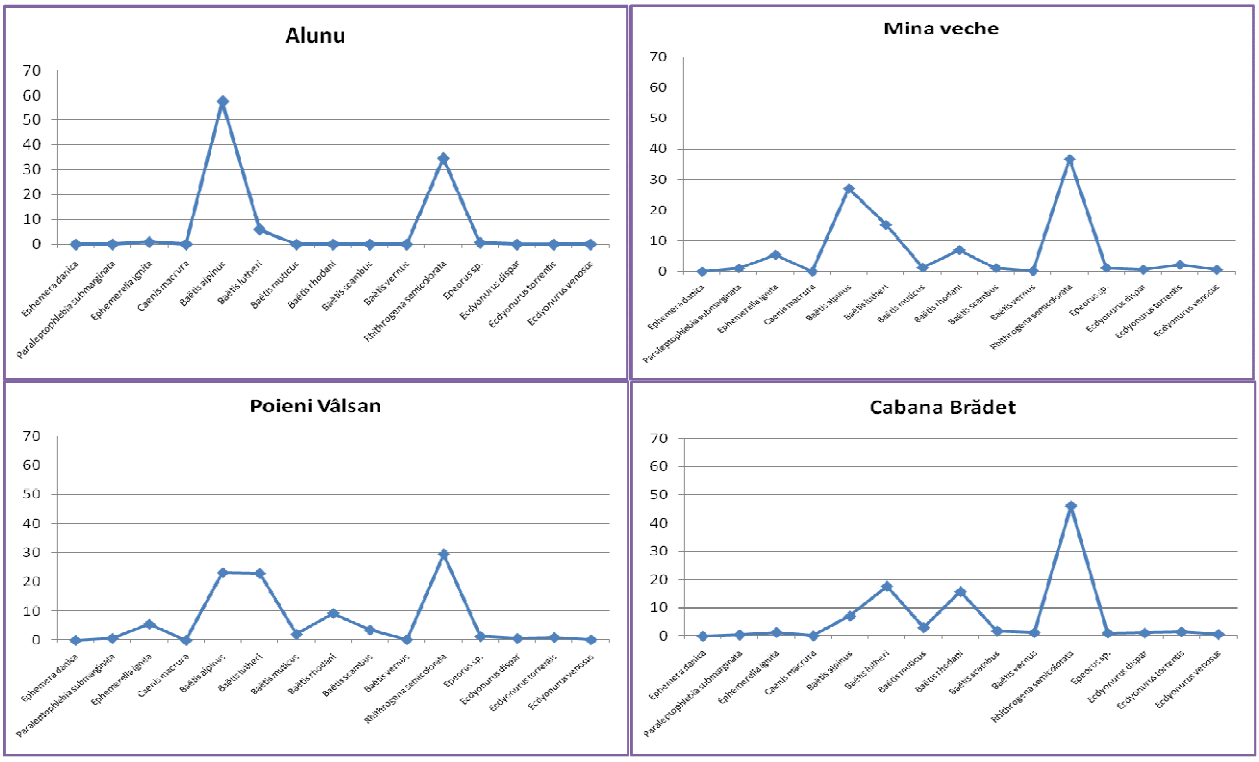

Figure 5. Relative abundance of Ephemeroptera species in Alunu – Cabana Brădet sampling stations

The last two sampling stations, Galeş and Muşeteşti maintain the downward trend of relative abundance for *Rhithrogena semicolorata* (20% and 11.97%) and *Baëtis lutheri* below 10%, with increasing relative

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abundance for *Baëtis rhodani* (over 30% in Galeş) and *Ephemerella ignita* (29.56% in Muşeteşti). Both are indicator species for ecosystems with high organic load.

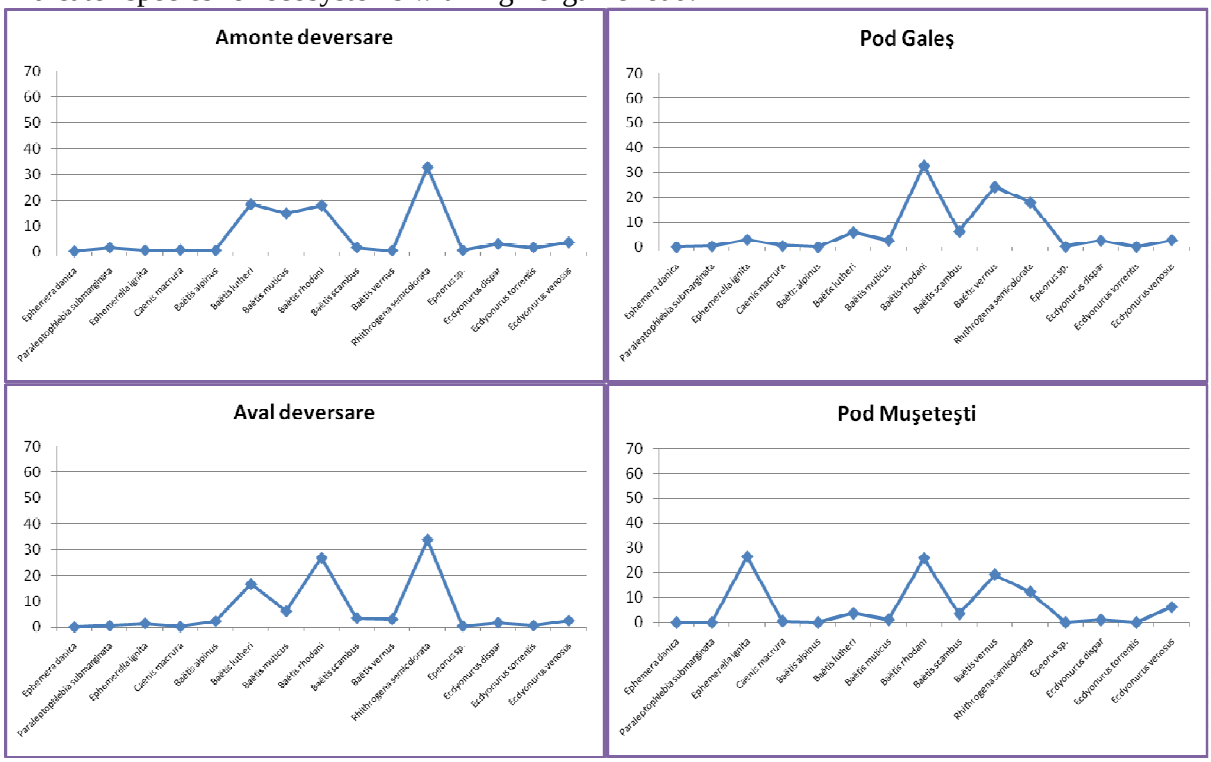

Figure 6. Relative abundance of Ephemeroptera species in the upstream inflow -Pod Muşeteşti

The *diversity, equitability and dominance indices* for each sampling station were calculated for an accurate assessment of the structural dynamics of Ephemeroptera in Vâlsan River along the watercourse. The lowest diversity was recorded in Alunu station, throughout the research period, whereas the highest diversity was recorded in Brădet station, in June 2001.

Based on data in every sampling period, it appears that both diversity and equitability (Figure 7) are the lowest in the upstream sector of the lake, greatly increasing downstream with a slight decrease in Cabana Brădet and Mina Veche. The values for the other stations are very close.

The analysis of frequency, relative abundance, diversity indices, equitability and dominance, as well as saprobity indices specific to each species reveal the following aspects related to ***ecological zoning and water quality in Vâlsan River:*** *Baëtis alpinus* (oligosaprobe indicator) is the dominant species in the upstream sector of the lake, along with *Rhithrogena semicolorata* (β-mezosaprobic). This structure of Ephemeroptera fauna encloses the area upstream of the lake in epirhitron sector dominated by erosion. The dominant underlayer is made up of coarse gravel, boulders, logs and branches providing shelter for wildlife (according to Gâldean, 1992). *Baëtis lutheri* is also present here, marking the transition to metarhitron area. In terms of quality, *Baëtis alpinus* species prevails with the highest frequency and relative abundance. As indicator of oligosaprobe waters, it shows that it is a weakly contaminated area, with a very good ecological state. Saprobity index (S) of this area, calculated for the entire research period is 1.3 specific to ***oligosaprobe area***, with a trend of development towards oβ-mezosaprobic. For the downstream dam - entrance to Cheile Vâlsan, structure of Ephemeroptera fauna, by the presence and dominance of *Baëtis lutheri* (oβ-mezosaprobic) *Baëtis alpinus*, *Rhithrogena semicolorata* (β-mezosaprobic), and *Ephemerella ignita* (β-mezosaprobic) includes the sector into metarhitron area with an underlayer of boulders, medium-size gravel, and areas accumulating fallen leaves. Saprobity index S (1.7) indicates an average organic load corresponding to ***oβ-mezosaprobic area.***

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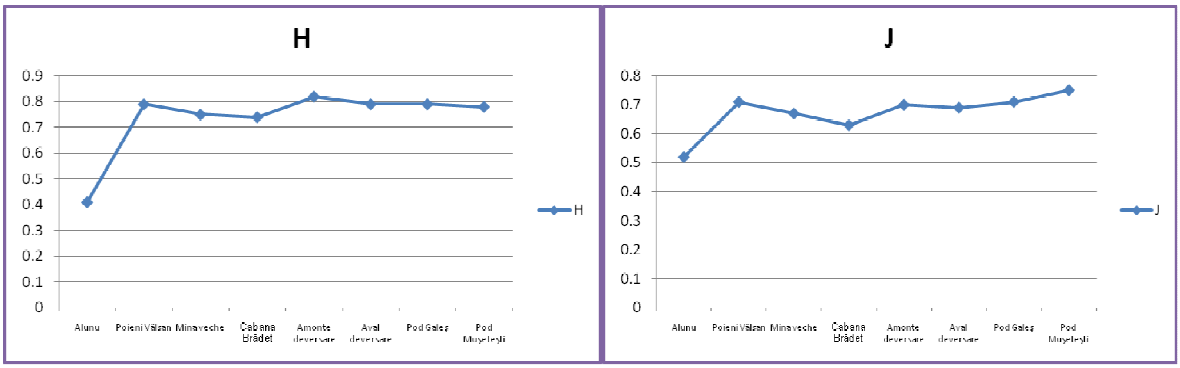

Figure 7. Diversity (H) and Equitability (J) of Ephemeroptera community in global Vâlsan River, for the entire research period

4. CONCLUSIONS

In conclusion, ecological areas of Vâlsan River, biotope and saprobiological characteristics can be summarized as follows:

RIVER SECTOR	UNDERLAYER TYPE	PREVAILING SPECIES	WATER QUALITY
UPSTREAM LAKE	boulders, course gravel, logs and branches providing shelter in fauna	*Baëtis alpinus*	oβ- saprobic
DOWNSTREAM DAM - ENTRANCE TO CHEILE VÂLSAN	boulders, medium size gravel, alternating with areas of fallen leaves	*Baëtis alpinus* *Baëtis lutheri* *Rhithrogena semicolorata*	β-saprobic
CHEILE VÂLSAN	big boulders and stone	*Baëtis alpinus* *Rhithrogena semicolorata*	oβ- saprobic
EXIT TO CHEI - GALEŞ	Medium size gravel, elements that can be driven by the tide, alternating with large clay and sandy areas, detritus accumulation on the river bank, and areas of leaves fallen during the autumn.	*Baëtis rhodani* *Baëtis lutheri* *Baëtis vernus* *Rhithrogena semicolorata*	β-saprobic
GALEŞ – CONFLUENCE WITH ARGEŞ RIVER	Fine gravel, medium size sand course	*Baëtis rhodani* *Ephemerella ignita* *Baëtis vernus*	βα-saprobic

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