THE „BABEŞ-BOLYAI" UNIVERSITY CLUJ-NAPOCA
Faculty of Biology and Geology
Department of Taxonomy and Ecology

STUDIES ON THE BENTHONIC DIATOM COMMUNITIES FROM THE ARIEŞ RIVER (TRANSYLVANIA)

PhD Thesis

(Summary)

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C O N T E N T

Keywords: epilithic and epipelic diatoms, Arieş River, water quality, specific diversity, the influence of abiotic factors, seasonal dynamics, degree of saprobity, biological diatom index.

The thesis is structured on six chapters comprising 187 pages and 3 annexes, 108 figures, 17 tables, one table in Annex (1) and 18 tables in Annex (2). The list of references includes 204 titles and 14 internet links.

INTRODUCTION

The study of diatom communities in the Arieş River was approached in the last decades of the 20^{th} century by the algological research team of Cluj-Napoca (Momeu and Péterfi, 1984, 1985) and the investigations subsequently continued up to the present day.

My research aims to complete with new findings the available data on the diatom communities in the catchment area of the Arieş. This study is based on the investigations carried out during the spring, summer and autumn of 2008 and 2009, targeting the diatom flora, characterization of communities inhabiting in the Arieş River and its major tributaries, between Arieşeni - Vârtop (ski slopes) and Luncani village (commune Luna), namely specific diversity, seasonal dynamics and floristic affinities among communities.

In this study I followed also the estimation of the watercourses quality investigated using Biological Diatom Index (BDI) and evaluating the level of saprobity by employing the saprobic index (SI) proposed by Zelinka and Marvan (Sládeček, 1973)

The main research directions proposed were:

1. To complete the check list of benthic diatom species living in the Arieş River and its main tributaries;
2. To establish the relative qualitative and quantitative compositions of benthic diatom communities in the Arieş River basin;
3. Calculation of diversity and equitability indices of the diatom communities based on samples taken in the Arieş and its major tributaries;
4. Assessment of the ecological status of water in the Arieş River and its major tributaries based on the biological diatom index (BDI).
5. Estimates on water quality using the saprobic index (SI).

Calculated indices may suggest the changing of water quality by pollution sources and layout making any arrangements necessary for the "recovery" Arieş River.

I. ABOUT STREAMS IN GENERAL

Streams and rivers are particularly fascinating ecosystems for research, very diversified, highly variables in space and time (Giller and Malmqvist, 2006).

They are characterized by a number of features, differing in many aspects from the other aquatic ecosystems:

- Flowing waters are unidirectional, for example flow in one direction, from hill to valley, but are no way uniform, the lower parts are influenced by the upper parts; physicochemical parameters as well as living communities present longitudinal zones (for stagnant waters contrast with vertical zones).
- They are more elongated and narrow waters like form (linear) flowing in a narrow channel (riverbed).
- The morphology of the riverbed is rather variable (unstable), rivers erode (demolish), transport and store (build).
- The ecosystems of the streams are open and are closely related to the surrounding terrestrial ecosystems, the connection being unidirectional in the upper part, from the land towards the river, but realizing in both directions in the lower parts (the relationship river - floodplain). River carries organic waste and dissolved substances from the source to its estuary.
- The space and temporal diversity (heterogeneity) is emphasized at all levels: geological substrate, flow velocity, riparian vegetation, water chemistry, and biodiversity as well as habitat variability.
- The ecosystems of the streams are apparently organized hierarchically; river systems are parts of systems increasingly higher, from the smallest particles to the whole river.
- The Differences between the rivers are high (high variability), each river varies from neighboring rivers because their fundamental characteristics are determined by location and morphology of the basin, geological substrate, altitude of the territory, surrounding vegetation, the way farming and livestock (Cummins et al., 1984).

Rivers are inhabited by communities of plants and animals adapted to these particular conditions.

II. GENERAL CHARACTERIZATION OF THE INVESTIGATED TERRITORY

About the Arieş river, Aureus in Latin, Aranyos in Hungarian, the oldest attestations one can find are in some texts written in Hellenic (Crisol) or Latin (Auratus). It is one of the rivers in Transylvania, northwestern Romania, it rises from Masivul Bihorean (the Bihor massif), the core of the Munţii Apuseni (the Romanian Western Mountains) (Fig. 1). The river has a total length of about 164 km and flows into the Mureş river by downstream of the town Luduş. The distance covered between the source and its influx, nearly two hundred miles, crossing the territory of two districts - Cluj and Alba, and passes through two larger towns Turda and Câmpia Turzii.

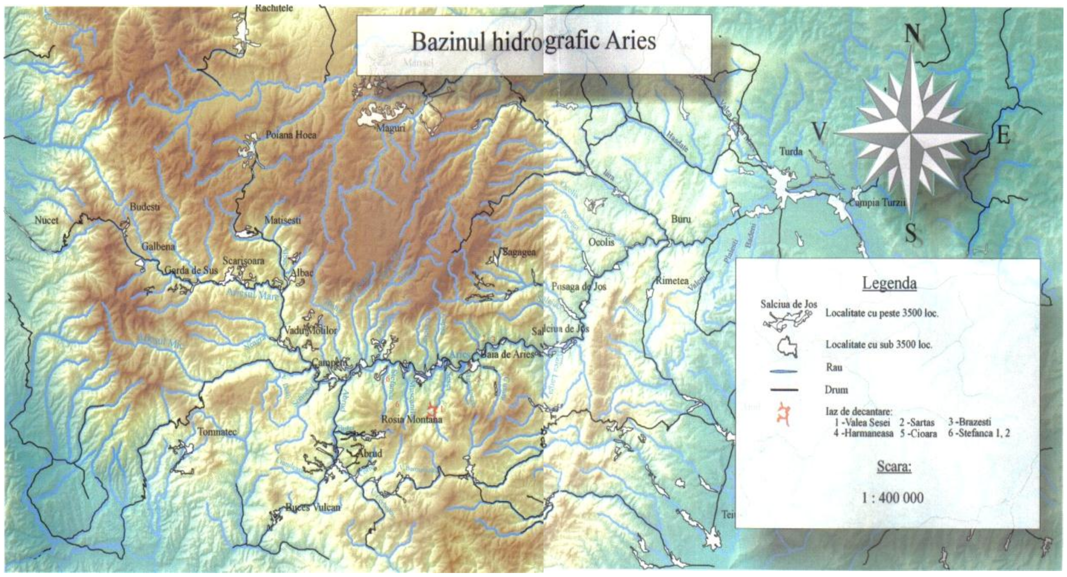


Fig. 1. Physicogeographical map of the Arieş river basin

(General atlas, 1974 Ed. Teaching and Pedag., Bucharest)

III. BRIEF HISTORY OF THE DIATOM RESEARCHES

In the Arieş basin the researches had been started in the late 20th century, but they were only intensified in recent years. These investigations were primarily related to the structure of diatom communities (Momeu, Péterfi, 1984, 1985). The latest investigations about the diatom communities in the Arieş basin, namely those in the 21th century have been published by Chiriac et al., (2005) and Momeu et al., (2009). Some of the recent researches deal with the assessment of water quality in the drainage basin of the river using epilithic diatoms like bioindicators (Momeu, Budurlean and Cristea, 2005; Momeu and Péterfi, 2007).

IV. DESCRIPTION OF THE SAMPLING SITES OF THE ARIEŞ RIVER AND ITS MAJOR TRIBUTARIES

4. 1. Presentation of the sampling sites

For exemplification we mention below four sampling sites, as follows: A. 4, A. 9, A. 13 and A. 18.

Sampling site A. 4. – „Arieşul Mare-amonte Albac"

It is a picturesque place, natural looking, located in the upper part of the catchment area of the Arieş, namely on the Arieşul Mare rivulet (arm) in the northwestern part of Alba district, at 19 km distance from the town Câmpeni. The sampling site is situated at an altitude of 592 m a.s.l. and lies next to the left bank of the rivulet. The substrate consists of stones and gravel, the average water depth is 35-40 cm and width of the bed of 2.5-3.5 m (Fig. 2).

Fig. 2. Sampling site A. 4 – „Arieşul Mare -upstream Albac”. Downstream view (a) upstream view (b)

Sampling site A. 9. – „Pârâul Şesii”

The sampling site is situated on Pârâul Şesii, the right tributary of Arieş, a stream with mountain character, at an altitude of 497 m a.s.l. The water flows from the Metaliferi Mountains and exhibits marks of the mining activities of Roşia Montana. The substrate consists of boulders, rocks and mud; the average water depth was 20-30 cm and the width of the bed of 1-1.5 m (Fig. 3).

Fig. 3. Sampling site A. 9 – „Pârâul Şesii”. Downstream view (a) upstream view (b)

Sampling site A. 13. – „Arieş-upstream shedding of Valea Ocolişului”

This sampling site is located on the left bank of the Arieş river, at an altitude of 417 m., upstream from spilling stream Valea Ocolişului. The substrate consists of stones and gravel, the average water depth is 60-80 cm and width of the bed of 6-7 m (Fig. 4).

Fig. 4. Sampling site A. 13 - River Arieş - upstream - shedding Valea Ocolişului: view towards downstream (a) - in the left side of image see the mouth of Valea Ocolişului. Upsream view (b)

Sampling site A. 18. Arieş „Luncani”

Luncani (Grind) is a village in Cluj district, and belongs to the commune Luna. It is the last sampling site on the Arieş River, jus that above its inflow into the River Mureş. The Arieş River ends its long “journey”, after crossing the whole basin, being one of the tributaries of the River Mureş, contributing with 16% to its flow. The sampling site is situated at an altitude of 278 m a-s.l., on the right bank of the Arieş. The substrate is composed of rocks and sand, the average water depth is 1-1.5 m, width of bed 15-17 m (Fig. 5).

Fig. 5. Sampling site A. 18 – Arieş „Luncani”. Arieş River: downstream view (a) upstream view (b)

V. MATERIALS AND METODS

Sampling of the algologic material

- Sampling of specimens from rivers and streams
- Labeling of samples
- Methods of preserving diatoms
- Methods for processing diatoms in the laboratory
- Examination of biological samples
- Making microscopic preparations
- Examination of preparations
- Statistical analysis

RESULTS AND DISCUSSION

VI. 1. PHYSICOCHEMICAL PARAMETERS OF ARIEŞ RIVER BETWEEN 2008 AND 2009

Table no. 1. Changes of the water temperature in Arieş River and its tributaries in 2008 and 2009

Sampling sites in the Arieş basin	28. 05. 2008	29. 10. 2008	06. 05. 2009
	Water temperatures (ºC)	Water temperatures (in ºC)	Water temperatures (in ºC)
Arieşul Mare Vârtop - mlaştină	15.6	8.0	8.2
Arieşul Mare Arieşeni – Vârtop	17.1	8.3	8.2
Gârda Seacă	13.9	7.5	12.5
Arieşu Mare amonte Albac	15.1	7.2	11.6
Valea Albacului	17.9	6.8	11.2
Arieşul Mic	17.8	7.4	13.6
Arieş Amonte Câmpeni	18.0	7.6	12.0
Abrud	18.8	7.2	13.01
Pârâul Şesii	22.2	7.2	12.7
Arieş la Valea Lupşii	17.5	7.7	11.6
Arieş Brăzeşti	18.1	8.3	11.9
Valea Ocoliş	21.7	8.3	16.8
Arieş amonte vărsarea Văii Ocolişului	17.4	7.0	11.5
Hăşdate	22.2	5.8	15.2
Arieş aval vărsare Hăşdate	17.6	8.1	13.7
Racoşa amonte vărsare	19.0	10.2	15.1
Arieş Racoşa	18.0	6.8	17.0
Arieş Luncani	18.4	2.5	14.7

Table no. 2. Changes in water conductivity (µS.cm-1) of the Arieş river and its tributaries in 2008

Sampling sites of the Arieş basin	28. 05. 2008	20. 08. 2008	29. 10. 2008
	Conductivity ($\mu S.cm^{-1}$)	Conductivity ($\mu S.cm^{-1}$)	Conductivity ($\mu S.cm^{-1}$)
Arieşul Mare Vârtop - mlaştină	15.20	21.0	13.22
Arieşul Mare Arieşeni – Vârtop	20.2	21.6	15.74
Gârda Seacă	8.5	20.1	13.43
Arieş Mare amonte Albac	7.3	14.80	11.29
Valea Albacului	8.59	14.26	13.93
Arieşul Mic	8.63	11.1	6.62
Arieş Amonte Câmpeni	11.0	64.7	12.39
Abrud	34.0	115.2	13.67
Pârâul Şesii	20.0	16.8	11.83
Arieş la Valea Lupşii	14.8	56.8	7.16
Arieş Brăzeşti	16.5	15.84	13.40
Valea Ocoliş	69.3	21.0	13.56
Arieş amonte vărsarea Văii Ocolişului	30.0	19.0	9.32
Hăşdate	85.4	21.7	12.22
Arieş aval vărsare Hăşdate	32.0	19.5	12.13
Racoşa amonte vărsare	66.2	27.0	8.55
Arieş Racoşa	79.8	26.0	9.96
Arieş Luncani	57.0	30.0	13.46

Table no. 3. Salinity variations in the Arieş River and tributaries in 2008

Sampling sites of the Arieş basin	28. 05. 2008	20. 08. 2008	29. 10. 2008
	Salinity ($mg.l^{-1}$)	Salinity ($mg.l^{-1}$)	Salinity ($mg.l^{-1}$)
Arieşul Mare Vârtop - mlaştină	8.36	11.4	6.62
Arieşul Mare Arieşeni – Vârtop	11.7	11.5	7.9
Gârda Seacă	14.1	9.39	7.8
Arieşu Mare amonte Albac	19.8	7.76	6.6
Valea Albacului	15.09	7.66	6.7
Arieşul Mic	15.51	20.4	3.69
Arieş Amonte Câmpeni	16.78	34.8	6.43
Abrud	18.0	65.8	7.53
Pârâul Şesii	35.5	10.2	6.42
Arieş la Valea Lupşii	27.6	31.1	4.90
Arieş Brăzeşti	31.6	8.57	6.67
Valea Ocoliş	36.4	11.3	7.67
Arieş amonte vărsarea Văii Ocolişului	16.1	10.2	5.58
Hăşdate	44.9	11.6	6.34
Arieş aval vărsare Hăşdate	17.6	10.2	6.1
Racoşa amonte vărsare	36.1	14.6	4.61
Arieş Racoşa	43.5	13.6	5.32
Arieş Luncani	29.9	15.3	6.48

Table no. 4. Variations of oxygen in water in Arieş river and tributaries in 2008 and 2009

Sampling sites of the Arieş basin	28. 05. 2008		29. 10. 2008	06. 05. 2009
	Oxygen (%)	0xygen ($mg.l^{-1}$)	0xygen ($mg.l^{-1}$)	0xygen ($mg.l^{-1}$)
Arieşul Mare Vârtop - mlaştină	106.4	10.63	13.46	16.50
Arieşul Mare Arieşeni – Vârtop	74.9	7.22	13.15	16.48
Gârda Seacă	83.0	8.59	16.42	11.10
Arieşu Mare amonte Albac	91.5	9.24	11.68	13.00
Valea Albacului	80.01	7.61	16.15	15.00
Arieşul Mic	85.5	8.13	13.00	11.17
Arieş Amonte Câmpeni	78.0	7.38	14.37	9.94
Abrud	90.0	8.38	12.70	12.55
Pârâul Şesii	89.9	7.83	13.66	9.49
Arieş la Valea Lupşii	83.1	7.95	9.12	11.80
Arieş Brăzeşti	74.0	6.99	14.20	12.50
Valea Ocoliş	90.3	7.93	13.40	11.98
Arieş amonte vărsarea Văii Ocolişului	80.4	7.71	13.31	12.48
Hăşdate	80.5	57.01	18.04	14.51
Arieş aval vărsare Hăşdate	84.3	8.03	14.99	13.83
Racoşa amonte vărsare	116.0	10.71	9.8	12.50
Arieş Racoşa	70.4	6.66	13.70	11.64
Arieş Luncani	95.8	8.99	9.1	11.03

Table no. 5. Variation of pH in the Arieş river and tributaries in 2008 and 2009

Sampling sites of the Arieş basin	28. 05. 2008	20. 08. 2008	29. 10. 2008	06. 05. 2009
	pH	pH	pH	pH
Arieşul Mare Vârtop - mlaştină	8.36	5.9	5.1	5.96
Arieşul Mare Arieşeni – Vârtop	6.63	6.9	5.3	6.55
Gârda Seacă	8.58	9.32	6.1	8.59
Arieşu Mare amonte Albac	8.07	8.4	6.0	8.92
Valea Albacului	7.94	9.2	5.8	7.62
Arieşul Mic	8.39	8.7	6.5	8.50
Arieş Amonte Câmpeni	8.35	8.5	7.2	7.03
Abrud	7.8	5.4	6.4	6.33
Pârâul Şesii	3.3	4.9	7.6	3.33
Arieş la Valea Lupşii	8.37	8.9	7.6	7.80
Arieş Brăzeşti	6.81	8.2	7.1	6.92
Valea Ocoliş	8.82	9.1	8.9	8.82
Arieş amonte vărsarea Văii Ocolişului	7.87	8.5	7.6	6.11
Hăşdate	8.6	8.4	8.2	8.53
Arieş aval vărsare Hăşdate	8.32	8.6	8.0	7.86
Racoşa amonte vărsare	8.29	7.4	7.8	8.23
Arieş Racoşa	8.65	8.3	7.6	8.11
Arieş Luncani	8.05	7.7	7.5	7.5

VI. 2. THE DIATOM FLORA OF THE ARIEŞ RIVER CATCHMENT AREA

6. 2. 1. General characterization of the diatom flora from the Arieş River and its major tributaries

During the investigations of the Arieş River and its tributaries, based on epipelic and epilithic samples collected in spring, summer and autumn 2008 and 2009, I identified 204 taxa belonging to phylum *Bacillariophyta*. The detected taxa belong to 33 genera, 21 of which are represented by less than 5 taxonomic units (Fig. 6). Only 5 genera comprise *Centrales* diatoms (Fig. 7).

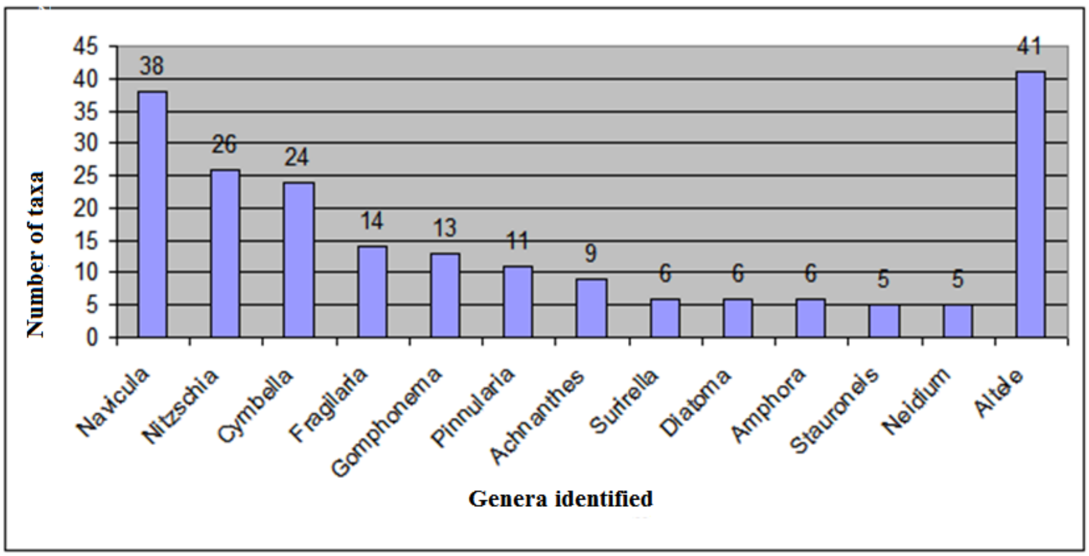


Fig. 6. The main diatom genera related to the number of afferent taxa

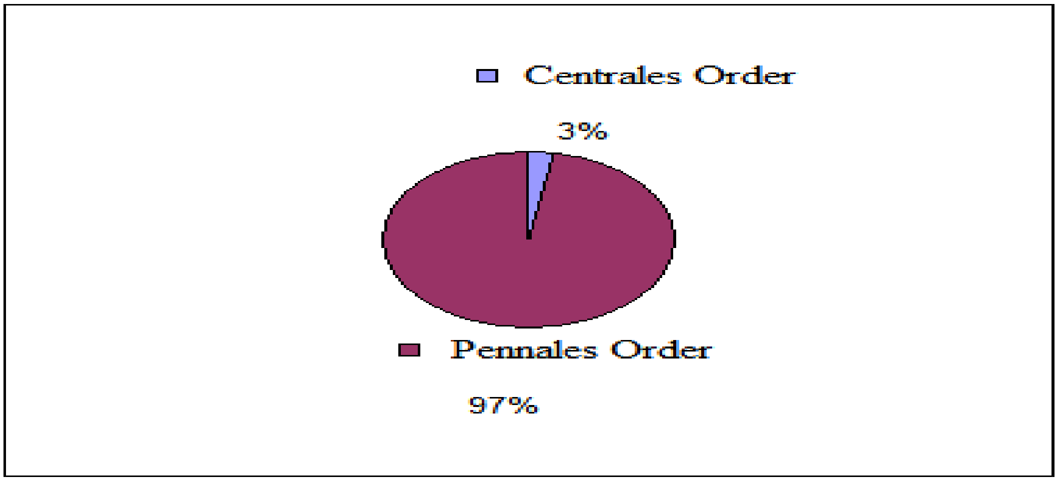


Fig. 7. Percentage contribution of the centric versus pennate diatoms to the composition of the diatom flora in the catchment area of the Arieş

Comparing the present findings for the Arieş basin with those recorded in previous studies dealing with the same territory (Momeu, Péterfi, 1984, 1985; Chiriac *et al*., 2005; Momeu *et al*., 2009; Momeu, Budurlean and Cristea, 2005; Momeu, Péterfi, 2007; Kosma, Péterfi, Momeu, 2001; respectively Biró Halmágyi *et al*., 2004), 44 taxa were found not yet been recorded previously in the Arieş river and its tributaries.

These are:

Achnanthes clevei Grunow

Achnanthes daui Foged

Actinocyclus nomanii (Gregory) Hustedt

Amphora inariensis Krammer

Asterionella formosa Hassall

Aulacoseira ambigua (Grunow) Simonsen

Aulacoseira distans (Ehrenberg) Simonsen

Caloneis molaris (Grunow) Krammer

Cocconeis placentula Ehrenberg var. *lineata* Ehrenberg

Cyclostephanos dubius (Fricke) Round

Cyclostephanos invisitatus (Hohn & Hellerman) Theriot Stoermer & Hakansson

Cyclotella atomus Hustedt var. *gracilis* Genkai & Kiss

Cymbella aequalis W. Smith

Cymbella cesatii (Rabenhorst) Grunow

Cymbella falaisensis (Grunow) Krammer & Lange-Bertalot

Epithemia sorex Kützing

Eunotia pectinalis (Dillwyn?, O. F. Müller ?, Kützing) Rabenhorst

Fragilaria capucina Desmazieres *var. capucina*

Fragilaria fasciculata (C. A. Agardh) Lange-Bertalot

Fragilaria mesolepta Rabenhorst

Fragilaria robusta (Fusey) Manguin

Gomphonema clevei Fricke

Meridion circulare (Greville) Agardh var. *constrictum* Ralfs

Navicula agrestis Hustedt

Navicula americana Ehrenberg

Navicula cincta (Ehrenberg) Ralfs

Navicula gibbula Cleve

Navicula halophila (Grunow) Cleve

Navicula molestiformis Hustedt

Navicula splendicula Van Landingham

Neidium apiculatum Reimer

Neidium iridis (Ehrenberg) Cleve

Neidium productum (W. Smith) Cleve

Nitzschia flexa Schumann

Nitzschia levidensis (W.Smith) Grunow

Nitzschia recta Hantzsch ex Rabenhorst

Nitzschia sigma (Kützing) W. Smith

Pinnularia divergentissima (Grunow) Cleve

Pinnularia lundii Hustedt

Pinnularia mesolepta Ehrenberg W. Smith

Stauroneis kriegerii Patrick

Stauroneis obtusa Lagerstedt

Surirella robusta Ehrenberg

Tabellaria fenestrata (Lyngbye) Kützing

After checking the list published by Cărăuş (2012) and the subsequent studies, six of the detected taxa are new records for the Romania algoflora:

Achnanthes daui Foged

Fragilaria robusta (Fusey) Manguin

Navicula agrestis Hustedt

Navicula gibbula Cleve

Navicula molestiformis Hustedt

Pinnularia lundii Hustedt

6. 2. 2. Considerations on ecological preferences and geographical distribution identified in the river Arieş

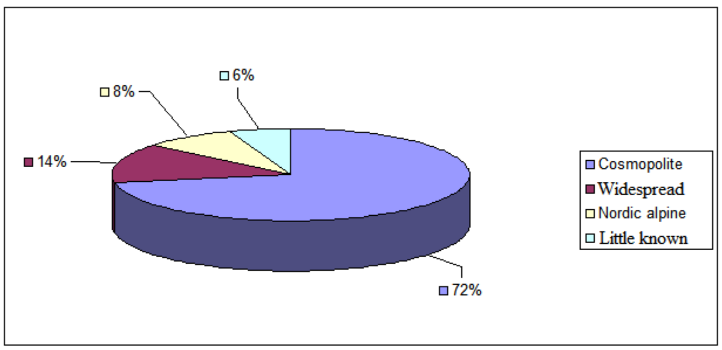


Fig.8. Distribution pattern of the diatoms occurring in the Arieş River and tributaries

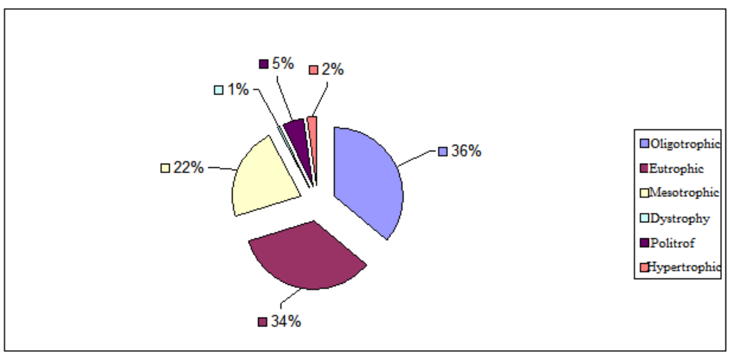


Fig. 9. Ecological categories of diatoms based on the trophic level of the water

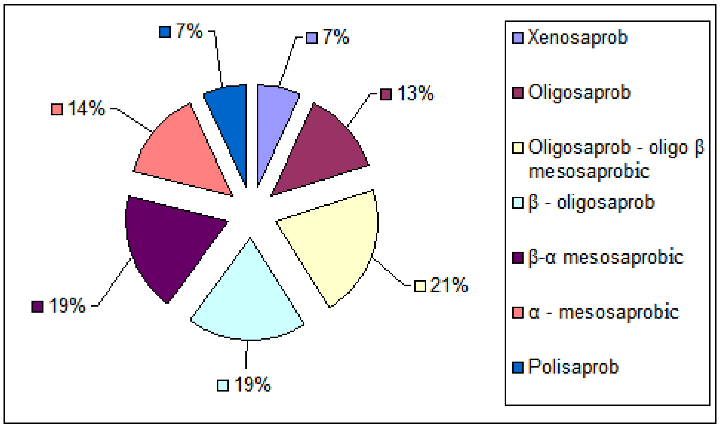


Fig. 10. Saprobity spectrum of the diatom flora in the Arieş basin

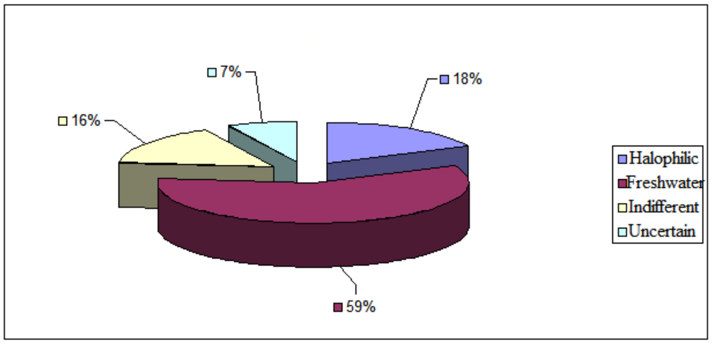


Fig. 11. Percentage distribution of the diatoms according to their tolerance to salinity of the water

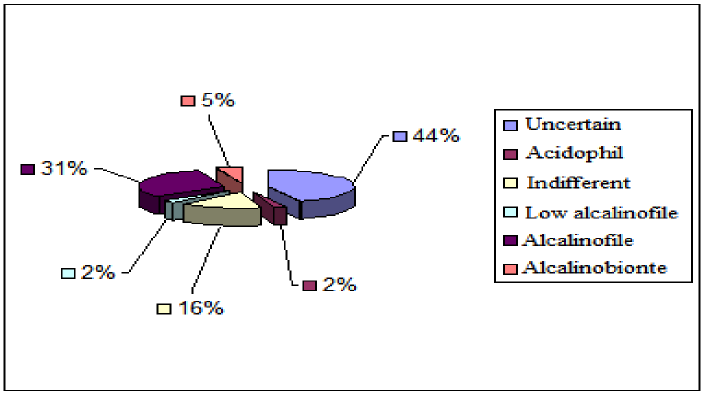
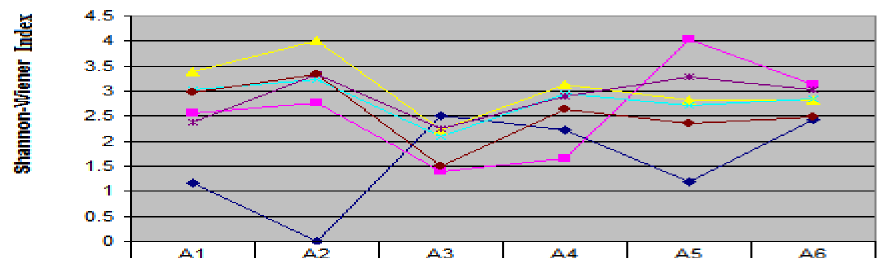


Fig. 12. Percentage distribution of the diatoms according to their tolerance to the waters pH

VI. 3. THE STRUCTURE OF DIATOM COMMUNITIES IN THE ARIEŞ RIVER CATHCMENT AREA

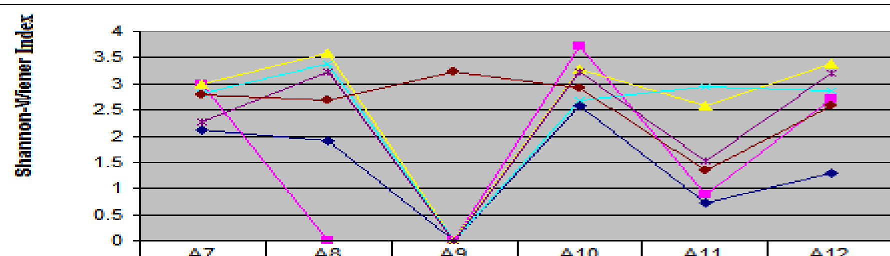
6. 3. 1 The Species diversity of communities

The values of the Shannon-Wiener diversity index were calculated for each community analyzed in the Arieş basin (Fig, 13, 14, 15).



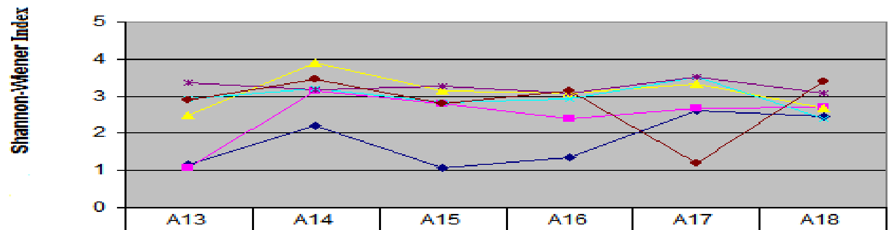
	A1	A2	A3	A4	A5	A6
28. 05. 2008.	1.175	0	2.511	2.227	1.187	2.421
20. 08. 2008.	2.551	2.761	1.386	1.643	4.046	3.119
29. 10. 2008.	3.396	4.008	2.22	3.135	2.828	2.826
06. 05. 2009.	3.014	3.24	2.106	2.954	2.716	2.856
03. 08. 2009.	2.391	3.325	2.245	2.895	3.285	3.023
04. 10. 2009.	2.985	3.337	1.5	2.631	2.36	2.483

Fig. 13. Changes in specific diversity on the upper river section of Arieş River and afferent tributaries



	A7	A8	A9	A10	A11	A12
28. 05. 2008.	2.107	1.918	0	2.59	0.718	1.287
20. 08. 2008.	3.006	0	0	3.714	0.881	2.701
29. 10. 2008.	2.998	3.584	0	3.286	2.586	3.37
06. 05. 2009.	2.821	3.38	0	2.688	2.952	2.867
03. 08. 2009.	2.263	3.225	0	3.215	1.518	3.189
04. 10. 2009.	2.79	2.693	3.228	2.923	1.346	2.58

Fig. 14. Changes of specific diversity on the middle course of the Arieş River and selected tributaries



	A13	A14	A15	A16	A17	A18
28. 05. 2008.	1.175	2.199	1.062	1.357	2.618	2.463
20. 08. 2008.	1.083	3.155	2.786	2.405	2.66	2.72
29. 10. 2008.	2.475	3.906	3.13	3.079	3.329	2.671
06. 05. 2009.	2.934	3.223	2.819	2.918	3.523	2.392
03. 08. 2009.	3.353	3.185	3.258	3.082	3.525	3.087
04. 10. 2009.	2.893	3.456	2.807	3.13	1.195	3.409

Fig. 15. Variation of specific diversity in the lower course of the Arieş River and afferent tributaries

6. 3. 2. The specific diversity of the communities based on the Dα index

In many recent studies in which the specific diversity was considered based on non-parametric diversity indices (ex. Shannon-Wiener), the values obtained do not match with the theoretical concepts, intuitive of diversity, and in fact these considerations refer to the entropy. Therefore, if we use Shannon-Wiener index, you have to use it in a form that removes uncertainties in interpreting the results, for example by adopting the index as amended by Jost (2006). The tendency of expressing the average values is actually a straight line which shows us drops of the affected sampling stations.

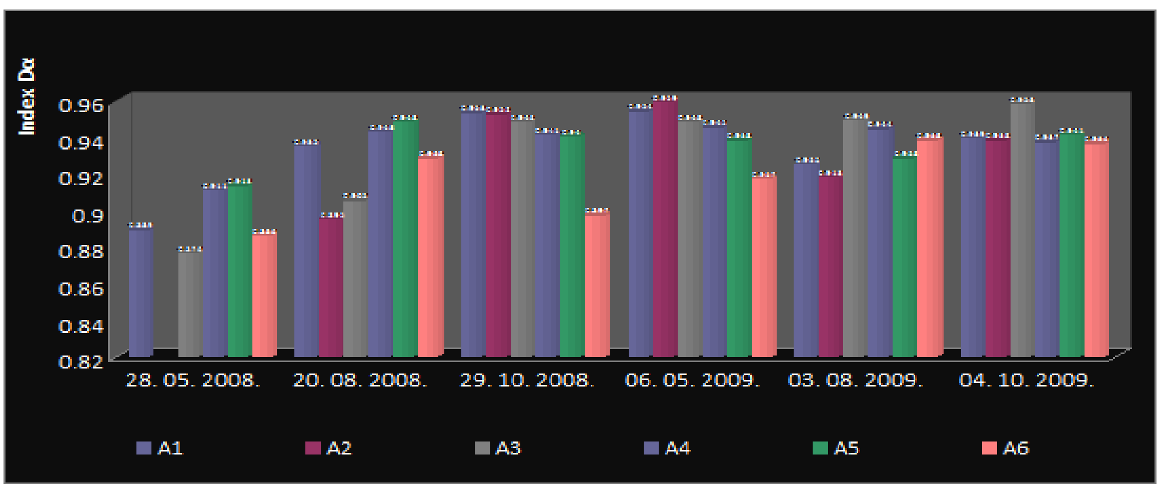


Fig. 16. Changes of specific diversity (Dα) of diatom communities inhabiting the upper course of the Arieş River and its tributaries in 2008 and 2009. (Sampling sites A1-A6)

Fig. 17. Changes in specific diversity Dα. on the middle course of the Arieş River and select tributaries

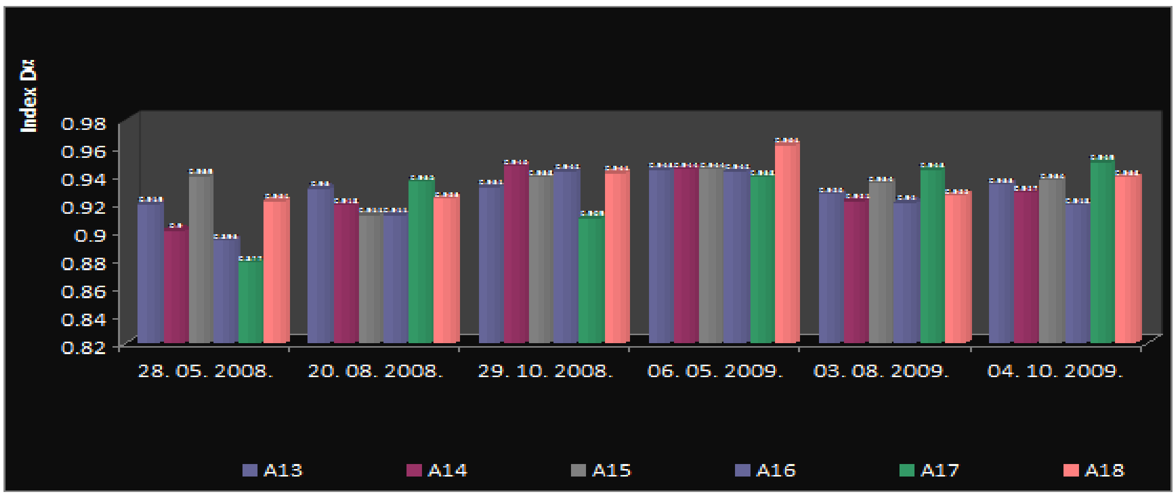


Fig. 18. Changes in specific diversity Dα. on the lower course of the Arieş River and selected tributaries in 2008 and 2009

6. 3. 3. The floristic affinity of the communities based on Sørensen index

The floristic affinities of the diatom communities in the Arieş river basin, tested with the Sørensen index in 2008 and 2009, are illustrated as dendrograms (Fig. 19 and 20). Having regard on the evident similarities in terms of the grouping trends, the grouping of communities, based on the similarity analyses in the two years, we do not comment dendrograms separatly. The analyzed communities are grouped generally by season, for instance forming two central units, relatively homogeneous and well individualized at a level of similarity of 60% - 65%. One of the groups includes the spring communities and the other the summer and autumn ones.

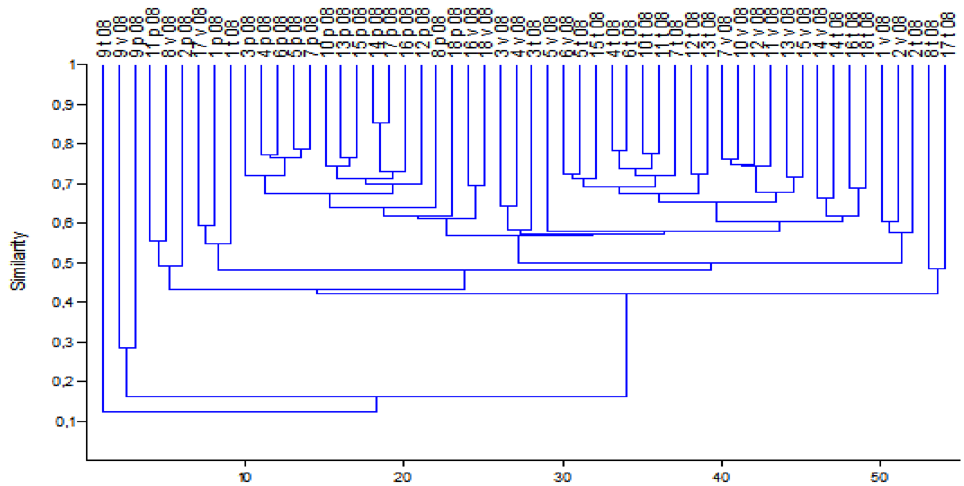


Fig. 19. Dendrogram exhibiting the floristic affinities among diatom communities surveyed in the catchment of the Arieş in spring, summer and autumn 2008 (p = spring, v=summer, t = autumn, 08 = 2008; numbers 1-18 represent sampling sites)

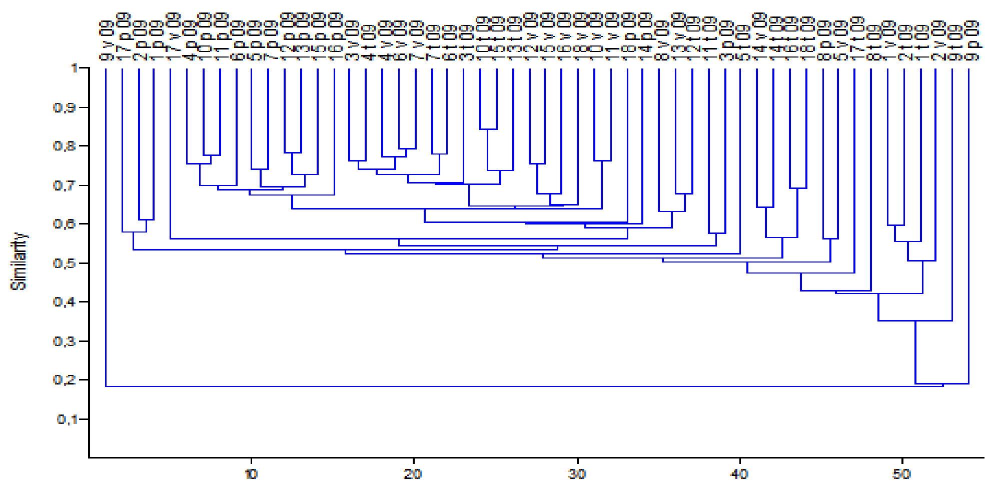


Fig. 20. Dendrogram of the floristic affinities of diatom communities investigated in the catchment area of the Arieş river in the spring, summer and fall of 2009 (p = spring, v=summer, t = autumn, 09 = 2009; numbers 1-18 represent sampling sites)

6. 3. 4. The influence of the abiotic factors on the diatom communities

In order to demonstrate the trend of distribution of sites according to the parameters of the environment we used the Principal Component Analysis (PCA). In the analysis were introduced data about the location of the sampling stations, altitude (‰), names of the stations as an important feature and the average of the physicochemical parameters of the water in the affected sampling stations in spring and summer of 2008 and spring of 2009 (EC, T, pH, S, O2). The first two axes explained 64.31% of the variance. The main parameters influencing the grouping stations are: dissolved oxygen, altitude, conductivity, pH of water and so on (Fig. 21). The first axis F1 (40.52%) is positively correlated with the pH, temperature, electric conductivity and salinity. It is negatively correlated with dissolved oxygen and altitude. The second axis F2 (23.79%) is positively correlated with dissolved oxygen, pH and temperature of the water (Fig. 21), but negatively correlated with salinity, electric conductivity and altitude.

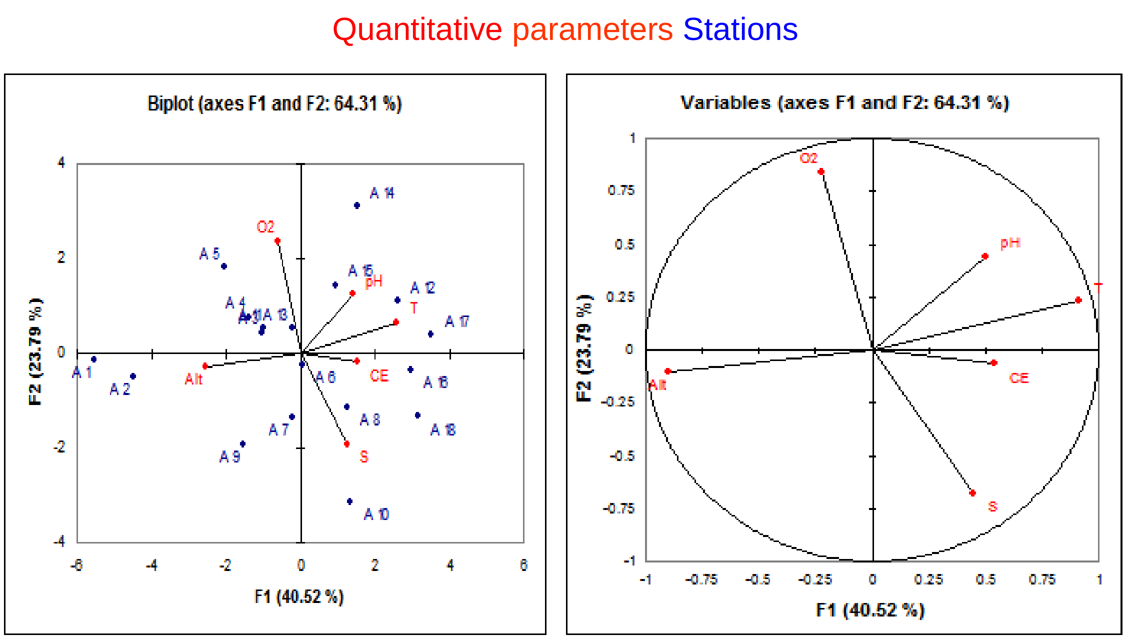


Fig. 21. Principal Component Analysis (PCA) between physicochemical parameters of the water samples collected in the sites of the Arieş catchment area. O2 - dissolved oxygen (mg.l-1). EC - Electrical conductivity (µS.cm-1). S - salinity (mg.l-1) T - Water temperature (° C) pH - pH values of the water and a character of sites (Alt-altitude)

The relationship between diatom communities and environmental parameters was tested by Canonical Correlation Analysis (CCA) (Fig. 22). In the canonical correlation analysis we introduced relative quantitative determination values for the diatoms of the communities (after counting 400 individuals), obtained for each sampling site in spring and summer of 2008 and in spring of 2009, together with the physicochemical parameters of the water: ammount of dissolved oxygen (mg.l-1), electrical conductivity (µS.cm-1), salinity (mg.l-1), temperature (° C) and pH values. The first two axes F1 and F2, explain 69.20% of the variance. The first axis F1 (42.13%) is positively correlated with the pH of the water, salinity, temperature and quantity dissolved oxygen, but it is negatively correlated to electric conductivity. F2 axis (27.07%) is positively correlated with salinity, electric conductivity and temperature and negatively with dissolved oxygen quantity and the pH of the water. On the Biplot graph (Fig. 22), one can observe three groups of sampling stations with the related diatom species.

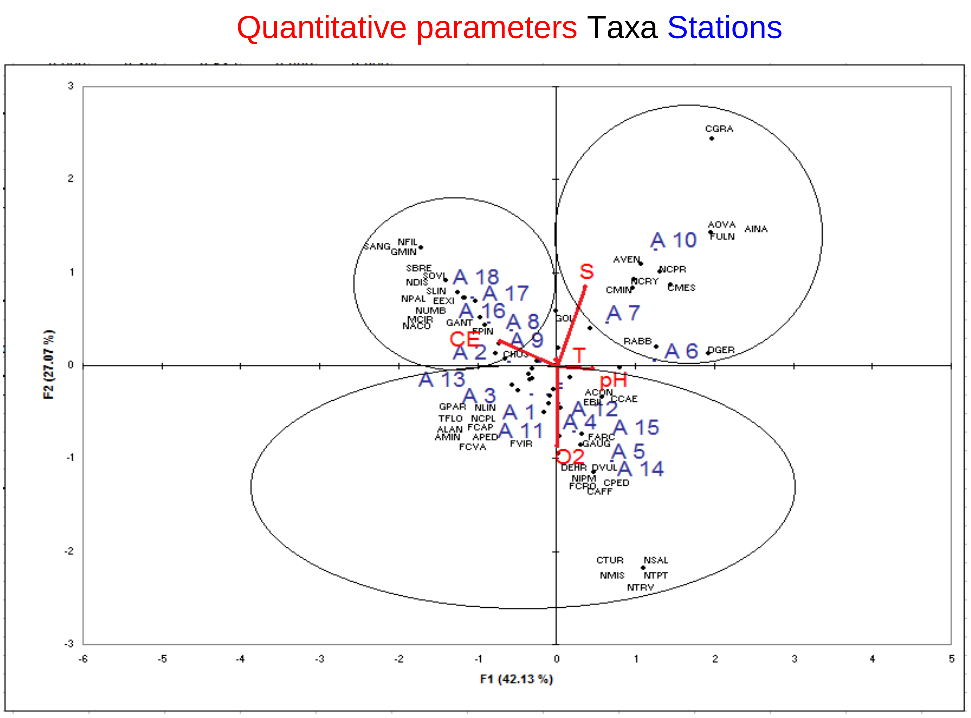


Fig. 22. Canonical Correlation Analysis (CCA) between diatom taxa and quantitative water parameters in sampling sites of the the Arieş river catchment area. O2 - dissolved oxygen (mg.l-1), EC - Electrical conductivity (µS.cm-1), S - salinity (mg.l-1), T - Water temperature (° C), pH - pH of the water

6. 3. 5. The seasonal dynamics of diatom communities from Arieş river and its major tributaries

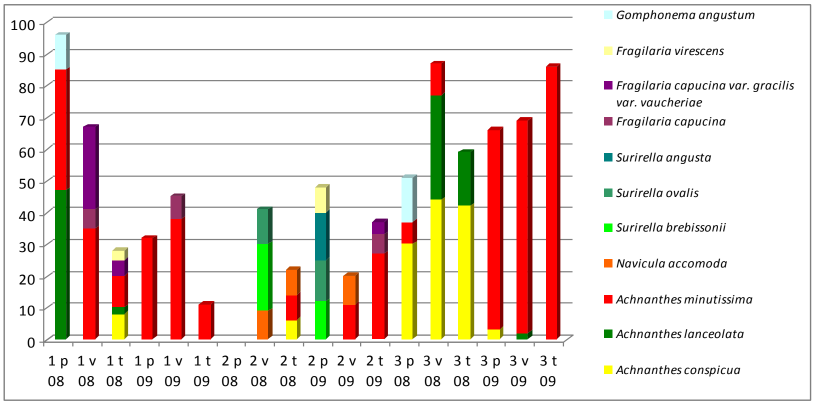


Fig. 23. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sites A1-A3 (Arieşul Mare Vârtop – mlaştină, Arieşul Mare Arieşeni – Vârtop, Gârda Seacă) in 2008 and 2009, (1=A1, 2=A2, 3=A3, p=spring, v=summer and t=autumn, 08= 2008, 09=2009)

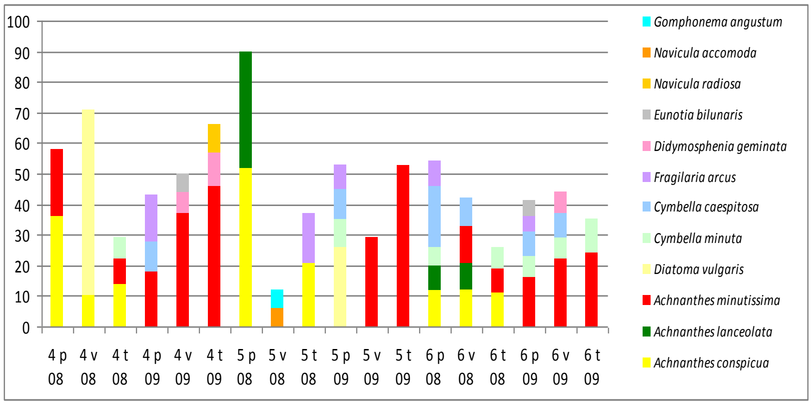


Fig. 24. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sampling sites A4-A6, (Arieşul Mare amonte Albac, Valea Albacului, Arieşul Mic) in 2008 and 2009 (4=A4, 5=A5, 6=A6, p=spring, v=summer and t=autumn, 08=2008, 09=2009)

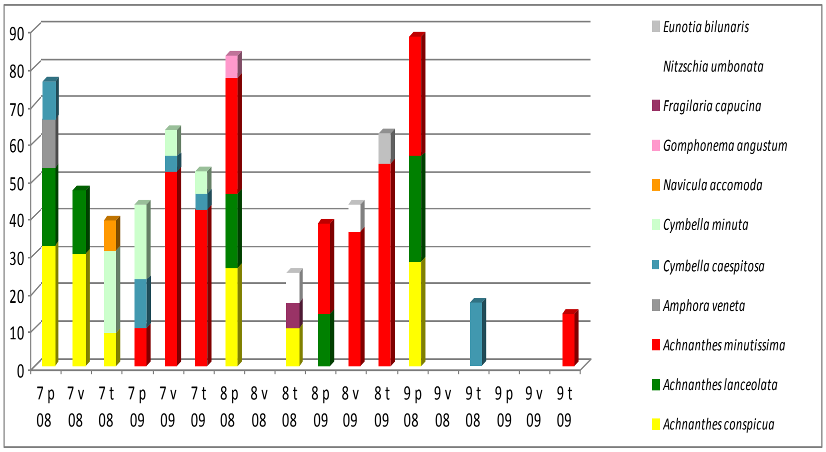


Fig. 25. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sampling sites A7-A9 (Arieş Amonte Câmpeni, Abrud, Pârâul Şesii), in 2008 and 2009 (7=A7, 8=A8, 9=A9, p=spring, v=summer and t=autumn, 08=2008, 09=2009)

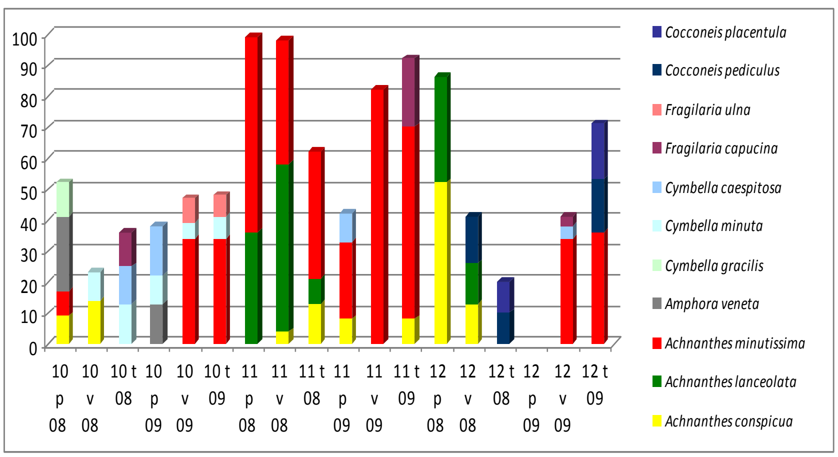


Fig. 26. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sampling sites A10-A12 (Arieş la Valea Lupşii, Arieş Brăzeşti, Valea Ocoliş), in 2008 and 2009 (10=A10, 11=A11, 12=A12, p=spring, v=summer and t=autumn, 08=2008, 09=2009)

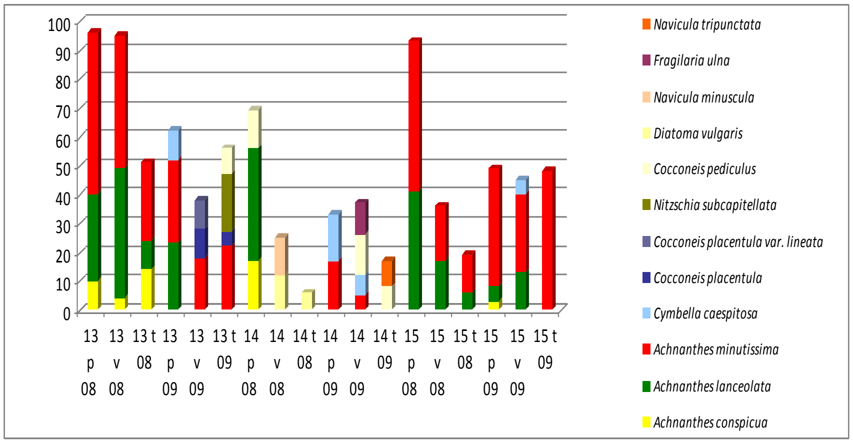


Fig. 27. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sampling sites A10-A12 (Arieş la Valea Lupşii, Arieş Brăzeşti, Valea Ocoliş), in 2008 and 2009 (10=A10, 11=A11, 12=A12, p=spring, v=summer and t=autumn, 08=2008, 09=2009)

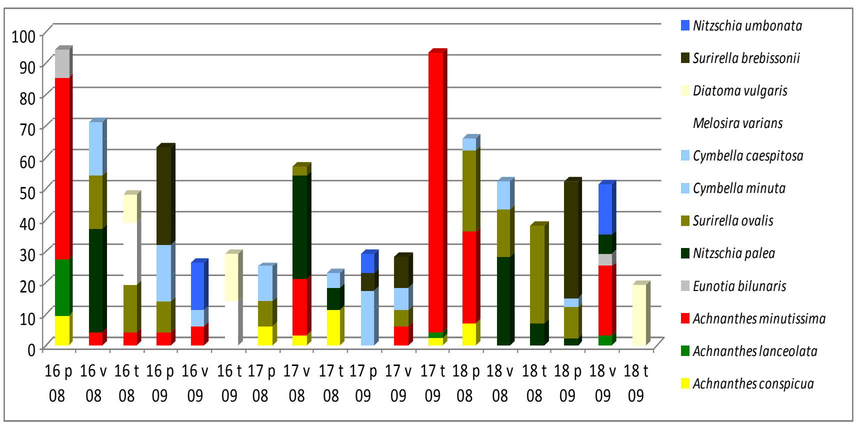


Fig. 28. The seasonal percentage abundance of dominant taxa in the Arieş river and tributaries, sampling sites A16-A18 (Racoşa amonte vărsare, Arieş Racoşa, Arieş Luncani), in 2008 and 2009 (16=A16, 17=A17, 18=A18, p=spring, v=summer and t=autumn, 08=2008, 09=2009)

VI. 4. WATER QUALITY ASSESSMENT AND ENVIRONMENTAL STATUS OF THE ARIEŞ RIVER

6. 4. 1. Estimation of water quality and the degree of water saprobity level in the Arieş river and selected tributaries

Using the list of Rott (1997), which includes 402 diatom taxa, for which has been set indicator values (1-5) and saprobic tolerance (1 - taxon very sensitive to pollution, up to 4 - taxa very resistant to pollution), the present author calculated the saprobity index values (SI) for all investigated stations in the Arieş catchment area, based on the identified diatom species and assessments on the relative abundance of species (Table no. 6).

Table no. 6. Saprobity index values (SI) calculated for epilithic diatom community of the Arieş river and its tributaries selected from samples taken in spring, summer and fall of 2008 and 2009 (1.4 - 1.7 – slightly polluted. low pollution, 1.8 - 2.1 – moderately polluted, 2.2-2.5 – moderately to heavily polluted)

Samolinf sites of the Arieş basin	28. 05. 2008	20. 08. 2008	29. 10. 2008	06. 05. 2009	03. 08. 2009	04. 10. 2009
Arieşul Mare Vârtop - mlaştină	1.688	1.526	1.616	1.818	1.571	1.523
Arieşul Mare Arieşeni – Vârtop	-	2.079	1.737	1.888	2.233	2.06
Gârda Seacă	1.909	1.706	1.537	1.909	2.043	1.914
Arieşu Mare amonte Albac	1.859	1.934	1.68	1.756	1.952	1.926
Valea Albacului	1.955	1.983	1.696	1.753	1.896	2.162
Arieşul Mic	1.955	1.603	1.739	1.703	1.851	1.826
Arieş Amonte Câmpeni	1.852	1.76	1.85	1.876	1.817	1.905
Abrud	1.825	-	1.87	1.94	2.266	2.192
Pârâul Şesii	-	-	-	-	-	-
Arieş la Valea Lupşii	1.625	1.841	1.921	1.586	2.048	1.999
Arieş Brăzeşti	2.031	1.638	1.923	1.76	2.054	1.605
Valea Ocoliş	1.763	1.824	1.753	1.594	1.854	2.04
Arieş amonte vărsarea Văii Ocolişului	1.73	1.792	2.013	1.826	1.822	2.06
Hăşdate	1.859	1.901	1.941	1.864	1.966	1.821
Arieş aval vărsare Hăşdate	1.974	1.939	1.89	1.584	1.801	2.186
Racoşa amonte vărsare	2.016	2.267	2.174	1.773	2.309	1.995
Arieş Racoşa	2.315	2.28	2.306	1.938	1.949	1.914
Arieş Luncani	2.061	2.117	2.182	1.817	2.121	1.824

6. 4. 2. Water quality assessment using the biological diatom index (DBI)

In our country DBI was first used as supporting method for the estimation of water quality assessment at the beginning of the 21st century, on the upper course of the Someşu Cald river (Battes, Momeu and Tudorancea 2004). In the Arieş catchment area I successfully used this index in all sampling stations (Table no. 7). Exceptions are those on Pârâul Şesii (in all periods) and another two outstanding cases (spring 2008 Arieşul Mare Arieşeni-Vârtop, and summer 2008 at Abrud) due to the lack of cohesive diatom communities.

Table no. 7. Values of the biological diatom index (BDI) calculated for the Arieş River and its major tributaries (≥17 – excelent, 13-17 – good, 9-13 – acceptable, 5-9 - mediocre)

Samolinf sites of the Arieş basin	28. 05. 2008	20. 08. 2008	29. 10. 2008	06. 05. 2009	03. 08. 2009	04. 10. 2009
Arieşul Mare Vârtop - mlaştină	17.63	16.06	15.8	14.37	17.29	18.97
Arieşul Mare Arieşeni – Vârtop	-	7.5	13.25	15.13	8.51	8.98
Gârda Seacă	11.06	8.81	9.68	9.5	10.78	11.6
Arieşu Mare amonte Albac	8.46	12.06	12.06	12.08	11.57	10.99
Valea Albacului	7.12	10.51	12.17	11.6	11.17	9.76
Arieşul Mic	10.13	13.71	12.26	12.91	13.56	11.85
Arieş Amonte Câmpeni	9.54	10.43	8.57	11.23	14.96	14.93
Abrud	15.4	-	10.39	12.7	11.86	11.35
Pârâul Şesii	-	-	-	-	-	-
Arieş la Valea Lupşii	10.5	10.83	12.55	12.1	13.74	12.84
Arieş Brăzeşti	17.72	16.78	13.27	9.16	11.67	17.15
Valea Ocoliş	17.05	16.89	13.68	12.47	14.13	13.76
Arieş amonte vărsarea Văii Ocolişului	12.22	11	13.07	14.61	13.78	11.77
Hăşdate	16.21	12.91	12.16	14.94	12.4	11.86
Arieş aval vărsare Hăşdate	10.51	10.95	11.03	12.55	10.42	11.88
Racoşa amonte vărsare	15.94	9.52	9.94	9.34	6.26	9.77
Arieş Racoşa	8.44	9.76	8.5	11.44	12.68	13.5
Arieş Luncani	10.19	7.34	7.47	14.63	12.56	11.77

CONCLUSIONS

1. Based on the physicochemical parameters measured during the present field investigations the author could formulate the following statements:

- **Water temperature of the Arieş and its tributaries** varies within normal limits, according to altitude, exposure and season. In the Arieş could be noticed a slight increase of temperature from the source to its influx into the Mureş River.
- **The salinity of the Arieş** water varies between 8.36 and 29.9 $mg.l^{-1}$, with increasing trend towards the shedding into the Mureş. Higher salinity values were recorded in spring, possibly due to allochthonous material entrained in the water after snowmelt floods. Higher salinity (65.8 and 44.9 $mg.l^{-1}$) recorded in tributaries, explains the increased turbidity in spring.
- The specific electrical **conductivity of the water in the Arieş** (CES) was decreased or moderate (spring between 7.3 and 11.0 $\mu S.cm^{-1}$), except the downstream sectors where it reached 85.4 $\mu S.cm^{-1}$, which is in accordance with "the natural aging" of the river. High values of CES were recorded in the water of the tributaries: Valea Ocoliş (69,3 $\mu S.cm^{-1}$) and Hăşdate (85,4 $\mu S.cm^{-1}$).
- The level of **dissolved oxygen** (DO) in water varies moderately between 7.22 and 10 $mg.l^{-1}$, with one exception - Pârâul Hăşdate, where 57 $mg.l^{-1}$ was recorded.
- The geological substrate and the human impact influence the amount of hydrogen ions in water, which makes the pH of the Arieş river in general circumneutral to moderately alkaline, except the downstream Pârâului Şesii , where due to the wastewater discharges from the mining it is strongly acid (3.3 to 3.33).

2. As a result of the studies on the diatom communities in the catchment area of Arieş, between Arieşeni - Vârtop (ski slopes) and Luncani, a few conclusions have been formulated:

- In the sampled watercourses, in the algological material collected in spring, summer and fall of 2008 and 2009, the present author identified 204 taxa belonging to the phylum *Bacillariophyta*.

- The detected taxa belong to 33 genera, of which 21 are represented by less than 5 taxa.
- From the 33 genera, 5 species represented Centrales diatoms.
- The genera with the most taxa are: *Navicula* (38), followed by *Nitzschia* (26), *Cymbella* (24), *Fragilaria* (14), *Gomphonema* (13), *Pinnularia* (11), *Achnanthes* (9) and *Surirella* (6).
- Among the identified diatoms 44 taxa are new records for the Arieş basin and 6 have not yet been detected in the Romanian flora.
- Most taxa identified in the Arieş catchment area, are of cosmopolitan distribution or widespread.
- Regarding the nutrient content of the water, most diatoms occurring in the Arieş basin prefer oligotrophic, eutrophic or mesotrophic conditions.
- As concerning the tolerance of the identified diatoms towards the organic loading of water, 7% taxa are xenosaprobic, 13% oligosaprobic, 21% oligosaprobic – oligo-β-mezosaprobic, 19% β – mezosaprobic, 19% β – α – mezosaprobic, 14% α – mezosaprobic and 7% polysaprobic.
- Most of the identified diatoms are freshwater elements.
- The most frequent and dominant diatoms are *Achnanthes minutissima* (in 54 samples), *Achnanthes conspicua* (in 14 samples), *Achnanthes lanceolata* (in 4 samples), *Cymbela minutes* (4 samples) *Diatoma vulgaris* (in 4 samples) *Surirella brébissonii* (in 3 samples) etc. The most important edifying species, widespread in the rivers of Central and Western Europe is *Achnanthes minutissima*.
- For the study of seasonal dynamics twelve taxa have been selected, but only *Achnanthes minutissima*, the edifying species, occurred most often, but especially in the upper and middle courses of the Arieş. *Achnanthes conspicua* appears in almost all sampling sites in spring of both years, with a high percentage abundance. *Achnanthes lanceolata* occurred most often in spring and summer and develops populations with increasing individuals from spring to summer. In the lower Arieş there were many other diatom species growing, but they developed populations with low number of individuals (high specific diversity).

- Specific diversity of the diatom communities (expressed by Shannon-Wiener index) appears in the graphic as a broken line (sinusoidal) from the source to its effusion into the Mureş River, when they are presented in the order of sampling stations, including values of the investigated tributaries, waters with varied characters differing from Arieş. At the upper course of the Arieş river (sites 4-8), as well as on its lower one of Arieş (paragraphs 15-18) the diversity values are rather constant.
- The saprobity index values (SI) indicates a gradual transition of water from the upper course of the Arieş, with reduced organic pollution (Class I-II), towards a moderate pollution (Class II) on the middle and lower courses. The waters of the tributaries in this area are generally cleaner than the main course of the Arieş. Beginning with the middle course of the Arieş the water is often moderately loaded with organic matter (Class II). The water in the tributaries of the middle course, due to various human activities (livestock, mining, excavation, household activities etc.), is usually more polluted than the Arieş. The water in the lower course of the Arieş becomes increasingly loaded, namely class II or II-III, indicating moderate to strong organic pollution. The water in the tributaries in this area is cleaner than that from the Arieş (except the Racoşa rivulet).
- The diatom biological index values (DBI) indicate, in the upper course of the Arieş, good to acceptable water quality, but exceptional only in spring. The waters of the tributaries in this area are of acceptable quality. In the middle course of the Arieş water is often acceptable. The water in the tributaries are more polluted (organic or toxic) than the water of the Arieş. On the lower course of the Arieş the water quality is acceptable, becoming even mediocre toward the shedding, as is the brook Racoşa.

SELECTED REFERENCES

1. Biró-Halmágyi, B., Kiss, A., Bányász, D., Péterfi, L. Ş., 2004, Preliminary studies on the epilithic diatom communities of the Turda Gorge (Cheile Turzii), Transylvania, Romania. *Contribuţii Botanice*, Cluj-Napoca, 39, 135-140.
2. Cărăuş, I., 2012, Alge of Romania. *Studii şi cercetări, Universitatea Bacău, Biologie* 7: 1-808.
3. Chiriac, G., Vintilă, F., Galasiu, L., Lungu, A., 2005, Inventarierea comunităţilor biotice acvatice din B. H. Mureş în conformitate cu cerinţele directivei cadru a apelor. *Muzeul Olteniei Craiova. Oltenia Studii şi comunicări. Stiinţele Naturii*. XXI, 216-220.
4. Cummins, K. W., Minshall, G. W., Cushing, C. E., Petersen, R. C., 1984, Stream ecosystem theory. *Internationale Vereinigung für theoretische und angewandte Limnologie*, **22**, 1818-27.
5. Giller, P. S., Malmqvist, B., 2006, *The biology of Streams and Rivers*, University Press, Oxford.
6. Jost, L., 2006, Entropy and diversity. *Oikos*. 113: 363-375.
7. Krammer, K., 2000, Diatoms of Europe. Diatoms of the European Inland Waters and Comparable Habitats. Vol. 1. The genus *Pinnularia*. A. R. G. Gantner Verlag K. G, Ruggell. 703 pp.
8. Krammer, K., 2002, Diatoms of Europe. Diatoms of the European Inland Waters and Comparable Habitats. Vol. 3. *Cymbella.* A. R. G. Gantner Verlag K. G, Ruggel. 584 pp.
9. Krammer, K., 2003, Diatoms of Europe. Diatoms of the European Inland Waters and Comparable Habitats. Vol. *Cymbopleura, Delicata, Navicymbula, Gomphocymbellopsis, Afrocymbella*. A. R. G. Gantner Verlag K. G, Ruggell. 530pp.
10. Krammer, K., Lange-Bertalot, H., 1986, Süβwasserflora von Mitteleuropa, *Bacillariophyceae,* 1. Teil: *Naviculaceae* (Nachdr.1997), Band 2/1. Spectrum Akademischer Verlag Heidelberg. Berlin.
11. Krammer, K., Lange-Bertalot, H., 1988, Süβwasserflora von Mitteleuropa, *Bacillariophyceae,* 2. Teil: *Epithemiaceae, Bacillariaceae, Surirellaceae* (Nachdr.1997), Band 2/2. Spectrum Akademischer Verlag Heidelberg. Berlin.
12. Krammer, K., Lange-Bertalot, H., 1991a, Süβwasserflora von Mitteleuropa, *Bacillariophyceae,* 3. Teil: *Centrales, Fragilariaceae, Eunotiaceae,* Band 2/3. Spectrum Akademischer Verlag Heidelberg. Berlin.
13. Krammer, K., Lange-Bertalot, H., 1991b, Süβwasserflora von Mitteleuropa, *Bacillariophyceae,* 4. Teil: *Achnanthaceae,* Literaturverzeichnis, Band 2/4. Spectrum Akademischer Verlag Heidelberg. Berlin.
14. Krammer, K., Lange-Bertalot, H., 2000, Bacillariophyceae: English and French translation of the keys, în Budel, B., Gartner, G., Krienitz, L. Lokhorst, G. M. (red.), *Süsswasserflora von Mitteleuropa,* Vol. 2/5, G. Fischer, Stuttgart, 311 pp.
15. Momeu, L., 2009, *Problems concerning the invasive species from continental aquatic ecosystems.* Case study: *Didymosphenia geminata* (Lyngb.) M. Smidt. În Rákosy, L., Momeu, L. (ed.) - Neobiota din România. Presa Univ. Clujeană, 11-30 p.
16. Momeu, L., Péterfi, L. Ş., 2004, Structure of diatom communities inhabiting the Târnava Mică and Târnava Mare rivers. *Transylvanian Review of Systematical and Ecological Research*, 2, 7-12.

17. Momeu, L., Péterfi, L. Ş., 2005, Structure of diatom communities inhabiting the Târnava Mică and Târnava Mare rivers. *Transylvanian Review of Systematical and Ecological Research*, 2, 7-12.
18. Momeu, L., Péterfi, L. Ş., 2007, Evaluarea calităţii apei din bazinul de drenaj al râului Arieş folosind diatomeele epilitice ca bioindicatori, *Contribuţii Botanice*, Cluj-Napoca, XLII, (2), 57-65.
19. Momeu, L., Péterfi, L. Ş., 2009, Assesment of the ecological state of rivers based on benthic algae especially diatoms, Studia Universitatis Babeş-Bolyai, Biologia, vol 54; 7-19.
20. Momeu, L., Budurlean, M., Cristea, V., 2005, Comuntăţi algale din Rezervaţia Naturală "Valea Morii"şi împrejurimi (Jud. Cluj. România), *Contribuţii Botanice*, XL, 145-152.
21. Momeu, L., Péterfi, L. Ş., Pándi-Gacsádi, O., Şipoş, C., 1988, Structure of diatom communities occurring in a Transylvanian river, Romania. Contrib. Bot., Cluj-Napoca, p. 153-164.
22. Momeu, L., Battes, K. W., Pricope, F., Avram, A., Battes, K. P., Cîmpean, M., Ureche, D., Stoica, I., 2007, *Preliminary data on algal, macronevertebrate and fish communities from the Arieş catchment area, Transylvania, Romania,* Studia Universitatis Babeş-Bolyai, Biologia, LII, 1; 25-36.
23. Momeu, L., Battes, K., Battes, K., Stoica, I., Avram, A., Cîmpean, M., Pricope, F., Ureche, D., 2009, *Algae, Macroinvertebrate and Fish communities from the Arieş river catchment area (Transylvania, Romania).* 151-182. Revista.
24. Péterfi, L. Ș., Momeu, L., 1984, Dezvoltarea comunităților de diatomee epilitice din râul Arieș, Transilvania, Studia Univ. Babeș-Bolyai, ser. Biologie, XXIV, 3-8.
25. Péterfi, L. Ș., Momeu, L., 1985, Structura comunităților de diatomee din Arieș sub influența stresului de poluare, Trav. Station „Stejarul", Limnol., 1(10), 263-267.
26. Péterfi, L. Ş., Momeu, L., Kerestély, J., 1988, Structure and stability of diatom communities from the south-east of Transylvania, Romania. *Evolution and Adaptation*, III., Cluj-Napoca, 177-188.
27. Péterfi, L. Ş., Momeu, L., Veres, M., 1983, Efectul concentraţiei ionice asupra stabilităţii comunităţilor de diatomee din câteva izvoare minerale din România, *Evolution and Adaptation*, Cluj-Napoca, I. 119-128.
28. Péterfi, L. Ş., Veres, M., Momeu, L., 1985, Composition and structure of benthic diatom communities from some Romanian mineral springs, *Evol. Adapt.,* Cluj-Napoca, 2: 187-199.
29. Rott, E., 1997, *Indikationslisten für aufwuchsalgen,* 1: *Saprobielle indikation,* Viena.
30. Sládeček, V., 1973, System of water quality from the biological point of view, în: Elster H.J., Ohle, W., *Ergebnisse der Limnologie,* Schweitzerh. Verl., Stuttgart, 1-121.

Published works from the PhD thesis subject

J. SZÉKELY – ANDORKÓ, L. MOMEU, L. Ş. PÉTERFI, 2011, Structure of the benthic diatom communities from the Arieş river catchment area (Transylvania, Romania), Contribuţii Botanice, Cluj-Napoca, XLVI: 93-106.

J. SZÉKELY – ANDORKÓ, L. MOMEU, L. Ş. PÉTERFI, 2011, Benthic diatoms used as bioindicators for water quality evaluation in the drainage basin of the Arieş river (Transylvania. Romania), Contribuţii Botanice, Cluj-Napoca, XLVI: 107-116.

Annex 1. List of abbreviations used in the presentation in the taxa epilithic communities dynamics on the Arieş river.

code	**gender**	**species**	**code**	**gender**	**species**
ACON	*Achnanthes*	*conspicua*	GANT	*Gomphonema*	*angustum*
ALAN	*Achnanthes*	*lanceolata*	GAUG	*Gomphonema*	*augur*
AMIN	*Achnanthes*	*minutissima*	GMIN	*Gomphonema*	*minutum*
AINA	*Amphora*	*inariensis*	GOLI	*Gomphonema*	*olivaceum*
AOVA	*Amphora*	*ovalis*	GPAR	*Gomphonema*	*parvulum*
APED	*Amphora*	*pediculus*	MCIR	*Meridion*	*circulare*
AVEN	*Amphora*	*veneta*	NACO	*Navicula*	*accomoda*
CPED	*Cocconeis*	*pediculus*	NCPR	*Navicula*	*capitatoradiata*
CAFF	*Cymbella*	*affinis*	NCRY	*Navicula*	*cryptocephala*
CCAE	*Cymbella*	*caespitosa*	NMIS	*Navicula*	*minuscula*
CGRA	*Cymbella*	*gracilis*	NSAL	*Navicula*	*salinarum*
CHUS	*Cymbella*	*hustedtii*	NTPT	*Navicula*	*tripunctata*
CMES	*Cymbella*	*mesiana*	NTRV	*Navicula*	*trivialis*
CMIN	*Cymbella*	*minuta*	NCPL	*Nitzschia*	*capitellata*
CTUR	*Cymbella*	*turgidula*	NDIS	*Nitzschia*	*dissipata*
DEHR	*Diatoma*	*ehrenbergii*	NFIL	*Nitzschia*	*filiformis*
DVUL	*Diatoma*	*vulgaris*	NLIN	*Nitzschia*	*linearis*
DGER	*Didymosphenia*	*geminata*	NPAL	*Nitzschia*	*palea*
EBIL	*Eunotia*	*bilunaris*	NIPM	*Nitzschia*	*perminuta*
EEXI	*Eunotia*	*exigua*	NUMB	*Nitzschia*	*umbonata*
FARC	*Fragilaria*	*arcus*	RABB	*Rhoicosphenia*	*abbreviata*
FCAP	*Fragilaria*	*capucina*	SANG	*Surirella*	*angusta*
FCVA	*Fragilaria*	*capucina var. gracilis var. vaucheriae*	SBRE	*Surirella*	*brebissonii*
FCRO	*Fragilaria*	*crotonensis*	SLIN	*Surirella*	*linearis*
FPIN	*Fragilaria*	*pinnata*	SOVI	*Surirella*	*ovalis*
FULN	*Fragilaria*	*ulna*	TFLO	*Tabellaria*	*floculosa*
FVIR	*Fragilaria*	*virescens*			