ECOLOGIA BALKANICA
2019, Vol. 11, Issue 1 June 2019 pp. 11-16

# *Hydromorphological Pressure in Mountain and Semi-mountain Rivers: Response of Macrophyte Communities*

***Gana M. Gecheva*[*], *Yordanka G. Hristeva***

University of Plovdiv, Faculty of Biology, 24 Tsar Asen Str., Plovdiv, BULGARIA
[*]Corresponding author: ggecheva@mail.bg

**Abstract.** Mountain and semi-mountain river sites (n=14) were subject to monitoring in 2016-2017. Sampling sites were selected in order to study the effects of small hydropower plants on the aquatic plant assemblages within local lotic habitats. Aquatic plant diversity and Reference index were applied as metrics to assess the response to physical disturbance. The results of the assessment revealed differences in ecological status upstream and downstream of the hydropower plants, indicating macrophyte communities as a reliable indicator of the hydromorphological degradation.

**Key words:** macrophytes, hydromorphological degradation, physical disturbance.

## Introduction

The Water Framework Directive implicitly requires that habitats are linked to biota, including macrophytes to physical habitat quality (Logan & Furse, 2002). Man's alterations to rivers through impoundments, realignment of channels, and in-stream engineering works can alter depth, velocity, substrate type, flow types and flow variability (Petts, 1984a; Brookes, 1988). Studies of physically altered rivers show impacts to macrophyte community structure. Following impoundment and canalisation changes include loss of species, altered species dominance and relative abundance (Petts, 1984b; Baattrup-Pedersen & Riis, 1999).

Most of the macrophyte species associated with physical variables that distinguish between ecological quality classes are present in both impacted and unimpacted stream sites (Baattrup-Pedersen *et al.*, 2006). However, these species may exhibit different abundances and spatial distributions in impacted as compared to un-impacted stream sites (O'Hare *et al.*, 2006). Moreover a number of macrophytes are tolerant to habitat degradation, e.g. *Sparganium emersum, Potomogeton crispus* and *Elodea canadensis* (O'Hare *et al.*, 2006).

Researches on hydromorphological pressure, over different geographic areas, show that the diversity of bryophytes in rivers is associated with depth and substrate (Suren & Duncan, 1999; Scarlett & O'Hare, 2006; O'Hare *et al.*, 2006). Bryophyte communities exhibited strong reduction in abundance and even disappeared along physical disturbance gradient (Gecheva *et al.*, 2017).

## Materials and Methods

Surveyed sites were located upstream and downstream of the hydropower plants (Table 1). At each site, a longitudinal stretch of the rivers about 100 m was sampled for macrophytes. The sampling procedure



Union of Scientists in Bulgaria – Plovdiv
University of Plovdiv Publishing House

included the collection of aquatic plants and the recording of abiotic habitat parameters. The abundance of plant species was estimated on site using a five-scale system (KOHLER, 1978).

The nomenclature followed GROLLE & LONG (2000) for liverworts, HILL *et al.* (2006) for mosses, DELIPAVLOV *et al.* (2003) for vascular plants.

Relative abundance was quantified based on per cent frequency of occurrence at the sampling sites.

Reference Index (RI) which defines type-specific reference and non-specific disturbance indicating taxa, and transformation into ecological quality ratio (EQR) were calculated after GECHEVA *et al.* (2013).

Statistics were performed using Canoco (TER BRAAK & ŠMILAUER, 2002).

**Results and Discussion**

*Community structure of macrophytes in the studied rivers*

Dominant substrates in the majority of studied sites were stones and gravel (Table 1). Studied sites along Arda and Struma Rivers were with average depth above 100 cm, while most of the other sites were with average depth up to 0.3 m. Riparian vegetation was dominated by trees of native species and urban areas.

Fifty-two species were registered, 48 to species level and 4 to genus level, among them macroalgae *Cladophora* and *Lemanea*. Twelve species belonged to bryophytes. Two taxa were pteridophytes. The most common species were *Fontinalis antipyretica* Hedw. from the group of aquatic mosses (relative abundance 50%, Table 2) and *Potamogeton crispus* L. as vascular plant. Riparian vegetation was represented with higher species diversity. The most recorded species was *Lythrum salicaria* L. (relative abundance 70%), followed by *Polygonum lapathifolium* L. (64%) and *Veronica beccabunga* L. (57%).

**Table 1.** List of surveyed sites: geographical coordinates dominant substrate and vegetation in riparian zone.

| | Site | Latitude | Longitude | Average depth, cm | Dominant substrate type | Dominant vegetation type (riparian zone) |
|---|---|---|---|---|---|---|
| 1 | Arda - Rudozem | 41°30'52.33" | 24°53'12.69" | 30-100; > 100 | rock bed | riparian forest; urban area |
| 2 | Arda - Madanska | 41°31'59.61" | 24°54'46.33" | 0-30 | stones | trees and shrubs; urban area |
| 3 | Arda – Vehtino | 41°33'11.46" | 25° 0'9.32" | > 100 | stones | trees of native species; artificial tree plantations; urban area |
| 4 | Arda – Stoyanov most | | | > 100 | stones | trees of native species; urban area |
| 5 | Bela - Betalovoto | 41°51'8.0579" | 23°23'34.572" | 0-30 | course gravel | herbs & perennial plants; trees of native species |
| 6 | Bela – before Razlog | 41°52'32.408" | 23°25'45.75" | 0-30 | stones | cultivated species & neophytes; urban area |
| 7 | Belishka – before | 41°56'38.426" | 23°33'47.852" | 0-30 | stones | trees of native |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | sHPP Belishka – after sHPP | 42°14'53.244" | 22°53'18.6779" | 0-30 | course gravel | species trees of native species |
| 9 | Vacha – Yoakim Gruevo | 42°7'9.662" | 24°33'20.837" | 30-100 | stones | trees of native species; urban area |
| 10 | Vacha - Kadievo | 42°8'12.833" | 24°36'5.079" | 30-100; > 100 | fine/med. gravel & course gravel | cultivated species & neophytes; urban area |
| 11 | Sedrach – after pumped storage | 41°55'57.525" | 23°26'32.739" | 0-30 | stones | trees of native species |
| 12 | Sedrach – after sHPP | 41°55'9.5039" | 23°27' 44.490" | 0-30; 30-100 | stones | trees of native species |
| 13 | Struma - Nevestino | 42°15'22.46" | 22°51'11.164" | > 100 | silt | trees of native species; urban area |
| 14 | Struma – before Eleshnitsa mouth | 42°14'53.244" | 22°53'18.6779" | > 100 | sand; silt | meadows & grassland; trees of native species |

**Table 2.** List of species, codes, relative abundance, and rivers, where they were registered.

| Species | Species code | Relative abundance, % | River |
|---|---|---|---|
| **Liverworts** | | | |
| *Marchantia polymorpha* L. | MAR.POL | 21 | Belishka, Sedrach |
| **Mosses** | | | |
| *Brachythecium rivulare Schimp.* | BRA.RIV | 14 | Belishka |
| *Bryum elegans* Ness | BRY.ELE | 7 | Bela |
| *Bryum turbinatum* (Hedw.) Turner | BRY.TUR | 14 | Bela, Sedrach |
| *Cinclidotus fontinaloides* (Hedw.) P.Beauv. | CIN.FON | 7 | Belishka |
| *Cratoneuron filicinum* (Hedw.) Spruce | CRA.FIL | 14 | Bela, Struma |
| *Drepanocladus exannulatus* (Schimp.) Warnst. | DRE.EXA | 7 | Bela |
| *Fontinalis antipyretica* Hedwig | FON.ANT | 50 | Bela, Belishka, Sedrach, Vacha |
| *Leptodictyum riparium* (Hedw.) Warnst. | LEP.RIP | 28 | Bela, Belishka, Vacha, Struma |
| *Plagiomnium undulatum* (Hedw.) T.J.Kop. | PLA.UND | 7 | Bela |
| *Platyhypnidium riparioides* (Hedw.) Dixon | PLA.RIP | 21 | Bela, Sedrach |
| *Rhizomnium punctatum* (Hedw.) T. Kop. | RHI.PUN | 7 | Belishka |
| **Vascular plants** | | | |
| *Agrostis stolonifera* L. | AGR.STO | 14 | Sedrach |
| *Bidens tripartita L.* | BID.TRI | 50 | Arda,Vacha,Struma |
| *Butomus umbellatus* L | BUT.UMB | 7 | Struma |
| *Cyperus fuscus* L. | CYP.FUS | 14 | Bela, Sedrach |
| *Cyperus longus* L. | CYP.LON | 50 | Arda, Belishka, Sedrach,Struma |
| *Echinochloa crus-galli* (L.) P. Beauv | ECH.CRU | 21 | Bela, Struma |
| *Elodea canadensis* Michx. | ELO.CAN | 7 | Vacha |
| *Epilobium hirsutum* L. | EPI.HIR | 7 | Belishka |
| *Equisetum arvense* L. | EQU.ARV | 43 | Arda, Belishka, Sedrach |
| *Equisetum fluviatile* L. | EQU.FLU | 21 | Belishka, Sedrach |
| *Glyceria maxima* (Hartm.) Holmb. | GLY.MAX | 21 | Arda |
| *Lemna minor* L. | LEM.MIN | 7 | Vacha |

| | | | |
|---|---|---|---|
| *Lycopus europaeus* L. | LYC.EUR | 21 | Arda, Vacha Belishka, Sedrach |
| *Lycopus exaltatus* L.f. | LYC.EXA | 7 | Vacha |
| *Lysimachia nummularia* L. | LYS.NUM | 7 | Sedrach |
| *Lythrum salicaria* L. | LYT.SAL | 70 | Arda, Vacha, Bela, Belishka, Sedrach, Struma |
| *Juncus effusus* L. | JUN.EFF | 7 | Bela |
| *Mentha longifolia* L. | MEN.LON | 21 | Bela, Sedrach |
| *Mentha piperita* L | MEN.PIP | 7 | Vacha |
| *Myosoton aquaticum* (L.) Moench | MYO.AQU | 14 | Bela, Belishka |
| *Myriophyllum spicatum* L. | MYR.SPI | 7 | Struma |
| *Myriophyllum verticillatum* L. | MYR.VER | 7 | Vacha |
| *Paspalum paspalodes* (Michx.) Scribn. | PAS.PAS | 21 | Arda, Vacha |
| *Petasites hybridus* (L.) P.Gaertn. B.Mey. & Scherb. | PET.HYB | 21 | Bela, Belishka, Sedrach |
| *Phalaris arundinacea* L. | PHA.ARU | 43 | Arda, Struma |
| *Polygonum hydropiper* L. | POL.HYD | 7 | Arda |
| *Polygonum lapathifolium* L. | POL.LAP | 64 | Arda, Vacha, Bela, Sedrach, Struma |
| *Potamogeton crispus* L. | POT.CRI | 21 | Arda, Struma |
| *Potamogeton nodosus* Poir. | POT.NOD | 7 | Struma |
| *Potamogeton pectinatus* L. | POT.PEC | 7 | Vacha |
| *Ranunculus repens* L. | RAN.REP | 43 | Arda, Bela, Belishka, Struma |
| *Sparganium erectum* L. | SPA.ERE | 14 | Struma |
| *Stellaria media* (L.) Vill. | STE.MED | 7 | Arda |
| *Typha angustifolia* L. | TYP.ANG | 7 | Arda |
| *Veronica anagalis-aquatica* L. | VER.ANA | 7 | Bela |
| *Veronica beccabunga* L. | VER.BEC | 57 | Arda, Vacha, Belishka,Sedrach |

*Metric response*

Species richness varied between local lotic habitats (range = 6 - 16, median = 10). Sites with highest richness (N4 and N11) were assessed in moderate and high status, while both sites with minimum richness (N1 and N3) achieved good status. This finding reflected that compositional changes are more reliable metric in conditions of physical disturbance.

Detrended correspondence analysis (DCA) was applied to relate the species' occurrences to flow velocity and substrate type as environmental variables with reference to the hydromorphological pressure, as well as to the assessed ecological status (Fig. 1). The first and second axes' eigenvalues were 0.766 and 0.504, respectively. The explained variation was 19.55 and 32.41% for the first and second axis. Species in high quality status habitats with rapidly running water and coarser bottom were inhabited by aquatic bryophytes *Cinclidotus fontinaloides* (Hedw.) P.Beauv., *Brachythecium rivulare* Schimp., *Bryum turbinatum* (Hedw.) Turner, *Fontinalis antipyretica* Hedw., *Marchantia polymorpha* L., *Plagiomnium undulatum* (Hedw.) T.J.Kop., *Platyhypnidium riparioides* (Hedw.) Dixon, *Sarmentypnum exannulatum* (Schimp.) Hedenäs (on the left hand side and center bottom of the diagram). Riparian assemblage at these habitats included pteridophyte *Equisetum fluviatile* L. and helophytes *Agrostis stolonifera* L., *Cyperus fuscus* L. and *Mentha longifolia* (L.) Huds. Aquatic macrophyte communities in sites under physical disturbance (reduced flow and silting) were dominated by vascular plants including invasive *Elodea canadensis* Michx., floating *Lemna minor* L., submerged *Myriophyllum spicatum* L., *M. verticillatum* L., *Potamogeton crispus* L., *P. nodosus* Poir., *P. pectinatus* L. (located in the center top and right of the plot).

Based on the results, pilot applying of genus *Lemanea* (in the center of the plot) as indicator from Group B was made. This indicator group includes species without preferences to any reference or other conditions.

In general, ecological status of sites upstream and those downstream of hydropower plants was with one category difference, i.e. sites under physical pressure were assessed in moderate status.

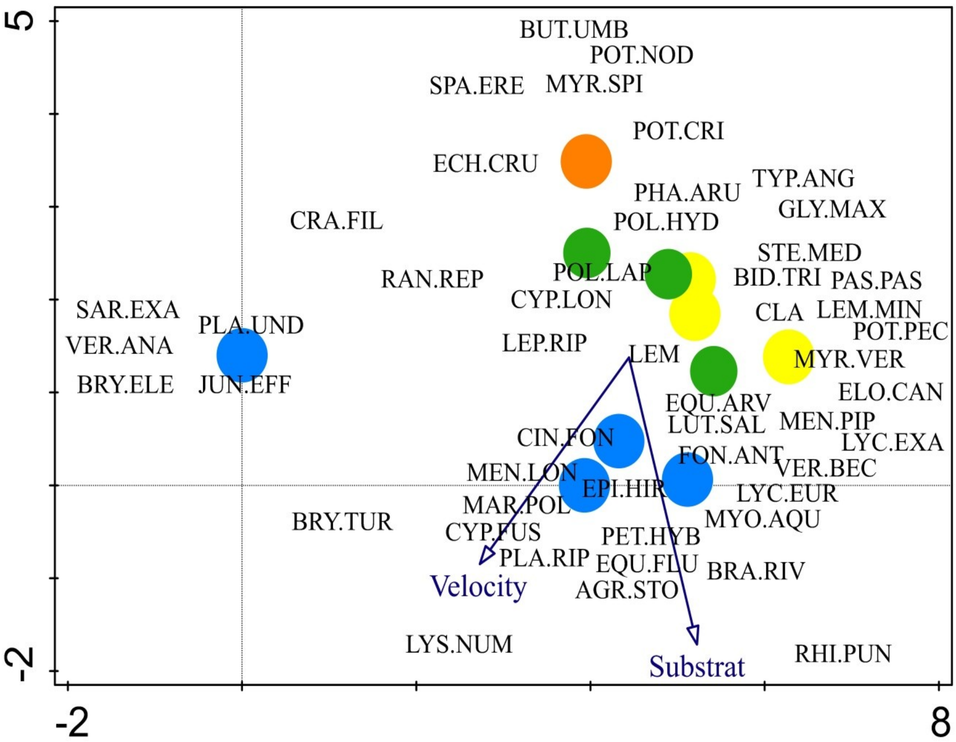


**Fig. 1.** DCA ordination plot with selected environmental factors and achieved ecological status (blue circle: high, green-good, yellow: moderate, orange: poor). Refer to Table 2 for species codes.

## Conclusions

The effects of hydroelectric functioning on river macrophyte communities were established trough alteration of local habitats, mainly substrate and water level homogenization. Macrophytes respond to this hydromorphological pressure and appear well suited to assess physical degradation. Species composition as a qualitative metric appeared to be reliable in conditions of physical disturbance. Aquatic bryophytes dominated in physically unaltered lotic ecosystems, while vascular plants including invasive species represented macrophyte communities downstream of the hydropower plants. Registered *Elodea canadensis*, *Myriophyllum spicatum* and *Potamogeton* spp. occur typically in lowland rivers and are positively related to physical disturbance and nutrients. Application of genus *Lemanea* as indicator should be further tested in similar studies.



### Acknowledgements

This study was supported by the East- and West-Aegean River Basin Directorates, Bulgaria.


## References


BAATTRUP-PEDERSEN A., K. SZOSZKIEWICZ, R. NIJBOER, M. O'HARE, T. FERREIRA. 2006. Macrophyte communities in unimpacted European streams: variability in assemblage patterns, abundance and diversity. – *Hydrobiologia*, 566: 179–196. [DOI].

BAATTRUP-PEDERSEN A., T. RIIS. 1999. Macrophyte diversity and composition in relation to substratum characteristics in regulated and unregulated Danish streams. - *Freshwater Biology*, 42: 375–385. [DOI].

BROOKES A. 1988. *Channelized rivers: perspectives for environmental management.* John Wiley. Chichester.

DELIPAVLOV D., I. CHESHMEDJIEV, M. POPOVA, D. TERZIISKI, I. KOVACHEV. 2003. [*A guide to the plants in Bulgaria*]. Plovdiv Agrarian University. (In Bulgarian).

GECHEVA G., I. DIMITROVA-DYULGEROVA, S. CHESHMEDJIEV. 2013. Macrophytes. - In: Belkinova D., G. Gecheva (Eds.).

*Biological analysis and ecological assessment of the surface water types in Bulgaria. Plovdiv. Plovdiv University Press, pp. 127–146.*

GECHEVA G., K. PALL, Y. HRISTEVA. 2017. Bryophyte communities' responses to environmental factors in highly seasonal rivers. – *Botany Letters*, 164 (1): 79-91. [DOI].

GROLLE R., D. G. LONG. 2000. An Annotated Check-List of the Hepaticae and Anthocerotae of Europe and Macaronesia. - *Journal of Bryology*, 22: 103–140. [DOI].

HILL M. O., N. BELL, M. A. BRUGGEMAN-NANNENGA, M. BRUGUÉS, M. J. CANO, J. ENROTH, K. I. FLATBERG, J.-P. FRAHM, M.T. GALLEGO, R. GARILLETI, J. GUERRA, L. HEDENÄS, D.T. HOLYOAK, HYVÖNEN, M.S. IGNATOV, F. LARA, V. MAZIMPAKA, J. MUÑOZ, L. SÖDERSTRÖM. 2006. An Annotated Checklist of the Mosses of Europe and Macaronesia. - *Journal of Bryology*, 28: 198–267. [DOI].

KOHLER A. 1978. Methoden der Kartierung von Flora und Vegetation von Süßwasserbiotopen. - *Landschaft&Stadt*, 10 (2): 73-85.

LOGAN P., M. FURSE. 2002. Preparing for the European Water Framework Directive - making the links between habitat and aquatic biota. - *Aquatic Conservation: Marine and Freshwater Ecosystems*, 12: 425–437. [DOI].

O'HARE M.T., A. BAATTRUP-PEDERSEN, R. NIJBOER, K. SZOSZKIEWICZ, T. FERREIRA. 2006. Macrophyte communities of European streams with altered physical habitat. - *Hydrobiologia* 566, 197–210. [DOI].

PETTS G. E. 1984a. The quality of reservoir releases. – In: Petts G.E. (Ed.), *Impounded Rivers: Perspectives for Ecological Management.* John Wiley & Sons. Chichester, pp. 54–83.

PETTS G.E. 1984b. Vegetation reaction and structure. – In: Petts G.E. (Ed.), *Impounded Rivers: Perspectives for Ecological Management.* John Wiley & Sons. Chichester, pp. 150–173.

SCARLETT P., M.T. O'HARE. 2006. Community structure of instream bryophytes in English and Welsh rivers. – *Hydrobiologia*, 553: 143–152. [DOI].

SUREN A.M., M.J. DUNCAN. 1999. Rolling stones and mosses: effect of substrate stability on bryophyte communities in streams. - *Journal of the North American Benthological Society*, 18: 457–467. [DOI].

TER BRAAK C. J. F., P. SMILAUER. 2002. CANOCO (Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination), Vers. 4.5. Ithaca: Microcomputer Power.

Received: 30.10.2018
Accepted: 15.04.2019