ENVIRONMENTAL FACTORS INFLUENCING THE MACROPHYTE SPECIES COMPOSITION AND DIVERSITY IN STREAMS OF THE ABAVA BASIN, LATVIA

Linda Uzule

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Macrophytes are important components of aquatic ecosystems and are widely used within Water Framework Directive (WFD) to establish ecological quality. In the present paper there are investigated macrophyte community structure and their relation to environmental conditions in 30 stream sites of Abava basin. The aim of this paper is to characterise the diversity of macrophytes and environmental factors on the selected part of Abava basin and to find the relationship between environmental conditions and macrophyte patterns.

A total of 41 taxa of macrophytes were identified in 30 surveyed sites and the average number of macrophytes per sampling site was 8 in small sized streams and 10 in middle sized streams, ranging from 3 to 19. The most frequently occurring macrophytes were *Cyperaceae spp.* (occurence at 70% of sampling sites), *Veronica anagallis – aquatica* (63%), *Sparganium emersum* (60%), *Phalaris arundinacea* (57%), *Alisma plantago – aquatica* (57%), *Nuphar lutea* (53%) *and Equisetum fluviatile* (47%).

Analyses showed correlation between number of taxa and substrate, as well as macrophyte coverage with stream velocity and stream depth.

Key words: macrophytes, environemntal factors, running water, Abava basin.

Linda Uzule. Department of Environmental Science, University of Latvia, Raiņa blvd. 19, LV – 1586, Riga, Latvia, e-mail: uzule.linda@inbox.lv

INTRODUCTION

Aquatic macrophytes are aquatic photosynthetic organisms, large enough to see with a naked eye, that actively grow permanently or periodically submerged below, floating on, or growing up through the water surface (Chambers et al. 2008). Macrophytes are important components of aquatic ecosystems and changes in community composition, or in the abundance of individual species, provide valuable information on how and why an ecosystem might be changing (Scott et al. 2002). According to the EU Water Framework Directive (Anonymous, 2000) European surface waters must achieve good ecological quality by the year 2015. The European Water Framework Directive lists aquatic macrophytes as one of the biological quality elements needed for assessing the ecological status of surface water bodies. Aquatic macrophyte communities constitute a fundamental component of many lowland river ecosystems. Macrophyes can contribute significantly to the physical and biological diversity, habitat structure and ecological functioning of river ecosystems (Haslam 1978, Baatrup – Pedersen et al. 2002, Lacoul & Freedman 2006). The relationship between aquatic macrophytes and the trophic status of rivers is a complex one because of the synergistic effects of a range of environmental variables – stream velocity (Haslam 1978, Riis & Biggs 2003, Franklin et al. 2008, Janauer et al. 2010), light availability (Dawson & Kern – Hansen 1979, Sand – Jensen 1989), substrate type (Barko & Smart 1986, Clarke & Wharton 2001, Gurnell et al. 2006, Jones et al. 2012), depth and width of river (Riis & Biggs 2003, Paal & Trei 2004), nutrient concentration (Demars & Harper 1998, Thiebaut & Muller 1998, Schulz et al. 2003).

Water movement has long been proposed as a prime factor regulating the growth and distribution of macrophytes in rivers (Haslam 1978, Madsen et al. 2001). Several studies have argued that water velocity is the main factor in regulating aquatic macrophyte distribution, composition, biomass and metabolisms in rivers (Haslam 1978, Chambers et al. 1991, Riis & Biggs 2003). Water velocity has an indirect effect on photosynthesis through the regulation of the availability of dissolved substances (Sand – Jensen 1989, Madsen et al. 2001). Stream velocity can also have notable indirect impacts upon instream macrophyte communities through its effect on other factors that regulate macrophyte establishment, growth and persistence (Franklin et al. 2008).

The quality and quantity of light available within the river system have an important influence on the growth and development of submerged macrophytes (Sand – Jensen 1989). Macrophytes require light for photosynthesis – if light availability is limited, there will be a negative impact on growth rates of macrophytes (Haslam 1978).

Macrophyte species are also shown to vary in their responses to sediment conditions (Haslam 1978). Substrate stability is a significant controlling factor because a stable substrate allows rooting and establishment of macrophyte communities (Haslam 1978, Riis & Biggs 2003).

It is well known that excessive plant growth in aquatic systems is largely caused by the supply of nutrients, especially nitrate and phosphate (Moore et al. 1994, Demars & Harper 1998, Clarke & Wharton 2001). The assessment of the effects of nutrients on the status of macrophytes in running waters is confounded by the synergistic effects of the other environmental and biotic variables that affect growth of aquatic macrophytes (Demars & Harper 1998, Franklin et al. 2008).

Mapping of macrophytes and studies of interaction between macrophytes and environmental variables in running waters were very intensive in the Danube countries (Cristofor et al. 2003, Schaumburg et al. 2004, O'Hare et al. 2006). In the teritory of Latvia, only few data have been published (Urtāns 1995, Grinberga 2010, Grinberga 2011).The aim of this paper is to characterise the diversity of macrophytes and environmental factors on the selected part of Abava basin and to find the relationship between environmental conditions and macrophyte patterns.

MATERIAL AND METHODS

Study area

The study was carried out at 30 sites located in the Abava basin on 13 streams (Fig. 1). Five (Amula, Imula, Pūre, Vēdzele, Viesata) of them were classified as medium sized streams (catchment area 100 – 1000 km^2) and eight (Bebrupe, Buļļupe, Dimžava, Īvande, Līgupe, Rumbulīte, Valgale, Virbupe) were small sized streams (catchment area <100 km^2). Sampling sites were selected in sites typical for the particular river and the selection was based on topographical maps (1: 100 000).

Macrophyte sampling

Macrophyte surveys were undertaken using the protocols associated with the Mean Trophic

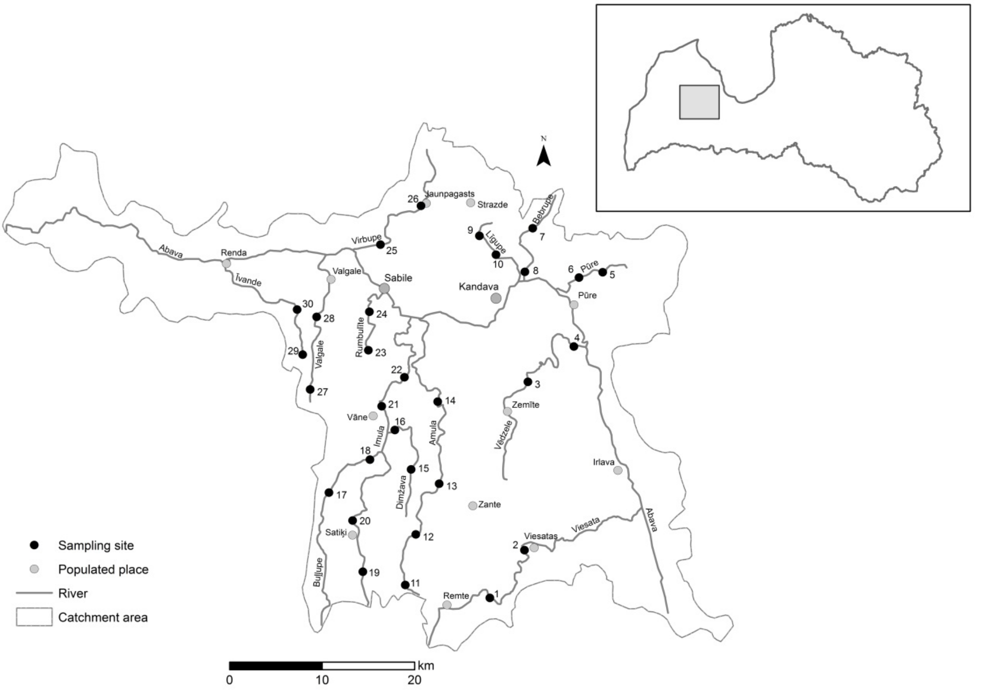

Fig.1. Map of sampling sites (n=30).

Rank (MTR) indexation method (Holmes et al. 1999). This method is the Standard method used in the United Kingdom and other Member States participating in STAR (Standardisation of river classifications: Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive) project (Furse et al. 2006). The sampling reach was 100 m in length. Macrophyte sampling was undertaken in August and early September 2011. All macrophytes present were recorded, together with the estimated percentage cover of each species. Macrophytes were identified to species or to the lowest practical taxonomic level. Macrophyte abundance was expressed in terms of the percentage of the survey length covered. A cover score was allocated to each macrophyte species present using the following scale 1: <0.1%, 2: 0.1 – 1%, 3: 1 – 2.5%, 4: 2.5 – 5%, 5: 5 – 10%, 6: 10 – 25%, 7: 25 – 50%, 8: 50 – 75%, 9: >75%.

Physical characteristics

Information on the physical characteristics of each site should also be recorded as an aid in the interpretation of macrophyte data. Water current velocity was recorded in three categories: 1= fast flowing (>0,4 m/s), 2= medium fast flowing (0,2 – 0,4 m/s), 3= slow flowing (<0,2 m/s). Shading was estimated by following three – grade scale: 1= no shading, 2= shading present (<33%), 3= shading extensive (>33%). A three – point scale was used for estimation of the substrate type: 1= sand, 2= sludge or organic matter, 3= gravel, pebble. The stream depth classified as follows: 1= <0,5m, 2= 0,5 – 1m, 3= >1m and water width was dividend into three clases: 1= <3m, 2= 3 – 5m, 3= >5m.

Data analysis

Relationships among environmental and vegetation parameters were evaluated by Pearson correlation coefficients calculated by SPSS 12.0.1.

RESULTS AND DISCUSSION

A total of 41 macrophyte taxa were found in the investigated streams. The macrophyte communities in the streams were dominated by *Cyperaceae spp.* (70% of the sites), *Veronica anagallis – aquatica* (63%), *Sparganium emersum* (60%), *Phalaris arundinacea* (57%), *Alisma plantago – aquatica* (57%), *Nuphar lutea* (53%) *and Equisetum fluviatile* (47%) (Table 1). These species are tolerant to habitat degradation and other types of impacts, such as organic pollution (Baatrup – Pedersen et al. 2003, Schneider & Melzer 2003). In Latvia, *Sparganium emersum* and *Nuphar lutea* are species, which are common and dominant in slow flowing streams on gravel substrate (Grinberga 2010). Macrophyte species such as *Alisma plantago – aquatica*, *Sparganium emersum* and *Nuphar lutea* are detected in all stream types (fast flowing streams on gravel substrate, slow flowing streams on gravel substrate, fast flowing streams on sandy substrate, slow flowing streams on sandy substrate and slow flowing streams with soft, silty substrate), which shows their resistance and toleration to many environmental factors (Grinberga 2010). The species richness ranged from 3 to 19 species per site and the average number of macrophytes per sampling site was 8 in small sized streams and 10 species per site in middle sized streams (Table 2). Vegetation cover in the investigated stretches varied from 1 to 90% and there are not diference in macrophyte coverage between small sized and middle sized streams.

Of all investigated stretches 27% were fast flowing streams, 23% - medium fast flowing streams and 50% were slow flowing streams. The dominating sediment type was sand (66% of all sites), stream sites with gravel, pebble were 21% and sites with sludge were 14%. The stream width varied from 1,5m to 9,5m. A half (50%) of investigated stream sites were with width from 3 to 5m, 27% of sites were <3m wide and 23% were >5m wide. The greatest part of surveyed sites were 0,5 – 1m (47%) and <0,5m (37%) deep. There were 17% of sites with deep >1m. A most part of stream sites with deep 0,5 – 1m and >1m were regulated streams (Latvijas Republikas Ministru Kabinets 2008).Stream sites where was not shading over the water were only 23%, sites with shading present (<33%) made up 40% and a great part of surveyed sites were with extensive shading (>33%) – 37%.

As pressures on water resources increase, the importance of being able to understand and predict they likely response of aquatic ecosystems to increased exploitation becomes greater. The important role of macrophytes in the structure and functioning of lowland river ecosystems therefore makes understanding the factors controlling the status of macrophytes essential for developing future management strategies for these systems. Relationships between species richness, coverage and physical parameters (stream velocity, shading, stream depth, stream width and substrate) were calculated (Table 3). There was a significant correlation among most of environmental parameters. Species richness was negatively correlated with substrate. The results of this study indicate that in streams with unstable substrate (sands, sludge) species richness and coverage of macrophyte is lower than in stable substrate. Substrate stability is a significant controlling factor because a stable substrate allows rooting and establishment of macrophyte communities (Haslam 1978, Riis & Biggs 2003). Streams with gravelly substrate are characterized by low water level that provides good habitats for macrophyte growth (Grinberga 2010). Analyses show a negative correlation between macrophyte cover and stream velocity and stream width. Stream velocity positively correlated with substrate and negatively correlated with stream depth, stream width were a positive correlation with stream depth and shading.

The results of the study reveals that one of most important factors affecting macrophytes species number and cover in streams of Abava basin are substrate conditions, stream velocity as well as stream width. Stream velocity and substrate stability have long been proposed as a prime factors regulating the growth and distribution of macrophytes in rivers (Haslam 1978, Madsen et al. 2001, Franklin et al. 2008). The hydrological

Table 1. Macrophyte taxa and their abundance in the investigated stream stretches of Abava basin

	Abundance, N		Abundance, N
Emergent macrophytes		**Submerged macrophytes**	
Butomus umbellatus	4	*Veronica beccabunga*	2
Scirpus lacustris	8	*Callitriche cohocarpa*	7
Ranunculus lingua	1	*Elodea canadenis*	8
Cyperaceae sp.	21	*Potamogeton crispus*	1
Sparganium erectum	3	*Potamogeton pectinatus*	3
Phalaroides arundinacea	17	*Chara sp.*	1
Sagittaria sagittifolia	4	*Myriophyllum verticillatum*	2
Alisma plantago-aquatica	17	*Fontinalis antipyretica*	8
Phragmites australis	10	*Callitriche palustris*	2
Typha latifolia	7	*Potamogeton filiformis*	1
Calla palustris	1	*Hottonia palustris*	4
Iris pseudocaris	7	*Batrachium trichophyllum*	2
Berula erecta	10	*Potamogeton praelongus*	4
Bidens tripartita	11	*Cladophora sp.*	3
Menyanthes trifoliata	1		
Equisetum fluviatile	14	**Free-floating macrophytes**	
Veronica anagallis-aquatica	19	*Lemna minor*	9
Mentha aquatica	10	*Hydrocharis morsus-ranae*	6
Rumex aquaticus	1	*Spirodela polyrhiza*	1
Sparganium emersum	18		
Juncus inflexus	1		
Ranunculus sceleratus	1		
Floating-leaved macrophytes			
Nuphar lutea	16		
Potamogeton natans	5		

Table 2. Number of sites, species richness and macrophyte coverage of small sized and middle sized streams of Abava basin

	Small sized streams	Middle sized streams
Number of sites	16	14
Macrophyte coverage (%)		
mean	28,2	27,5
range	1 - 90	5 – 80
Species richness		
mean	8	10
range	4 – 16	3 – 19

Table 3. Pearson linear correlation coefficients among species number, cover and environmental variables

	Number of taxa	Cover (%)	Stream depth	Substrate	Stream velocity	Stream width	Shading
Number of taxa	1						
Cover (%)	0,159	1					
Stream depth	0,189	-0,029	1				
Substrate	-0,533**	-0,290	-0,482**	1			
Stream velocity	-0,337	-0,362*	-0,410*	0,749**	1		
Stream width	-0,041	-0,383*	0,510**	-0,159	0,103	1	
Shading	-0,110	-0,199	-0,039	-0,033	0,103	0,397*	1

(*) $p<0.05$; (**) $p<0.01$ N=30

regime of a river is a considered to be of major importance to the vegetation, affecting both the species present and their abundance (Riis & Biggs 2003, Franklin et al. 2008). Both the abundance and diversity of macrophytes are stimulated at low to medium velocities, and growth restricted at higher velocities (Madsen et al. 2001). Grinberga (2010) suggests, that each stream group (fast flowing on gravelly substrate, slow flowing on sandy substrate, fast flowing on sandy substrate, slow flowing on sandy substrate and streams with soft, silty substrate) has different primary factors controlling macrophyte diversity and abundance in streams.

CONCLUSIONS

In running waters aquatic vegetation is influenced by some abiotic factors like stream velocity, substrate material, light availability, river depth and width, ph, nutrient concentration etc. The distribution of macrophytes in streams is never determined by only one environmental factor. Most important factors affecting macrophytes species richness and cover in small sized and middle sized streams of Abava basin are substrate conditions, stream velocity as well as stream width. Results show that there are not significant diferences of species richness and coverage of macrophytes between small sized and middle sized streams of study area.

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