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Macrophytic Distribution and Trophic State of Some Natural and Impacted Watercourses - Belgium Wallonia

Regular Paper

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Abstract In the present paper we investigated macrophyte community structure in 60 natural and impacted stream and river sites distributed throughout the Walloon river network.

The objectives were to describe the distribution of macrophyte assemblages in relation to physico-chemical parameters of their environment and to assess the variability in ecological metrics within these watercourses.

Two-way clustering allowed us to simultaneously assign sample units and species to groups by performing two separate cluster analyses. Indicator species analysis allowed us to assess the degree to which a species indicated a group, based on its constancy and distribution of abundance.

Six end-groups were identified as a result of using two-way clustering and indicator species analysis techniques. *Hygroamblystegium fluviatile*, *Chiloscyphus polyanthos* and *Lemanea fluviatilis* were found to characterize acidic and low impacted streams and rivers (G1), while *Ranunculus fluitans* was found in all low impacted large streams (G2). *Potamogeton pectinatus*, proved to be more common in eutrophicated waters in the calcareous areas particularly in the "Loess low plateaux" region (G6). *Cinclidotus riparius*, *Fissidens crassipes* and *Pellia endiviifolia*, appeared in rivers situated in the Condroz region (G4), which was characterized by a high concentration of nitrogen.

Keywords Water Framework Directive (WFD), Macrophytes, Walloon Network, Ecological Quality, Rivers

1. Introduction

The European Union (EU) Water Framework Directive (WFD), which came into force in December 2000 [1], requires European Member States to assess the ''ecological status'' of their country's surface waters.

The main focus of the WFD is the use of biological quality elements (macrobenthic fauna, fish and aquatic flora) in stream assessment, which is a concept new to many European countries [2]. As part of the WFD, aquatic macrophytes are considered as one of the biological quality elements for which an assessment of status must be made. Macrophytes have been studied not only in the context of lake and ditch trophic systems [3-5], alkalinity [6] and acidification but also as indicator species or as vegetation in running waters [7-15].

As in most of the countries in Western Europe, the study of aquatic macrophytes has long since been abandoned in Wallonia. Macrophytes have been used as key bioindicators for assessing global water quality [16-21]. Nevertheless, many of these existing studies deal mainly with phanerogames or bryophytes, while only a few focus on all the macrophyte groups (phanerogames, macro-algae, mosses and liverworts).

For the purposes of implementing the WFD, macrophyte data was collected from several stream and river sites throughout Wallonia. The Macrophyte Biological Index for Rivers (MBIR) [22 and 23] was used to define the ecological status of rivers in response to eutrophication pressure.

The purpose of this study was i) to categorize the watercourses analysed according to their floristic composition, ii) to identify the characteristics of their macrophyte assemblage and iii) to identify physico-chemical parameters in relation to macrophyte distribution.

2. Material and methods

2.1 Macrophyte and environmental database

Surveys were conducted on 60 sites along 100m stretches, which included both swift and slow flowing habitats.

The sampling sites were distributed throughout the Walloon network and covered the five natural regions: the Loess low plateaux, the Condroz, the Famenne, the Ardennes and the Jurassic regions. These five areas correlate well to the geological differences between the calcareous areas of Wallonia and were characterized as indicated in Figures 1 and 2, Table 1 and electronic appendix 1.

The sites were selected in order to provide relevant and representative hydrological and geographical coverage according to the monitoring networks of Walloon rivers.

Macrophyte surveys were undertaken using the protocols associated with the Macrophyte Biological Index for Rivers (MBIR) indexation method [22 and 23].

The submerged macrophytes were surveyed twice during the main vegetation period in 2009-2012.

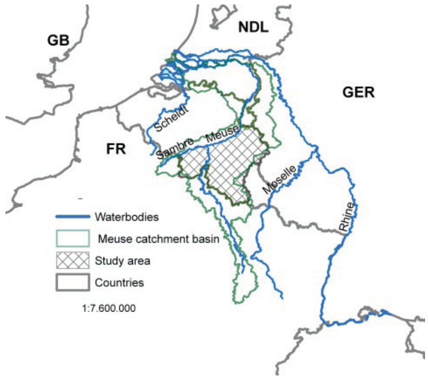

Figure 1. Study area

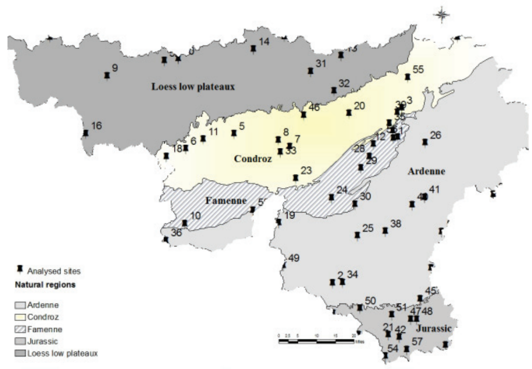

Figure 2. Sites analysed

Percentage cover was estimated in the field for all the macrophyte taxa, and classified according to a scale of cover, ranging from one to five [22]. The nomenclature used follows the literature for spermatophytes [25], for bryophytes [26] and for algae [27].

In each botanical sampling site, several physico-chemical variables were analysed: nitrite (mgN/l), nitrate (mgN/l), ammonium (mgN/l), conductivity (µs/cm), pH, Complete Title Alcalimetric (TAC) (°F), calcium (mg/l), magnesium (mg/l) and $P\text{-}PO4^{3-}$ (mgP/l).

Different environmental variables were also estimated: stream width (five modalities: ≤ 1m, 1.1 to 3m, 3.1 to 5m, 5.1 to 8m and > 8m), stream depth (five modalities: ≤ 0.1m, 0.11 to 0.3m, 0.31 to 0.5m, 0.51 to 1m and > 1m), riverside land cover (grassland, grassland and deciduous, deciduous forest, deciduous and coniferous forest and urbanized area), luminosity (four modalities: ≤ 25%, 26 to 50%, 51 to 75% and > 75%) (Appendix 1).

2.2 Statistical analysis

The distribution of macrophytic communities in the different watercourses sampled was analysed by two-way clustering analysis (PC-ORD [28]).

Natural region	Region surface area %	Forests % (*)	Cultivated areas %	Grass lands %	Built-up areas % (**)	Miscellaneous % (***)	Altitude m (mean)	Prevailing geology	Other geology	Soils
Loess low plateaux	30.3	10.8	57.3	17.7	10.5	3.7	20-200 (100)	Tertiary	Cretaceous	Silt, sand-silt (locally calcareous-laden)
Condroz	20.3	26.1	23.8	37.5	8.9	3.7	100-350 (250)	Carboniferous Upper and Middle Devonian	Cretaceous (Plateau de Herve)	Schist, calcareous, psammite (+ calcareous clay in Plateau de Herve)
Famenne	11.3	41.9	14.5	38.2	2.6	2.7	100-250 (200)	Upper and Middle Devonian		Schist, calcareous, clay
Ardennes	33.4	58.5	3.6	34.6	1.1	2.3	200-694 (400)	Lower Devonian, Cambrian	Ordovician, Silurian	Schist, phyllade, siliceous (sandstone, quartzite)
Jurassic	4.7	38.6	10.4	43.9	3.3	3.8	195-465 (300)	Jurassic		Schist, clay, marl (locally calcareous)

Total surface area: 16844 km²; (*) leafy and coniferous woods and forests; (**) dense and discontinuous built-up domestic and industrial areas; (***) quarries, city green areas, fallow areas, railways, hydrographical network, military areas.

Table 1. The five natural regions in Wallonia [24].

This method allowed us to simultaneously assign sample units and species to groups by performing two separate cluster analyses. Indicator species analysis was used to assess the degree to which a species indicated a group, based on its constancy and distribution of abundance [29] (PC-ORD; [28]).

Principal component analysis was performed to characterize the different groups according to the physico-chemical parameters of their environment. The ecological metric calculated was the mean Macrophyte Biological Index for Rivers [22]. This metric is based on information regarding species tolerance to eutrophication. The metric was developed in France to assess water eutrophy and organic pollution in rivers and was applied in Wallonia. MBIR scores vary between 0 (degraded) and 20 (high quality) [22].

3. Results

3.1 Floristic assemblage and physico-chemical results

Helophytes and species that occurred less than three times were removed from the analysis. Stations with less than three species were also discarded. Only 30 taxa were kept; they included 13 bryophytes, 12 phanerogams and five macroalgae.

Using two-way-clustering analysis, we identified six groups on the basis of their macrophytic composition (Figure 3). The most characteristic species in each group were then determined using Indicator Species Analysis. Finally, Principal Component Analysis (PCA) was used to characterize the different physico-chemical groups (Figure 4).

Group 1 (Figure 3) comprise stations mainly in the Ardenne region whose water originates from groundwater in Eodevonian slatey sandstone, slatey quartz or phillite slate formations. The typical macrophytic community in this group included a moss (*Hygroamblystegium fluviatile*), a liverwort (*Chiloscyphus polyanthos*), a red alga (*Lemanea fluviatiles*) and, to a lesser extent, *Fontinalis squamosa*, *Ranunculus penicillatus*, *Riccardia chamaedryfolia* and *Stigeoclonium* sp. The watercourses of this group were characterized by low mineral content water, a low to medium buffer capacity and low levels of phosphorus and nitrogen compounds.

Group 2 includes calcareous and non-calcareous rivers, which were characterized by the macroalga Oedogonium sp.

As in the case of Groups 4, 5 and 6, the stations in **Group 3** are in silty calcareous, marly calcareous or slatey calcareous formations with high conductivity and a high calcium bicarbonate load. The macroalga *Cladophora glomerata* was common to all stations. This group could be split into three subgroups, based on trophic levels: i) the first subgroup (sg1) was made up of sites on major rivers characterized by the high occurrence and abundance of

Ranunculus fluitans, ii) the second subgroup (sg2) included stations on rivers flowing mainly on the Loess low plateaux, characterized by the algal proliferation of *Cladophora glomerata* (as long filaments) and iii) the third subgroup (sg3) covered the Rabais and the Lamfranba, two rivers from the Jurassic region, characterized by *Cratoneuron filicinum, Fissidens crassipes* and *Pellia endiviifolia*. In terms of chemicals, the stations in Subgroups 1 and 3 had low levels of phosphorus and nitrogen compounds, but those in Subgroup 2 had highly eutrophic waters (0.06–0.57mgP/l orthophosphates and 0.05–3.27mg N/l ammonium nitrogen).

The most characteristic macrophytic community in **Group 4** comprised *Callitriche platycarpa, Potamogeton crispus* and *Sparganium emersum*. It also included *Elodea nuttallii, Pellia endiviifolia* and *Myriophyllum spicatum*, but at a lower occurrence. The stations in this group were located in the Jurassic region on slatey-clayey-marly soils and the water had a high mineral content (average conductivity ranging between 465 and 537µs/cm).

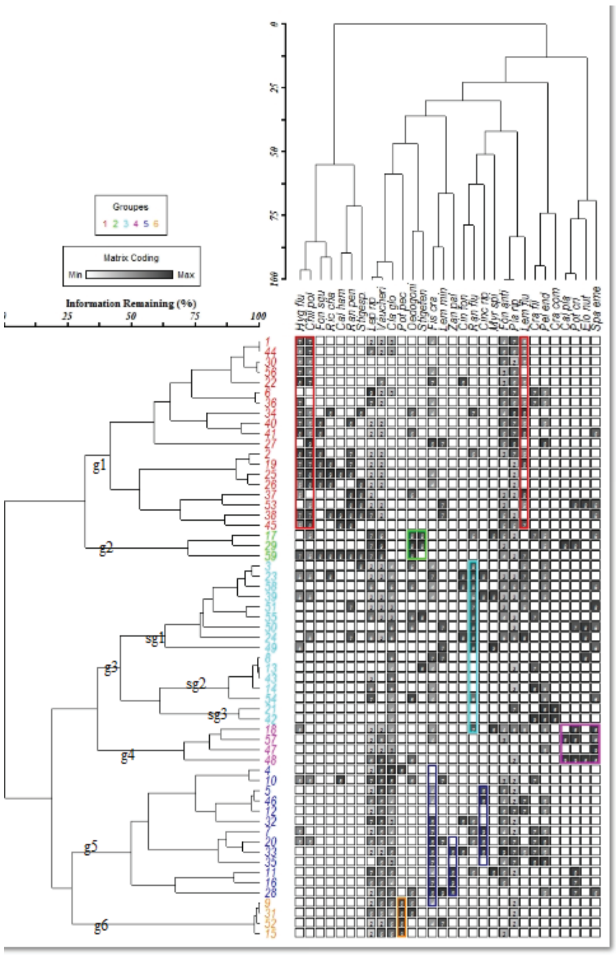

Figure 3. Two-way clustering results. The intensity of the colour of the circles reflects the abundance of each species. The full name of the species appears in electronic appendix 2.

The streams in **Group 5** were situated in the Condroz region and are characterized by high nitrate levels. The characteristic community of this group consisted of *Cinclidotus riparius, Fissidens crassipes, Pellia endiviifolia* and *Zannichellia palustris*. In addition to high alkalinity and high mineralization, the Group 5 stations are characterized by high nitrate content.

Potamogeton pectinatus was typical of the **Group 6** sites. These sites have highly mineralized water (flowing on Jurassic and Loess low plateaux limestone and showing strong eutrophication). The following taxa were also observed at the Group 6 stations: the moss *Leptodictyum riparium* and two macroalgae, *Vaucheria* sp. and *Cladophora glomerata.*

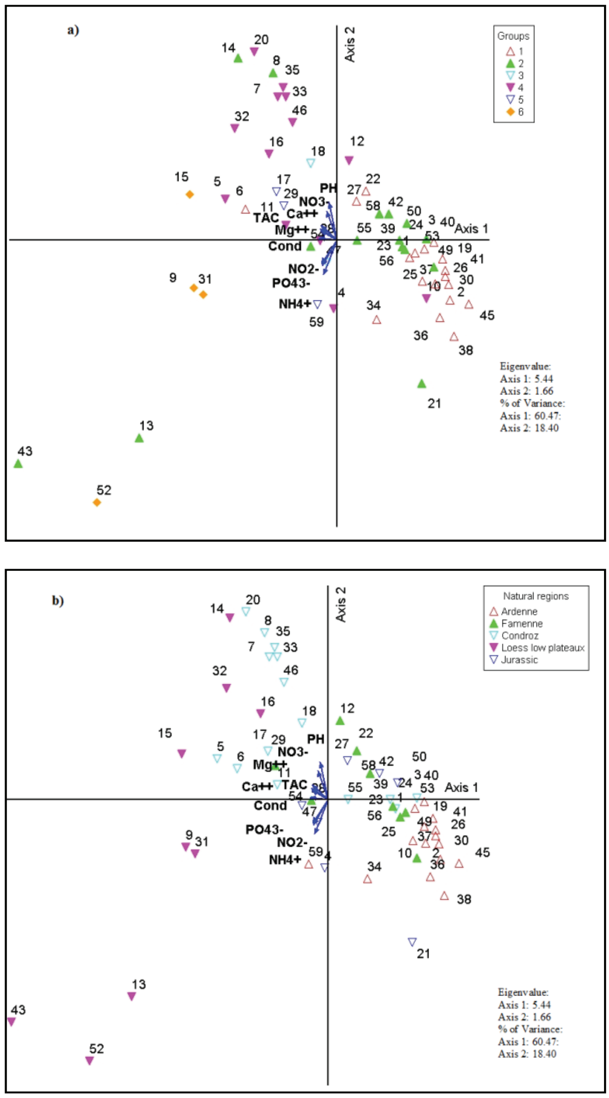

Figure 4. Outcome of the Principal Component Analysis applied to the physico-chemical data of 55 out of the 60 stations under study. Sites are colour-coded to differentiate the six groups of stations as determined by Two-way clustering Analysis (a) and by their location in the natural regions (b).

The following species ('ubiquitous species') occurred in more than three out of the six groups: the mosses *Platyhypnidium riparoides*, *Leptodictyum riparium* and *Fontinalis antipyretica* and a macroalga belonging to the *Vaucheria* genus.

3.2 MBIR results

Macrophyte biological indices were calculated for each site and four trophic states were detected in all the monitored stations. Only 1% of sites showed a high quality trophic state, 19% showed a good state, with a high occurrence in the Ardennes area (gI), 31% showed a moderate state and 25% of the sites showed a poor trophic state, with a high occurrence in the Jurassic and the Loess low plateaux regions.

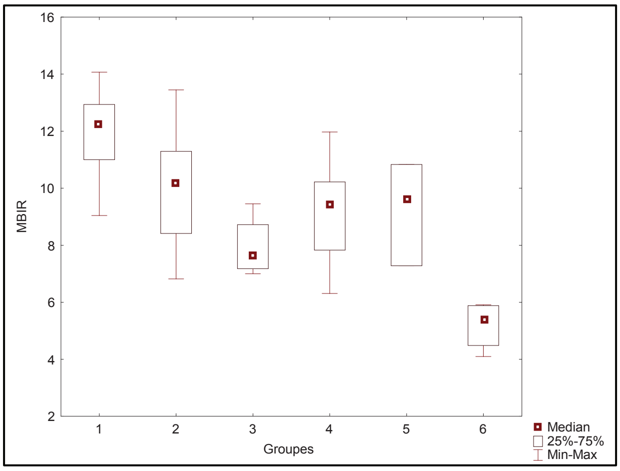

Figure 5. Variation in trophic level between the six groups

A box-whisker plot test (Figure 5) showed a significant difference between the six groups (Kruskal-Wallis test, $p<0.005$). The MBIR scores were slightly higher in the a priori defined gI group, corresponding to the Ardennes sites and lower in the end-defined group, corresponding to the watercourses of the Jurassic and Loess low plateaux regions **(**Group 6).

The linear relationship of the MBIR index to the physico-chemical parameters was quantified using Spearman's coefficient of correlation (Table 2).

Physico-chemical parameters	MBIR
PH	**-0.18**
Conductivity	**-0.66****
Ammoniacal nitrogen	**-0.81*****
Nitrates	**-0.23***
Nitrites	**-0.80*****
Soluble orthophosphates	**-0.72*****
Magnesium	**-0.58****
Calcium	**-0.58****
Complete Title Alcalimetric	**-0.54****

Table 2. Significant Spearman's rank correlation coefficients between environmental characteristics and MBIR. Probability levels used: *p<0.05; **p<0.01; ***p<0.001.

A highly negative correlation was observed between the MBIR value calculated for each of the analysed sites and all the analysed parameters. Nevertheless, this correlation was lower with nitrates and pH.

4. Discussion

Our investigations showed that macrophytes occurred in most of the streams and rivers studied. We also noted that their abundance could be constrained by unfavourable environmental conditions (high anthropic pressure and shading by the riparian vegetation).

To gain a better understanding of the differences attributable to environmental conditions (e.g., geology) and to external pressures on water courses and their plant components, we looked at the different groups of stations in terms of the physical and chemical conditions of the environment, the geology and land use at the level of the watershed.

The distribution of stations and macrophytic species showed a division between the stations with acidic water (G1) and those with alkaline water (G2-G6). This division could be explained geologically (Ardenne stations with water flowing from water tables in Eodevonian slatey sandstone, slatey quartz or phillite slate formations (G1), or from other regions located on silty calcareous, marly calcareous and slatey calcareous formations (G2 to G6), but also by the type and degree of environmental disturbance (differences among the three groups of stations with water courses flowing on calcareous substrates).

Group 1 was characterized by a community dominated by mosses and liverworts and by a higher plant *Ranunculus penicillatus*. The natural ecological properties of this area (altitude, climate, trophic level, etc.) are substantially different from those of other parts of Wallonia. Its particular, features such as acidic soils and therefore acidic water, its high altitude and its extreme climate make it a truly autonomous entity. Watercourses at these heights are still relatively undegraded because of low housing and industrialization pressures and significant forest and grass cover. These characteristics are reflected in the type of vegetation in these generally unspoilt streams. Most of the rivers in this area are within the reference sites under the implementation of the Water Framework Directive.

The ecological tendencies of most macrophytes found matched the findings of previous studies. The occurrence of the mosses and liverworts *Chiloscyphus polyanthus* and *Hygroamblystegium fluviatile* in the Ardennes upstream area is corroborated by the literature [30- 33].

The comparison of plant communities in this group with those described by Birk & Willby [33] as being the 'Siliceous mountain brooks' type (R-C3) in the Central and Western Europe and the Baltic region group of countries, shows many similarities and a few differences. The similarities relate to the floristic composition of mosses and liverworts. Most species associated with the R-C3 European type were also observed at the sites of this group; these sites can therefore be linked to the R-C3 type.

There was a discrepancy, however, with regard to the vascular plant *Ranunculus penicillatus.* Birk & Willby [33] classified this species in river communities of the 'Medium-sized lowland streams' (R-C4) type. In our region, however, *R. penicillatus* is considered to be characteristic of the Ardennes streams [21, 25 and 34]. It has been observed frequently and in great abundance in Ardennes streams, but occurs less frequently and less abundantly in 'Medium-sized lowland streams' (R-C4) type watercourses.

The remaining five groups (G2-G6) had a more or less limy subsoil in common. They were located in natural regions characterized by silty limestone, marly limestone or slatey calcareous formations. According to reference [34], water from these areas share similar chemical characteristics. This also applies to vegetation. The observed differences therefore stemmed from varying levels and types of pressure on the natural environment and, consequently, on the vegetation.

For example, Group 5 included stations located mainly in the Condroz region. The landscape of this region is a mosaic of environments where crops, grassland, forest edges and streams alternate. The morphology of this particular area is linked to the succession of sandstone plateaux, occupied mainly by crops or by deciduous woodlands with rocky outcrops and calcareous depressions dominated by grasslands on clay loam less suitable for crops. This resulting high concentration of nitrates enriches the water in the area. There is a community of species specific to these environments.

A review of our results showed that some nitrate-rich sites (Group 5) contained natural species in terms of the MBIR index [22]. We identified *Cratoneuron filicinum*, *Chiloscyphus polyanthus*, *Cinclidotus riparius*, *Fissidens crassipes* and *Hygrohygroamblystegium fluviatile*. This accords with findings reported by reference [35], who showed that nitric nitrogen plays no role in determining aquatic vegetation and that its concentration gradients often run counter to the eutrophication series. They also noted that oligotrophic vegetation dominated by *Potamogeton coloratus* or *P. polygonifolius* is often characterized by nitrate rates equal to or greater than those found in more eutrophic sites. Eco-physiological tests have confirmed that most oligotrophic species have a high nitrate reductase activity [36].

Group 6, however, brings together highly mineralized nutrient-rich sites (located on Jurassic and Loess low plateaux calcareous soils). The naturally eutrophic water found in the limestone soils of both regions has become polytrophic in many places because of human influence (fertilizers, and man-made and industrial effluents). The rivers in these two regions are also highly anthropized. The longitudinal (and transversal) reshaping of rivers has completely changed the natural environmental conditions. These changes, combined with strong light, laminar flow and a sandy-gritty substrate have favoured some opportunistic pollution-tolerant species (e.g., *Potamogeton pectinatus*) and caused the disappearance of the most sensitive species.

It has been shown that 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 [37, 38]. These variables define the physical niches in rivers. Macrophytes have known preferences for these variables [39-40].

Alteration amounts to, inter alia, a simplification of flows (facies) and therefore of the aquatic habitats [37 and 38]. This facies homogenization leads almost directly to a simplification of aquatic biota and a drastic decline in biodiversity and biomass [41 and 42]. At sites in this region, *P. pectinatus* is showing a high recovery rate (>30%), as has also been reported by the literature [42-45].

Baatrtrup-Pedersen & Riis [42] analysed the abundance, composition and diversity of aquatic macrophytes in regulated and natural watercourses. They showed that species richness and Shannon's diversity index were very low in regulated streams. They also showed a positive correlation between substrate homogeneity and reduced diversity.

5. Conclusion

Species distribution along the 60 watercourses studied was linked to the nature of the geological formations crossed by the rivers and to the degree and nature of the pressure exerted on these environments. There was a clear difference between the Ardennes streams draining slatey sandstone, slatey quartz or phillite slate formations and those flowing on silty limestone, marly limestone or slatey calcareous formations (Jurassic, Condroz, Famenne and Loess low plateaux regions). The importance of forest and grass cover along the Ardennes watercourses and their low degradation favours the development of natural vegetation.

In the four groups where the watercourses flow on silty calcareous, marly calcareous or slatey calcareous formations (Jurassic, Condroz, Famenne and Loess low plateaux), the observed differences were related to the type and degree of pressure on the ecosystem.

In Condroz (Group 4), the environment is dominated by crops and grasslands. The characteristic community is specific and less resistant than the one in the Loess low plateaux region or the Jurassic, where pressure is high (eutrophication, artificialization of banks, etc.). Group 6, however, comprised the most highly eutrophized sites (located in the Jurassic and Loess low plateaux natural regions) and was characterized by the most resistant species.

The results of the Macrophyte Biological Index for River (MBIR) calculated for the sites in the different groups corroborate the physico-chemical quality measured for each of the these groups. The trophic level was low in Group 1 for rivers in the Ardennes and very high for the sites in the Loess low plateaux region.

6. Acknowledgements

We would like to thank the Walloon region, which supported this study. The study was carried out as a result of a collaboration between the Department of Sciences and Environmental Management at Liege University (ULg) and the Walloon Public Service (SPW).

N°	Water courses	land cover	luminosity	stream width classes	stream depth classes	x	y	Natural regions	Forests %	Cultivated areas %	Grass lands (%)	Built-up areas %	Miscellaneous %
19	Houille	Deciduous and coniferous forest	1	4	2	184369	81541	Ardennes					
26	Lienne	Deciduous and coniferous forest	2	5	3	247000	115934	Ardennes					
2	Aleines	Deciduous and coniferous forest	2	4	3	207339	55685	Ardennes					
25	LhommeHat	Grassland and deciduous	2	5	2	218036	76027	Ardennes					
30	Masblette	Grassland and deciduous	2	4	2	216867	89585	Ardennes					
34	Muno	Deciduous forest	2	4	2	211494	56057	Ardennes					
36	Oise	Grassland and deciduous	1	2	2	135869	73981	Ardennes					
37	Our	Zone urbanisée	3	5	1	276250	93694	Ardennes					
40	OurthOrtho	Deciduous and coniferous forest	3	5	2	241519	89373	Ardennes	**58.5**	**3.6**	**34.6**	**1,1**	**2,3**
38	OurthBonner	Grassland	2	4	2	230018	77900	Ardennes					
41	Outheorr	Deciduous and coniferous forest	2	5	2	246695	92492	Ardennes					
45	Rulles	Deciduous forest	1	2	1	244912	49000	Ardennes					
49	SemoisBoh	Grassland and deciduous	3	4	1	186134	63149	Ardennes					
53	Sûre	Grassland and deciduous	3	4	3	249631	62108	Ardennes					
59	Wiltz	Grassland and deciduous	3	4	3	254000	77706	Ardennes					
3	Amblève	Urbanized area	3	5	3	237065	130806	Condroz					
5	Biesme	Urbanized area	3	4	2	165076	119744	Condroz					
6	Biesmelle	Deciduous forest	1	4	2	144339	113277	Condroz					
7	Bocq	Deciduous forest	1	5	2	189076	114221	Condroz					
8	Burnot	Deciduous forest	2	3	2	184110	117040	Condroz					
11	Eau d'heure	Urbanized area	3	5	3	151928	117399	Condroz					
17	Gueule	Grassland	3	4	3	260819	161238	Condroz					
18	Hantes	Grassland	2	4	2	136135	110066	Condroz					
20	Houyoux	Deciduous and coniferous forest	2	5	3	214436	128420	Condroz	**26.1**	**23.8**	**37.5**	**8.9**	**3,7**
23	Lesse	Grassland and deciduous	3	5	2	191526	100677	Condroz					
33	Molignée	Grassland and deciduous	2	3	2	185003	111970	Condroz					
35	Neblon	Grassland and deciduous	2	4	4	231673	124197	Condroz					
39	OurthCombl	Grassland	3	4	3	235027	128914	Condroz					
46	Samson	Grassland and deciduous	3	4	2	194977	127726	Condroz					
55	Vesdre	Urbanized area	3	5	3	239631	143935	Condroz					

N°	Water courses	land cover	luminosity	stream width classes	stream depth classes	x	y	Natural regions	Forests %	Cultivated areas %	Grass lands (%)	Built-up areas %	Miscellaneous %
1	Aisne	Grassland and deciduous	1	5	2	233283	117853	Famenne	**41.9**	**14.5**	**38.2**	**2,6**	**2,7**
10	Eau blanche	Grassland	2	3	2	143936	81251	Famenne					
12	Eau de Somme	Grassland and deciduous	1	4	2	224861	115248	Famenne					
22	Lembre	Grassland and deciduous	1	4	1	233090	120961	Famenne					
24	LhommeEprave	Grassland	3	5	3	206853	92337	Famenne					
28	MarchetteHotton	Grassland and deciduous	3	4	1	223047	109972	Famenne					
29	MarchetteMarche	Grassland and deciduous	3	2	2	219483	105054	Famenne					
56	Vieux fourneau	Grassland and deciduous	1	3	1	235227	118319	Famenne					
58	Viroin	Grassland	3	5	3	173117	86973	Famenne					
21	Lamframba	Deciduous forest	2	1		231118	33503	Jurassic	**38.6**	**10.4**	**43.9**	**3,3**	**3,8**
27	Marche	Deciduous forest	3	4	4	218404	33636	Jurassic					
4	Messancy	Urbanized area	3	4	2	255725	29033	Jurassic					
42	Rabais	Deciduous forest	2	4	2	235994	32482	Jurassic					
44	Tremble	Grassland and deciduous		4	2	207553	42680	Jurassic					
47	SemoisEt	Grassland and deciduous		5	3	240750	40204	Jurassic					
48	SemoisVa	Grassland	3	5	3	243458	40207	Jurassic					
50	SemoisLacui	Grassland and deciduous	3	4	3	218977	44853	Jurassic					
51	SemoisTint	Urbanized area	3	4	3	232601	42060	Jurassic					
54	Ton	Urbanized area	3	4	3	230013	24351	Jurassic					
57	Vire	Grassland	4	4	4	239095	27244	Jurassic					

N°	Water courses	land cover	luminosity	stream width classes	stream depth classes	x	y	Natural regions	Forests %	Cultivated areas %	Grass lands (%)	Built-up areas %	Miscellaneous %
9	Dendre orientale	Urbanized area	2	4	2	110644	144546	Loess low plateaux	**10.8**	**57.3**	**17.7**	**10.5**	**3,7**
13	Geer	Grassland and deciduous	2	5	4	210935	153175	Loess low plateaux					
14	Glabais	Grassland	2	2	2	173343	155967	Loess low plateaux					
15	Grandegette	Urbanized area	3	4	3	186577	161291	Loess low plateaux					
16	Grande Honnelle	Grassland	3	4	4	101519	119832	Loess low plateaux					
	Hain	Grassland	3	3	2	141108	151940	Loess low plateaux					
31	MehaiEmbre	Grassland	3	4	3	197885	146491	Loess low plateaux					
32	MehaiMoh	Urbanized area	2	5	2	207878	138053	Loess low plateaux					
43	Rhosnes	Grassland	3	4	3	86198	161185	Loess low plateaux					
52	SenneQuena	Grassland and deciduous	3	3	1	135145	151052	Loess low plateaux					

Electronic appendix 1. The Sampling sites: geographical situation and land cover (To: Sossey K & Rosillon F. Macrophytic distribution and trophic state of some natural and impacted watercourses - Belgium Wallonia.)

Abbreviations	**Full name**
Ambflu	*Hygrohygroamblystegium fluviatile (Hedw.) Loeske*
Calham	*Callitriche hamulata (Kütz. ex Koch);*
Calpla	*Callitriche platycarpa (Kütz.)*
Chipol	*Chiloscyphus polyanthus (L.) Corda*
Claglo	*Cladophora glomerata (Linnaeus) Kützing.*
Crafil	*Cratoneuron filicinum (Hedw.) Spruce.*
Cinfon	*Cinclidotus fontinaloides (Hedw.) P. Beauv.*
Cinrip	*Cinclidotus riparius (Web. & Mohr) Arnott*
Elonat	*Elodea nuttallii (Planchon) St John*
Fiscras	*Fissidens crassipes (Wilson ex Bruch et Schimp.)*
Fonant	*Fontinalis antipyretica (Hedw.)*
Fonsqu	*Fontinalis squamosa (Hedw.)*
Leaspx	*Lemanea fluviatilis (Linnaeus) C. Agardh*
Lemmin	*Lemna minor L.*
Leprip	*Leptodictyum riparium (Hedw.) Warnst*
Myrspi	*Myriophyllum spicatum L.*
Oedogonium sp	*Oedogonium sp. Link*
Palucom	*Palustriella commutata (Hedw.) Ochyra*
Pelend	*Pellia endiviifolia (Dicks.) Dumort.*
Potcris	*Potamogeton crispus L.*
Potpec	*Potamogeton pectinatus L.*
Ranflu	*Ranunculus fluitans Lam.*
Ranpen	*Ranunculus penicillatus (Dum.) Bab.*
Plarip	*Platyhypnidium riparioides (Hedw.) Dixon*
Riccha	*Riccardia chamedryfolia (With.) Grolle*
Spaeme	*Sparganium emersum (Rehm.)*
Stigeoclonium tenue	*Stigeoclonium sp. Link (excluding S. tenue)*
Stigeoclonium sp	*Stigeoclonium tenue Link*
Zanpal	*Zannichellia palustris* L.
Vaucheria sp	*Vaucheria sp de Candolle*

Electronic appendix 2. Sossey K & Rosillon F. Macrophytic distribution and trophic state of some natural and impacted watercourses - Belgium Wallonia

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