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Comparison of the Performance of a Quality Rating System in Two Contrasting Ecoregions

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Abstract: A comparison of the Irish Quality Rating System (Q-Scheme) and the Bulgarian version of the scheme was made for two different ecoregions. A total of 16 macroinvertebrate samples were taken from 11 rivers and their tributaries in Ireland and Bulgaria. Eight of the sites were situated on six rivers flowing into the Black Sea. Eight samples were taken from two main Irish rivers and their tributaries; one of them runs directly into the Atlantic Ocean and the second one into Lake Lough Leane in Killarney National Park. An adapted version of the Q-Scheme was introduced for bioassessment of rivers and has been officially used in the Bulgarian national monitoring system since 1998. Biotic index values and EQR scale have been developed and are standardised for Irish and Bulgarian national legislation. Their versions also find broad application in several benthological studies in Bulgaria. Analysis of the parameters of the water shows that the studied Irish sites are characterised by more acidic water, higher oxygen saturation, lower conductivity, and relatively lower values of water temperature than the Bulgarian sites. The present study, undertaken at two ends of Europe, shows that a system based on invertebrate assemblages is extremely adaptable across a wide biogeographical range. In addition therefore, these biotic indices can be adopted for other ecoregions.

Keywords: Q-Scheme, EQR, Water Quality, Macroinvertebrate, Ireland, Bulgaria

Introduction

Bioassessment of water quality using macroinvertebrates is well established in Europe (Armitage et al. 1983, Friberg et al. 2006, Rosenberg, Resh 1993, Sandin, Hering 2004, Hering et al. 2004) for several decades now. A variety of different approaches are in use to present and interpret the community data including univariate metrics (e.g. biotic indices), multimetric indices and multivariate models (Bonada et al. 2006). Confidence in their application has become more crucial with the monitoring requirements of the Water Framework Directive (WFD) 2000/60/EC. Furthermore, there is a requirement to ensure that status designations have to be comparable across EU member states and in line with definitions in the WFD; this is being achieved through intercalibration exercises (Sandin, Hering 2004). Many of the metrics in use across Europe have a common origin (Andersen et al., 1994) and have been modified to suit local conditions.

The Irish Quality Rating System (Q – Scheme) was first introduced in the 1970s by Flanagan, Toner (1972) and has since been used in the assessment of river water quality within the Irish rivers monitoring program (Toner et al. 2003, Callanan et al. 2008, McGarrigle, Lucey 2009).

An adapted version of Irish biotic index was presented into Bulgaria for bioassessment in rivers and has been officially used here as the national monitoring system since 1998 (Cheshmedjiev 1998, Soufi, Uzunov 2008). The index is based on the

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Table 1. Level of identification of the organisms

Turbellaria:	genus
Oligochaeta:	family
Hirudinea:	genus
Mollusca:	genus
Crustacea:	family
Plecoptera:	family
Ephemeroptera:	genus
Trichoptera:	family
Odonata:	genus
Megaloptera:	genus
Heteroptera:	family
Coleoptera:	genus
Diptera:	family
Rheotanytarsus sp. or *Chironomus* sp. or other Chironomidae	
Hydrachnidia (Hydracarina)	presence
Other "water groups"	presence

Q-scheme (Irish Biotic Index) system and calculation is the same but some additional taxa are used. The terms "Taxon/Taxa" are defined by the level of identification as follows in the Table 1.

Such additional taxons are *Potamon ibericum* (Crustacea)*,* some Turbellaria and water bugs (Heteroptera). The corrections are necessary due to the difference in the fauna between Ireland and Bulgaria.

The aforementioned adapted version of the Irish Quality Rating System finds broad application in several benthological scientific studies in the Bulgaria (Soufi et al. 2006, Soufi, Uzunov 2008). Biotic index values (IBI_BG) and a relevant river type-specific scale for Ecological Quality Ratio (EQR) have been developed and are standardized in the Bulgarian legislation (Ordinance H-4/ 2013). At this moment IBI_BG is applied also experimentally for ecological status determination of lentic water bodies (lakes and reservoirs) using a correction for depositing river sections (Cheshmedjiev et al. 2009, Varadinova et al. 2011). In 2011, the IBI_BG was successfully intercalibrated for Bulgaria within the East Continental Geographical Intercalibration Group (ECGIG), and Ireland's Q-Value was intercalibrated within the Northern and Central Baltic GIGs in 2008, (Commission Decision 2008/915/EC).

The aim of this paper is to compare the Quality Rating System and its adapted version on selected sampling sites under different environmental conditions. To consider the possibility of adaptation of the system to other countries where there is no such system or it is outdated. To illustrate how the Bulgarian system has evolved from the original Irish metric and what might account for differences in values calculated by both indices.

Materials and Methods

Study Areas

The Bulgarian sites were situated in one Ecoregion: 12 (Pontic Region) (Table 2), and belong to several Bulgarian river national types R4, R9, R10, R11 which are determined in accordance with the recent typology of Bulgaria. The characteristics of the given types are described in detail in the Black Sea River Management Plan (Water management plan BSBD, 2010).

The R4 type is hilly, widespread in the Danubian plain and includes the fore-part of the Balkan Mountains Kamchia Ichera (Kamch_Ich), Kamchia Beronovo (Kamch_Ber); The R9 type – Dobrudzha vanishing rivers, is a specific type that is linked to the underground Karst waters. Usually the rivers of this type in Bulgaria have large watersheds (Batova); The R10 type – Large Rivers flowing into the Black Sea, characteristic of the lower course of the Veleka River (Veleka_Brod, Vel_Kosti) and R11 – a small or medium rivers flowing into the Black Sea – Ropotamo, Dvoinitsa, and Sredetska). The last mentioned rivers are most distinct from the large rivers as seasonal river sections usually dry up at the summer, which are, poorly studied ecosystems.

The Irish sites were on relatively small (<15 m wide), moderate to fast flowing rivers dominated by coarse substrates also situated in one ecoregion 17 (Ireland & Northern Ireland). The sites represent three typologies, all with >25% calcareous geology and slopes of >0.005 (types 31), 0.005-0.02 (type 32) and 0.02-0.04 (type 33) (Kelly-Quinn et al. 2009).

Sites from both countries differed in some characteristics. For example, the Irish sites were on relatively short rivers that flow into the Atlantic Ocean. These rivers are salmonid rivers, their waters are generally clean, and the rivers are almost at sea level. Similar rivers in Bulgaria are situated at over 800 m above sea level (Pehlivanov *et al.* 2012). Furthermore, unlike Ireland, in Bulgaria there are great temperature amplitudes in the seasons. Water temperature in the summer in Bulgaria reaches values as high as 23ºC, and in some cases more than 30ºC (Hristova 2012). This predetermines more extreme conditions (high temperature, low oxygen concentration, critically low water levels), as registered in the period when the macroinvertebrate samples were collected. Part of the rivers run dry as they traverse limestone substratum (i.e. the rivers that flow into the Black Sea). Some of the large tributaries of the studied rivers originate from karst sources – the Batova, the Veleka (upper part). Another fact should be noted that the chosen Bulgarian sites are potentially at reference conditions, which means that they are assumed to be relatively unaffected by anthropogenic activities. Irish sites were also minimally impacted with the exception of the site Deenagh.

With regard to the elevation above sea level, six of the Bulgarian sites and all the Irish sites are situated at the relatively similar elevations, with a difference of about 150 m. Only the sites of Kamch_Ich and Kam_Ber (Semi-Mountain Rivers with gravel substrata in the Pontic Province) were situated at considerably higher elevations above sea level (on 301 m and 435 m, respectively).

The Bulgarian sites were positioned on rivers in the Black Sea watershed, which flow directly into the Black Sea. The Irish sites were located at a shorter distance from the river mouth (0.3-30.1 km) than the Bulgarian sites (4-189 km). It should be noted that, for the purpose of considering the factor of the distance from the river mouth, we have also included in this study the more distant sites of Kamchia Beronovo and Kamchia Ichera, situated on the largest inland Bulgarian river – Kamchia, at a distance of 159 km and 189 km from the sea, respectively.

The list of the studied sites and the main physico-geographical characteristics, elevation above sea level, geographic coordinates, and distance from the river mouth, are presented in Table 2. More details on Irish national river typological descriptions are given in Kelly-Quinn et al. (2009) and for Bulgaria in (Cheshmedjiev, Marinov 2008).

Fig. 1. Location of the study sites in Bulgaria

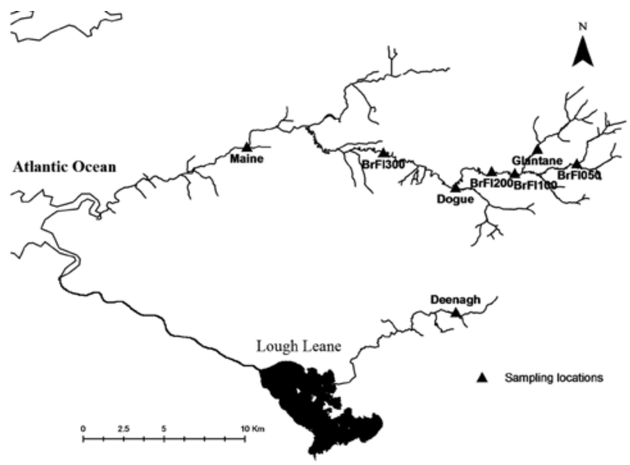


Fig. 2. The location of the study sites in Ireland

Macroinvertebrate Sampling

A total of 16 benthic samples were taken from 11 rivers and their tributaries in Bulgaria and Ireland. Samples were taken in low water conditions, respectively at the end of August of 2011 for Bulgarian sites and September for Irish sites (Figure 1, Figure 2).

Macroinvertebrate samples collected from the Bulgarian rivers were taken using an adapted multi-habitat method (Cheshmedjiev et al. 2011) with different sampling techniques (ISO 7828:1985/EN 27828:1994; ISO 8265:1988/EN 28265:1994). This method uses the frame of standard FBA net as limiting area from which the samples were taken, for example 25 x 25 cm or 30 x 30 cm (mesh 1mm). The method is combined with washing stones and kick sampling usually at ratio 50:50 for mountain and semi-mountain river types from different habitats. The ratio depends on the operator judgment. Usually ten replicates are enough per sampling site. Finally the macroinvertebrate results are calculated as number/m^2. A multi-layer concept is developed to translate macroinvertebrate abundance data from "3-D" large water macrophytes (relative macrophyte biovolume or m^3) to area in m^2 (Cheshmedjiev *et. al.* 2011).

In Ireland, a two-minute multihabitat sample was collected using a standard FBA pond net (1 mm mesh size) (McGarrigle, Lucey 2009). In parallel, physicochemical parameters (water temperature, oxygen concentration (O2 mg/l EN 25814,) and saturation (O2 %), conductivity (µS/cm, EN 27888) and pH (pH, ISO 10523) were measured on site by means of portable Windaus-Labortechnik Package and WTW multi-parameter instruments, in Bulgaria and Ireland, respectively.

Indices

Q-values (Original Irish Q-scheme) and IBI_BG were calculated. The original Q-value system is a five point scale (Q1-Q5: with intermediate scores obtainable, e.g. Q3-4) based on the proportions of five groups of macroinvertebrates, with different pol-

Table 2. List of studied sites and their location

Rivers	Site Name	Ecoregion/National type	Elevation (m. a. s. l.)	Latitude	Longitude	Distance from river mouth
Glantane	Glantane	17/33 Ireland and Northern Ireland	135	52° 11’ 12.26”	9° 21’ 29.97”	2.3 km
Maine	Maine	17/31 Ireland and Northern Ireland	5	52° 11’ 4.59”	9° 37’ 17.79”	1.7 km
Deenagh	Deenagh	17/32 Ireland and Northern Ireland	71	52° 5’ 42.3”	9° 25’ 45.39”	0.3 km
Dogue	Dogue	17/32 Ireland and Northern Ireland	149	52° 9’ 52.43”	9° 25’ 53.92”	12.6 km
Brown Flesk	BrFl050	17/31 Ireland and Northern Ireland	158	52° 10’ 44.86”	9° 19’ 21.24	30.1 km
Brown Flesk	BrFl100	17/31 Ireland and Northern Ireland	106	52° 10’ 22.56	9° 22’ 42.55	24.5 km
Brown Flesk	BrFl200	17/31 Ireland and Northern Ireland	91	52° 10’ 25.62	9° 23’ 58.05	21.8 km
Brown Flesk	BrFl300	17/31 Ireland and Northern Ireland	38	52° 10’ 59.04	9° 29’ 51.71	10.2 km
Batova	Batova	12/R9 Pontic Region	62	43° 29’ 13.9”	27° 56’ 97.6”	16 km
Kamchia	Kam_Ber	12/R4 Pontic Region	301	42° 49’ 50.7”	26° 40’ 49.0”	158 km
Kamchia	Kam_Ich	12/R4 Pontic Region	435	42° 46’ 52.2”	26° 30’ 21.1”	189 km
Veleka	Vel_Brod	12/R10 Pontic Region	12	42° 04’53.4”	27° 51’ 37.3”	14 km
Veleka	Vel_Kosti	12/R10 Pontic Region	22	42° 03’ 21.0”	27° 45’ 51.4”	26 km
Dvoinitsa	Dvoinitsa	12/R11 Pontic Region	30	42° 50’ 22.9”	27° 46’ 34.5”	4 km
Ropotamo	Ropotamo	12/R11 Pontic Region	17	42°17’58.30”	27°42’40.11”	5 km
Sredetska	Sredetska	12/R11 Pontic Region	100	42° 18’ 31,2”	27° 02’ 22,3”	41 km

lution tolerances. A Q5 rating represents high status while Q1 is bad status (McGarrigle *et al.* 1992).

The results of the newly developed classification system showed that in order to cover the complete typology of rivers in Bulgarian, the Q-scheme had to be shortened for some types. However, it retained the same indicator groups and methods of calculation. Several types of rivers such as: R9 and R10 from Pontic province ecoregion, and some intermittent rivers achieve a maximum Q-value of 3.5 or 4 and can never reach a maximum value of 5 of the normal Q-scheme. For these types the scheme is altered and the number of taxa that meets the high condition is 11+ taxon compared to 16+ for other rivers.

One of the differences between two indices, is the inclusion of *Crenobia alpina* (Turbellaria) into Group A (most sensitive) and *Dugesia gonocephala* (Turbellaria) in Group B (relatively sensitive). The representatives of the order Turbellaria serve as a complementary element to the groups B and C to determine the quality of the water. The Family Astacidae (3 species in Bulgaria) has been moved from the more tolerant C group into the more sensitive B group. Added to Group C are the genus *Potamon* (freshwater crab) and all species of the genus *Baetis*, and not only the *Baetis rhodani* species as in the Irish-Q system (Cheshmedjiev 1998). This correction is necessitated because of the large number of species of this genus in Bulgaria that have similar ecological requirements.

Water quality was assessed in accordance with WFD requirements (2000/60/EC), reflected in the national legislation – Bulgarian Ordinance No 1/2011 and Irish Statutory Instrument 272 of 2009. The ecological status was defined by means of the Irish Q-Value (Clabby, Bowman 1979, Cheshmedjiev 1998, Ordinance No 412/2011). Ecological quality ratios (EQR), based on number of taxa and biotic indices were recalculated according to the Bulgarian Ordinance (H-4/2013) and in the case of Ireland regulations (SI 272, 2009) and EU Commission Decision (2008/915/EC).

For the purpose of comparability of the ecological status, based on the two methods, EQR values were calculated. (EQR IBI_BG and EQR Q-value). The scale falls into five categories, in accordance with the Water Framework Directive.

Feeding Type Indices (RETI/PETI) (Schweder 1990), and its adapted version (Cheshmedjiev *et al.* 2013) was also used.

It should be emphasized that in Bulgaria the IBI_BG system is the leading tool for the Ecological Status determination. The trophic index RETI/PETI has a supportive role in the assessment and can be indicative for any kind of disorders in the benthic communities caused by organic pollution, building dams, quarries, straighten river beds and etc.

Statistical analysis

Cluster analysis method Primer 6.1.6 (Clarke, Warwick 2001) with complete Linkage was performed to test Sörensen similarity in the macroinvertebrate community structure of the sites. Canoco 4.5 was also used to assess species and environmental interactions (Ter Braak, Šmilauer 1998). Sörensen coefficient was used (Sörensen 1948) for the comparison of similarity of different indicator groups in the sites.

Results

Physico-chemical results

The physico-chemical analysis of the study sites showed that the Irish sites were characterized by more acidic water (pH 6.6-7.6), higher oxygen saturation, lower conductivity, and relatively lower values of water temperature than the Bulgarian sites (Table 3).

The more varied conditions of the environment in Bulgarian rivers create more favorable conditions and predetermine the considerably higher number of taxa found. For example, at the Batova River site the number of taxa reached 49 in a single sample.

CCA, Cluster and Similarity analysis

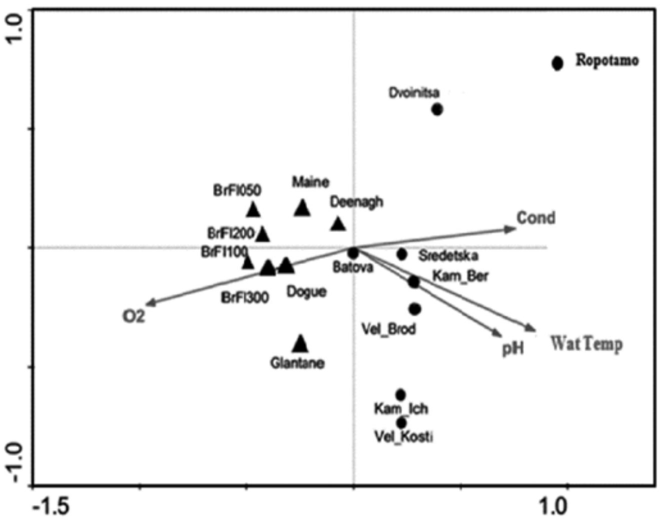
CCA – ordination analysis (Figure 3) gives a clear picture of the distribution of species composition of the studied sites among the vectors of the measured physico-chemical environmental parameters. The Monte Carlo Test was statistically significant for oxygen ($p=0.002$) and water temperature ($p=0.022$). The first axis correlates highly and negatively with the oxygen ($r^2= – 0.942$) and positively with the water temperature ($r^2= 0.717$), conductivity ($r^2 = 0.567$) and pH ($r^2 = 0.478$). In this way, the Irish sites are located on a gradient formed by higher oxygen values, lower water temperature and pH. In contrast, the indicators at the Bulgarian sites are situated between gradient formed by the higher temperature and pH, and lower oxygen values.

The comparisons of the overall taxonomic composition at sites in the two countries showed that in Bulgaria, taxonomic richness is considerably richer (refer to Table 4 and Table 8). Taxonomic richness in the orders Plecoptera and Ephemeroptera were three times greater than in Ireland. These contain taxa belonging to Groups B, and C, which are, indicators of clean to moderately polluted water. The considerably greater richness observed in Bulgaria was also evident for Group A, especially for the already mentioned groups Plecoptera and Ephemeroptera (Tyufekchieva *et al.* 2013, Vidinova 2003). Most Bulgarian sites are with 4 taxa from Group A compared to 2-3 for Irish, except those from R11 river type.

The representatives of the main taxonomic groups of organisms, found in the studied Bulgarian sites, showed relatively even distribution. The order Ephemeroptera dominated (32 %), most represented by genera such as *Baetis* (Group B, C) and *Ecdyonurus* (Group A). Representatives of the Plecoptera were found in five of the studied Bulgarian sites, mainly from genus *Leuctra.* The latter belong to the more tolerant group B fauna. The representatives of genus *Perla* were recorded only in the Kamchia River, at more than 300 m above sea level. It should be noted that at most Irish sites, representatives of the Plecoptera order were present and genus *Perla* was recorded in four sites. Another significant difference related to the occurrence of several representatives of indicative group A (for example *Perla bipunctata, Rhithrogena sp., Electrogena sp. Heptagenia sp.*) in the Irish sites, while the Bulgarian benthic fauna usually comprised

Table 3. Physico-chemical parameters of the studied sites at the time of sampling

	Glantane	Maine	Deenagh	Dogue	BrFl050	BrFl200	BrFl100	BrFl300
pH	7.5	7.6	7.4	7.6	6.7	6.6	6.5	6.8
O_2	10.5	10	9.5	10.5	10.5	11	10.8	10.7
O_2%	104.4	94.8	90.3	100	101.7	103.7	101.8	102.7
Cond. μS/cm	84.5	237	124.8	121.4	87.2	101.5	98.2	114.3
Water temp.	14.4	12.9	12.6	12.7	11.3	12.5	12.3	13.2
	Batova	**Kam_Ber**	**Kam_Ich**	**Vel_Brod**	**Vel_Kosti**	**Dvoinitsa**	**Ropotamo**	**Sredetska**
pH	7.98	7.91	8.22	8.05	7.98	7.79	7.62	7.92
O_2	8.91	7.89	8.63	7.98	8.75	6.63	4.1	7.97
O_2%	92.2	89	101.6	85.6	90	72.1	43	88.9
Cond. μS/cm	607	392	387	455	434	753	438	582
Water temp.	19.9	19.2	21	20.5	22.5	20.8	18.4	20.8



Axes	1	2	3	4	Total inertia
Eigenvalues	0.715	0.568	0.438	0.396	5.920
Species-environment correlations	0.993	0.971	0.951	0.971	
Cumulative percentage variance of species data of species environment relation	12.1 33.8	21.7 60.6	29.1 81.3	35.8 100	
Sum of all eigenvalues					5.902
Sum of all canonical eigenvalues					2.117

Fig. 3. CCA ordination diagram showing site distribution along the environmental factors gradients

Table 4. Distribution and group richness of the five macroinvertebrate indicative groups at sites in the two countries

				Ireland				
Groups	Glantane	Maine	Deenah	Dogue	BrFl050	BrFl100	BrFl200	BrFl300
A	2	3	0	2	3	3	3	2
B	4	6	1	4	2	3	3	4
C	9	10	7	12	10	6	9	8
D	2	4	1	0	1	2	2	2
E	1	1	1	0	0	0	0	1
Total	**18**	**24**	**10**	**18**	**16**	**14**	**17**	**17**
				Bulgaria				
Groups	Batova	Kam_Ber	Kam_Ich	Vel_Brod	Vel_Kosti	Dvoinitsa	Ropotamo	Sredetska
A	4	4	4	0	2	1	0	4
B	9	2	2	11	9	3	5	6
C	23	20	20	17	20	20	22	32
D	9	7	2	14	7	4	8	6
E	0	0	0	0	0	1	2	0
Total	44	32	27	42	37	29	37	47

only one representative from this group (Batova, Vel_Kosti, Dvoinitsa, Sredetska) (Table 4).

The Trichoptera was represented mainly by the genus *Hydropsyche*, (all Bulgarian sites and all Irish sites except Deenagh) which belongs to the more tolerant Group C. The representatives of Odonata order (Groups B, C) prevailed at some Bulgarian sites namely Ropotamo (43%) and Sredetska (22%) compared to no one taxa in Irish sites. The family Chironomidae (Group D, E) was also found in almost all the sites in both countries with generally over 30 individuals per sample.

For most of the Irish sites there was a fairly even distribution of abundances among the major taxonomic groups except for the Dogue where the Ephemeroptera (Group A and B) constituted 88% of the abundances and the Glantane where one mollusc genus (*Hydrobia* sp.) (Group D) dominated (55%). The most diverse group overall was the Diptera followed by Coleoptera and Trichoptera. The Plecoptera were not abundant or particularly diverse, although present at all sites.

Group B faunal richness in some Bulgarian sites was two to three times higher than at the Irish sites, caused by presence of genera *Cordulegaster*, *Anax*, *Sympetrum*, (Odonata) *Hydroptila* and *Mystacides* (Trichoptera) *Habrophlebia* (Ephemeroptera) (Table 4). The most common genera in the sites of both countries were *Baetis, Leuctra, Nemoura* and some cased Trichoptera.

In both countries Group C recorded the highest taxon richness but they differed in the representative taxa. In Bulgaria the Group C fauna mainly comprised Ephemeroptera and Trichoptera while Coleoptera and Diptera were the key representatives at the Irish sites. This is due to the richer diversity of Ephemeropterian fauna in Bulgaria, consisting of many species with different ecological requirements (Tyufekchieva *et. al.,* 2013; Vidinova 2003). This difference in taxonomic composition of Group C was confirmed by the Sörensen similarity coefficient (Tables 5-6). Mean value did not exceed a similarity of 25%. While between Irish sites the mean similarity of Group C was 51% and for the Bulgarian sites 42%. The maximum similarity between two countries (Table 7) is 60% for the sites Sredetska and BrFl050 which is due to high variety from genus *Hydropsychae*, *Rhyacophila* and *Baetis*.

The cluster analysis detected two main groups (Figure 4). The first group includes the Irish sites and the second ones Bulgarian. This analysis demonstrates clearly distinct geographical differences in the taxonomic composition of the benthic fauna of the two countries.

Assessment, based on IBI_BG and Q-value

Both methods are based on the Trent Biotic Index (Woodiwiss 1964), and generally there are no significant computational differences between the two versions of the index, especially regarding scales, method of calculation and value assessments.

In the context of the given differences in the taxonomic composition, it is interesting to explore differences in the values of the measured biotic index BI and the additional ecological assessment metrics such as the trophic indices RETI/PETI (Table 8), discussed later. We can say that as a whole most of the sites from the both countries are at high and good ecological status.

The IBI_BG values ranged from 3.5 to 5. The values of the Irish Q-value (Figure 5) varied between 3 (Deenagh) and 4.5 (Glantane and Maine), which corresponds to an EQR of 0.6 and 0.9, respectively. According to the adapted Bulgarian variant of the index, these values correspond to 3.5-4.5, with EQRs of 0.7 and 0.9, respectively. For five (BrFl200, BrFl100, Batova, Kamch_Ber, Dvoinitsa.) of the studied sites, the EQR assessment, calculated according to the two indices, were in agreement. The EQR assessments for one site (Kamch_Ich) differed by 0.5, but both values (IBI_BG 5 and Q-value_IRE 4.5) were within the limits of high ecological status. For the other 10 sites (Table 8) the EQR differences were also 0.5, but this difference placed them in different quality categories; seven of them had values that varied from high to good. For two of the studied sites (Deenagh and Ropotamo), the status assessment was good according to the Bulgarian EQR scale and moderate according to the Irish EQR scale.

The assessments, based on the two biotic indices, show that the index values, calculated according to the Bulgarian scale, were half a grade higher values in the lower limit, compared to the assessment following the Irish method (respectively, Q-value from 3.5 to 3). The EQR assessments according to the Bulgarian scale were higher and they determined all the studied sites to be in high and good ecological condition. The exceptions were only three sites (Glantane, Maine and Sredetska), which were rated as high status according to the Q-scheme, unlike the IBI_BG which rated them as good.

The reason for the differences is the additional taxa that have been added to make the original index applicable to Bulgarian conditions which give higher rate for these sites.

The richness for Bulgarian sites varies from 42 to 26 taxa (see Table 7). The lowest number of taxa was registered at the site placed on the Dvoinitsa River. The Irish river sites recorded taxon richness was much poor with the values between 16 (BrFl050) to 26 taxa (Maine).

The indices, based on the trophic structure, characterize the functioning of the communities; as applied here (RETI/PETI) they can be informative on the magnitude of the biotic response to outer impacts (Wallace et al. 1989, Grubaugh et al. 1996).

According to the second EQR scale based on number of taxa (Ordinance H 4/2013), fifteen Irish and Bulgarian sites were classified in good or high ecological status.

In terms of the EQR scale, based on RETI/PETI, values have been proposed for each status class (1.00-0.80-high; 079-0.51-good; 0.50-0.35-moderate; 0.34-0.25-poor; <0.25-bad). Values higher than 0.50 characterize stable, undisturbed water

Table 5. Sörensen similarity coefficient of taxonomic groups C between Bulgarian studied sites

Similarity	Batova	Kam_Ber	Kam_Ich	Vel_Brod	Vel_Kosti	Dvoinitsa	Ropotamo	Sredetska
Batova	1							
Kam_Ber	0.5	**1**						
Kam_Ich	0.418	0.65	**1**					
Vel_Brod	0.588	0.45	0.222	**1**				
Vel_Kosti	0.372	0.232	0.421	0.526	**1**			
Dvoinitsa	0.444	0.555	0.285	0.486	0.294	1		
Ropotamo	0.5	0.266	0.375	0.410	0.437	0.642	**1**	
Sredetska	0.4	0.476	0.228	0.444	0.324	0.421	0.410	**1**

Table 6. Sörensen similarity coefficient of taxonomic groups C between Irish studied sites

Similarity	Glant	Maine	Deenah	Dogue	BrFl050	BrFl1006	BrFl200	BrFl300
Glant	**1**							
Maine	0.743	**1**						
Deenah	0.444	0.307	**1**					
Dogue	0.48	0.5	0.24	**1**				
BrFl050	0.727	0.5	0.375	0.84	**1**			
BrFl100	0.6	0.285	0.173	0.571	0.666	**1**		
BrFl200	0.5	0.58	0.285	0.5	0.514	0.666	**1**	
BrFl300	0.571	0.551	0.307	0.476	0.465	0.761	0.782	1

Table 7. Sörensen similarity of organisms of group C between two countries

	Glant	Maine	Deenah	Dogue	BrFl050	BrFl100	BrFl200	BrFl300
Batova	0.312	0.484	0.26	0.4	0.303	0.275	0.25	0.258
Kam_Ber	0.551	0.6	0.37	0.375	0.333	0.307	0.275	0.285
Kam_Ich	0.551	0.6	0.37	0.375	0.333	0.307	0.275	0.285
Vel_Brod	0.384	0.518	0.416	0.344	0.296	0.173	0.153	0.24
Vel_Kosti	0.344	0.466	0.222	0.312	0.4	0.307	0.275	0.285
Dvoinitsa	0.344	0.4	0.37	0.312	0.2	0.23	0.206	0.214
Ropotamo	0.322	0.312	0.275	0.166	0.185	0.071	0.064	0.133
Sredetska	0.322	0.437	0.413	0.217	0.285	0.166	0.195	0.2
Average	**0.391**	**0.477**	**0.337**	**0.312**	**0.291**	**0.229**	**0.211**	**0.237**

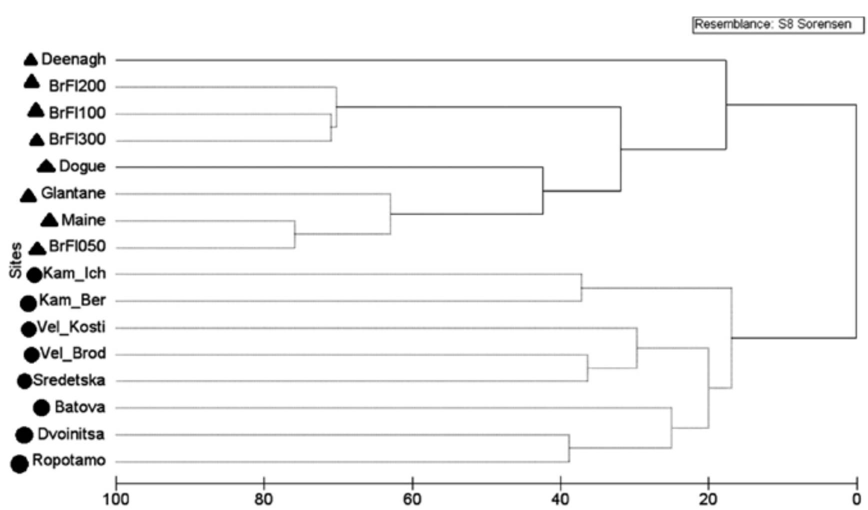


Fig. 4. Cluster analysis of the similarities between the studied sites

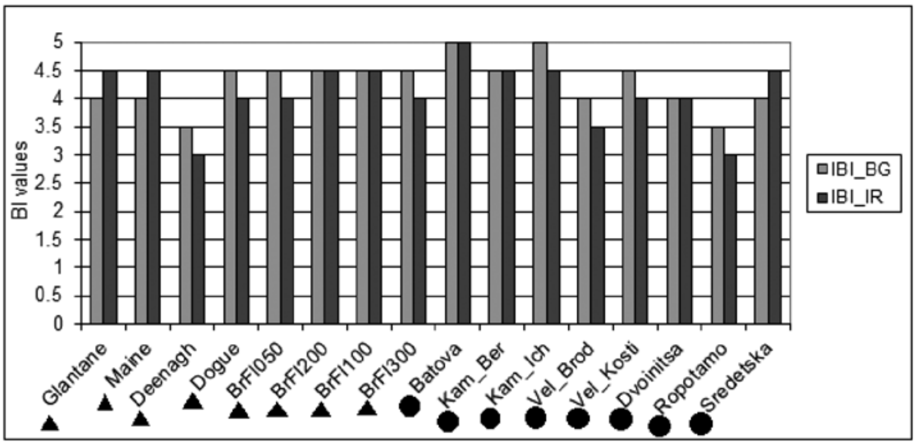


Fig. 5. The dynamic of BI values for the studied Irish and Bulgarian sites

ecosystems and correspond to good/high ecological state. Our results show that, with two exceptions, all calculated values for these metrics correspond to good and high status. The sites Dvoinitsa and BrFl050 are an exception, with RETI/PETI values that define moderate status but they fell close to the boundary value of the good state (Table 8).

Discussion

If we compare species composition of the sites in both countries, we find that Bulgarian sites were predominated by taxa from Groups C, B and A; however representatives of the Group A were mainly from family Heptageniidae. On the other hand, for the Irish sites were dominated representatives from Group A belonging from Perlidae family.

The different historic, climatic and environmental factors between the two countries are main reason to the differences in taxonomic composition of the macroinvertebrates. In Bulgaria in contrast to Ireland, higher water temperatures, create more extreme hydrological and chemical conditions (Hristova 2012). This influences the distribution of species, and is a premise for the predominance of specific species with adaptive capabilities for surviving in the conditions of low water current, which in extreme cases would lead to the rivers running dry.

The absence of representatives from the group A from more Bulgarian studied sites than Ireland can be explained by the fact that prefer cold water and where there are no major fluctuations in water temperature. Such are the environment conditions at the studied Irish sites. An important peculiarity is that such species have been found generally at high elevations > 300 above sea level in Bulgaria, in the Mountain Rivers characterized as trout areas. The same species in Ireland can be found at sea level.

The differences in the scores of indices are not considerable, because the deviations are within the limits of two adjacent EQR grades (Table 8). Considering that the WFD requirement is to reach at least good ecological status, only in 2 out of 16 sites were the graded was lower than “good”, according to the Q-value and therefore either of the metrics would have determined that the sites pass the minimum WFD objective.

The EQR values of the trophic index correlate to the assessment made according to the two biotic indices, but there are some differences. For Irish sites (Deenagh and BrFl100) Q-value_IRE and RETI differ in one degree, while BRF050 in two degrees, which means that the difference in ecological status calculated by IBI_BG and the trophic index is significant. For Bulgarian sites Dvoinitsa, Ropotamo and Sredetska the difference is also one degree. These results suggest that, for various reasons, trophic structure is distorted although biotic indices suggest good status.

We propose that the lower value of the trophic index for the river Dvoinitsa site is due to the lack of riffles in the summer period, there is also siltation at this point. (Water Management Plan, BSBD, 2010). This presupposes the disturbance in trophic structure. Another possible reason is the registered higher values of water temperature in the summer and critically low water levels. As for BrFl050, the occurrence of a large number of molluscs from genus *Hydrobia* at this site is probably responsible for the moderate status score. The operator probably hit a high density patch of this taxon. Otherwise this site recorded the highest taxon richness of the Irish sites.

The values of the trophic index RETI/PETI showed that the macroinvertebrate communities of all the studied sites were characterized as balanced (since most trophic groups were almost equally represented) and with a complex trophic structure. The functional

Table 8 Values of the biotic and trophic, indices and ERQ estimates (according Bulgarian classification system) of the studied sites

Sites	**Glantane**	**Maine**	**Deenagh**	**Dogue**	**BrFl050**	**BrFl200**	**BrFl100**	**BrFl300**
Number of taxa	19, high	26, high	20, high	21, high	16, high	21, high	17 high	18 high
IBI_BG	4 good	4 good	3.5 good	4.5 high	4.5 high	4.5 high	4.5 high	4.5 high
Q-value	4.5 high	4.5 high	3 moderate	4 good	4 good	4.5 high	4.5 high	4 good
EQR_BG	0.8 good	0.8 good	0.7 good	0.9 high	0.9 high	0.9 high	0.9 high	0.9 high
EQR_Q-value	0.9 high	0.9 high	0.6 moderate	0.8 good	0.8 good	0.9 high	0.9 high	0.8 good
RETI/PETI/ EQR	0.83 high	0.83 high	0.85 high	0.79 good	0.35 moderate	0.83 high	0.68 good	0.77 good
	Batova	Kam_Ber	Kam_Ich	Vel_Brod	Vel_Kosti	Dvoinitsa	Ropotamo	Sredetska
Number of taxa	49 high	38 high	37 high	42 high	34 high	26 high	29 high	37 high
IBI_BG	5 high	4.5 high	5 high	4 high	4.5 high	4 high	3.5 high	4 high
Q-value	5 high	4.5 high	4.5 high	3.5 good	4 good	4 good	3 moderate	4.5 high
EQR_BG	1 high	0.9 high	1 high	0.8 high	0.9 high	1 high	1 high	1 high
EQR_Q-value	1 high	0.9 high	0.9 high	0.7 good	0.8 high	0.8 good	0.6 moderate	0.9 high
RETI/PETI &EQR	0.81 high	0.85 high	0.81 high	0.72 good	0.72 good	0.47 moderate	0.52 good	0.57 good

feeding groups represented conform to principals of the River Continuum Concept (Vannote et al. 1980).

Despite the considerable differences in taxonomic composition between the two regions the quality status determined by the two metrics differed in EQR by no more than 10%.

The comparative analysis between two version of biotic index and overall received results has demonstrated that Irish Q – Scheme can be adopted from other regions with distinctly different Physico-chemical characteristics and climatic conditions. Thus, with some fairly minor adjustments through expert knowledge of the local fauna they can be easily applied for water quality assessment. Such adaptability should help towards development of water quality metrics for other countries (Balkan and some countries from Caucasus region, see EPIRB Project, 2011) where there is no existing metrics that could be involved in future processes of intercalibration in the assessment of the ecological status of water bodies.

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