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The PERLA system in the Czech Republic: a multivariate approach for assessing the ecological status of running waters

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Abstract

The assessment of running water quality has a long tradition in the Czech Republic, but in the past it focused on the evaluation of organic pollution using the saprobic system. Considering the modern trends of stream ecological status evaluation in water management a new assessment system named PERLA was developed. The system is a complex of biological methods of ecological status assessment of running waters and connected activities in the Czech Republic. It involves 300 reference sites with respective biotic and abiotic data and a prediction model using a newly developed software HOBENT. The model generally follows the published mathematical principles of RIVPACS and represents the site specific and stressor non-specific approaches. The HOBENT software allows the prediction of the target assemblage of benthic macroinvertebrates for any site based on a set of environmental variables (latitude, longitude, distance from source, altitude, slope, catchment area, and stream order) which characterise the site. The predicted assemblage can be compared with the fauna observed at the same site. The comparison makes it possible to evaluate the extent of disturbance, expressed by index B. The model allows to evaluate spring, summer, and autumn seasonal data of the majority of wadable streams in the Czech Republic. The practical application of the PERLA system has started in 2001.

Introduction

Assessment of the water quality of running waters based on biota has a long tradition in the Czech Republic. In relation to strong organic pollution, in Central Europe regarded as a cardinal problem of water management for the past century, a wide range of saprobiological methods have been applied (Bernardová et al., 1996). Nevertheless, wide ranging social and economic changes since 1989 have lead to a decrease of organic pollution in the Czech Republic (WRI, 1993, 2002). Owing to this fact and in accordance with European Union policies concerning the assessment of the ecological status of aquatic ecosystems (European Commission, 2000), there is a necessity for new methods for evaluating the impact of issues such as changed river morphology and unnatural discharge regimes. The British RIVPACS (Armitage et al., 1983; Wright, 1995; Wright et al., 1989,

1993) has been adopted as the most suitable approach, being based on a comparison with a reference status of benthic macroinvertebrate assemblages. However, the application of the system requires the compilation of a reference data set for the given geographical region. This condition has been fulfilled through PERLA, a newly constituted system for evaluating running water quality. It is named after the stonefly genus *Perla*, which occurs predominantly in clear running waters. The PERLA system is a complex of biological methods of ecological status assessment of running waters and connected activities in the Czech Republic, taking into account the official activities of the Czech Republic (Kokeš, 2002).

Material and methods

Study area

The Czech Republic is an inland state that is situated in the middle of a temperate climate zone of the Northern hemisphere of the central part of Europe. The total area is 78,864 km^2 with a population density of about 131 inhabitants/km^2. The climate of the Czech Republic is characterised by the mutual penetration and mixing of oceanic and continental influences. The oceanic influence is most evident in the western part of the country; increasing continental climate effects are more pronounced in the eastern areas. Elevations range from 116 to 1,602 m a.s.l. with the average altitude of 430 m a.s.l.. The lowlands (up to 200 m a.s.l.) are situated along the lower parts of large rivers and as well as mountain areas (altitudes above 800 m) cover only a small part of the country (Fig. 1a). From a geomorphological point of view (Demek, 1987), the mountains of the Hercynian orographic system form a ring along the state border in the western (Bohemian) part; the Outer Carpathian Ridge follows along the eastern border of the state. The Pannonian lowlands and the Polonium in Moravia and Silesia represent a band of lowland areas dividing the Hercynian and Carpathian mountain systems. Geological differences between the regions are expressed by a higher proportion of flysch and molasse and a lower share of acid silicate rocks in the Carpathian catchments. Consequently, water alkalinity and

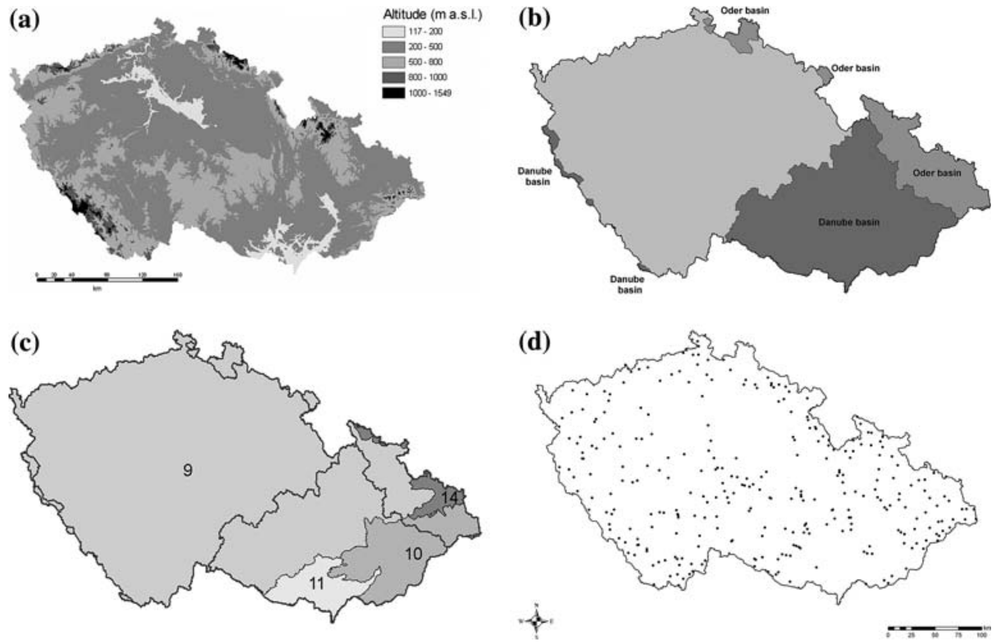

Figure 1. Map of the Czech Republic: (a) distribution of altitude categories, (b) main river basins, (c) ecoregions – detailed delineation after Culek (1996). 9 – Central Highlands, 10 – The Carpathians, 11 – Hungarian lowlands and 14 – Central plains, (d) distribution of reference sites.

total hardness are higher in the flysch and molasse region.

The Czech Republic is sometimes called the "Roof of Europe" because only atmospheric precipitation water supply harbours the three main river basins and/or sea drainage areas. These are the Labe (Elbe) River Basin (North Sea) - 51,399 km^2, the Odra (Oder) River Basin (Baltic Sea) – 4,721 km^2, and the Dunaj (Danube) River Basin (Black Sea) – 22,744 km^2 (Fig. 1b). Thanks to its geographic position, the Czech Republic is characterised by a vast majority of very small, small, and medium-sized permanent running waters (catchment areas <1,000 km^2 covering 94% of the territory). Very small streams with catchment areas <10 km^2 covering 20% of the territory play an important role in forming the conditions of densely inhabited landscape and intensive land use.

The study area is a part of four European ecoregions based on Illies (1978): No. 9 (Central Highlands), No. 10 (the Carpathians), No. 11 (Hungarian lowlands), and No. 14 (Central plains). A detailed delimitation of ecoregion borders was done by Culek (1996). The respective catchment areas of the individual ecoregions of the Czech Republic are the Elbe catchment belonging to European ecoregion No. 9, the Danube catchment belonging partly to No. 9, 10 and 11, and the Oder catchment belonging to No. 9, 10 and 14 (Fig. 1c).

Site selection and reference conditions

The network of potential reference sites was suggested on the basis of data published earlier (e.g., Landa & Soldán, 1989; Soldán et al., 1998), on the database of long-term saprobiological monitoring results, and on expert advice. More than 400 sampling sites were taken into account; this number was reduced to about 350 after detailed screening in the field. Laboratory analyses (both biological and chemical data) showed only 300 sampling sites that meet the requirements of European standard EN ISO 8689-1:2000, which states "A reference site is a site where only natural stresses are present and man-made stresses are considered to be insignificant. The community present at a reference site is a natural community when it is influenced only by natural stress (e.g. flood) and man-made stress is not significant." The following criteria were taken into consideration in order to meet the requirements of Czech National Standards:

- The degree of urbanisation, agriculture, and silviculture in a catchment must be as low as possible.
- A reference site floodplain should preferably not be cultivated. If possible, it should be covered with natural climax vegetation and unmanaged forest.
- Coarse woody debris must not be removed.
- Stream bottoms and stream banks must not be fixed (old river bank fixation by a belt of trees is acceptable).
- Natural riparian vegetation and floodplain conditions must still exist, making lateral connectivity between the stream and its floodplain possible.
- No alterations of the natural hydrographic and discharge regime.
- No hydrological alterations such as water diversion, abstraction, or pulse releases.
- No (or only minor) upstream impoundments, reservoirs, weirs, or reservoirs retaining sediments may be present (a dam 20 km upstream is acceptable for some stretches of mid-sized or large streams).
- Physical and chemical conditions close to natural background levels describing the baseload of a specific catchment area.
- No point sources of pollution or nutrients.
- No signs of acidification.
- No liming activities.
- No impairment due to physical conditions, especially the thermal conditions, which must be close to natural.
- Physical and chemical conditions are checked by physico-chemical and chemical analyses of water and sediment.
- There must not be any significant impairment of the allochthonous biota by introduced Crustacea or Mollusca.
- The value of the Czech saprobic index must not be higher than 2.2 (beta-mesosaprobity).

Naturally, it was not possible to determine real reference sites for all stream types present in the Czech Republic, since the landscape has generally been exploited for centuries. In such cases, the optimum sites within the corresponding stream type were considered as the reference sites.

Large lowland water flows seem to be extremely difficult to treat because of pronounced morphological changes and/or advanced eutrophication. Consequently, we are not able to identify any suitable reference sites for the largest rivers (e.g. lowland stretches of the Morava, Elbe, and Vltava Rivers).

Field and laboratory methods

Field sampling was done from 1997 to 2000. The PERLA sites were sampled 3 times a year in the spring (March–May), summer (July–August) and autumn periods (September–November) to meet the requirements of all the seasons.

A stream stretch typical for the watercourse in question was selected. In narrow streams, the length of this stretch was equal to 14 times the average stream width (a width of less than 5 m). In wider streams, the length of the characteristic stretch was 100 m. Because it was impossible to sample the characteristic stretch completely, a representative sampling section inside the characteristic one was chosen. Sampling points inside the sampling section were then sampled. The sampling section was sampled for benthic macroinvertebrates using a multi habitat sampling method. Semi-quantitative 3-minute kick samples gathered with a hand net (25×35 cm aperture and 500 μm mesh size) were taken. All habitats (riffle, pool, macrophytes, woody debris, etc.) were sampled in proportion to their area within the sampling section. Samples were pre-selected in the field (to preserve fragile organisms) and transferred to the laboratory where final sorting was done. Samples were preserved in 4% formaldehyde or 70% ethanol solution (Mollusca, Oligochaeta, Simuliidae). With some quantitatively extremely rich samples, their half or quarter was processed and the final number of individuals was estimated by simple multiplication. Taxonomic identification was done to the lowest level, preferably to a species level. However, in some cases (e.g., Oligochaeta, Hydracarina, and some Diptera), only genus or higher taxa could be identified. The following set of environmental variables was recorded at each site of the characteristic stretch: mean substratum – phi (Furse et al., 1986), mean current velocity, mean width and mean depth, ratio of riffles and pools, slope, shading, riparian vegetation, and surrounding terrestrial biotopes.

Other variables were obtained from respective hydrological maps and GIS layers (latitude, longitude, altitude, distance from the source, catchment area, stream order based on Strahler (Strahler, 1952), affiliation to catchment, ecoregion, geomorphologic unit, etc.). There were three series of physico-chemical and chemical analyses done of the water for a large range of parameters (pH, conductivity, alkalinity, total hardness, Ca^{2+}, Mg^{2+}, SO_4^{2-}, N–NO^{3-}, N–NH^{4-}, P_{tot}, DO, BOD, COD, TOC, etc.). One series of chemical analyses of the sediment was done for specific pollutants (PCB, PAU) and heavy metals (Pb, Cd, As, Hg) (Kokeš, 2002). All chemical analyses were done using international standards (ISO) or the Czech national standards according to the rules of quality assurance and quality control (QA/QC).

Data processing

Prior to any treatment, a taxonomical adjustment was made according to the abundance and frequencies of each taxonomical level (AQEM consortium, 2002). A taxonomic adjustment was done to prevent data inconsistency (Nijboer & Verdonschot, 2000). This means that there should be no taxa overlap, as taxonomic overlap results in the multiplication of the same information in one sample.

The adjusted taxonomic data was classified into groups by TWINSPAN (Hill, 1979). Five pseudospecies cut levels were defined (0, 3, 30, 120 and 300); minimum group size for division was 7 and the maximum level of division was 8. All other settings remained as default.

For the evaluation of the importance of environmental variables for benthic invertebrate communities, the forward selection analysis in Canonical Correspondence Analysis (CCA) was performed in CANOCO for Windows (ter Braak, 1986). Data were transformed ln $(x+1)$, 9999 permutations vas used.

Results

Reference sites

The 300 sites are more or less evenly distributed within the area (see Table 1 and Fig. 1d). For the basic characteristics of the 300 selected sites see Table 2. In compliance with the abiotic conditions

Table 1. Distribution of reference sites within WFD System A stream types

Site altitude (m a.s.l.)	Upstream catchment size (km^2)	Ecoregion	Central highlands		The Carpathians		Hungarian lowlands		Central plains	
		Geology	Siliceous	Calcareous	Siliceous	Calcareous	Siliceous	Calcareous	Siliceous	Calcareous
≤ 200	≤ 10		1							
	> 10–100		1							
	> 100–1,000		1							
	> 1,000–10,000		1				2			
201–800	≤ 10		80	9	2	18		1	11	2
	> 10–100		61	4	1	7	3	1	5	
	> 100–1,000		62	1	3		1		2	
	> 1,000–10,000		13	1	2				1	
> 800	≤ 10		1							
	> 10–100		1							
	> 100–1,000		1							
	> 1,000–10,000									

of the Czech Republic, three of the most frequent abiotic stream types amongst the reference sites were very small streams (26.7%), small streams (20.3%), and medium streams (20.7%), all belonging to the altitude category of 200–800 m a.s.l. and with siliceous geology.

Altogether more than 1,500,000 individuals have been collected. After taxonomic adjustment, they belong to 419 taxa in the spring data set, 372 in the summer set, and 335 in the autumn set. The Chironomidae family was not included in the summer and autumn evaluations. The whole dataset based on 300 sites was used for the spring season evaluation. Some sites of very small streams sampled in spring dried up in summer (9 sites) and autumn (3 sites).

Classification

TWINSPAN classification resulted in 20 end groups in spring (Fig. 2), 18 end groups in summer (Fig. 3) and 20 groups in autumn (Fig. 4).

The selection of environmental variables

The environmental variables suitable as predictors for RIVPACS type model were identified by the forward selection of environmental variables in CCA. The spring season dataset was used for this analysis. The following 23 environmental variables were included in the analysis: distance from source, order of stream according to Strahler, BOD, mean width, mean depth, catchment area, slope, COD_{Cr}, $N–NO_2$, P_{tot}, mean annual air temperature, TOC, $N–NO_3$, altitude, conductivity, total hardness, SO_4^{2-}, mean substratum roughness , latitude, DO, longitude, pH and $N–NH_4$.

When an automatic forward selection was done (only 7 the best fitted), the following variables were chosen: stream order, mean substratum roughness, distance from source, latitude, BOD, conductivity, and $N–NO_3$ (Table 3).

Regarding the fact that the chemical and physico-chemical analyses represent only one analysis per sample and parameters like substratum roughness and mean depth and width are not suitable variables for prediction due to the man-made changes at evaluated localities, the manual forward selection was done with the aim to (i) avoid these problematic variables and (ii) to prefer a more practical one between the strongly correlated variables (e.g. altitude and mean annual air temperature). The final set of variables is as follows: distance from source, stream order, altitude, longitude, latitude, slope, and catchment area. For variance explained by the variable selected and p-value, see Table 4.

Discriminant analysis

Discriminant analysis (Klecka, 1980; Deichsel & Trampisch, 1985) is an important mathematical

Table 2. Characterisation of the reference sites data set – selected environmental variables

Variable	Minimum	Maximum	Median
Stream order (Strahler)	1.00	7.00	3.00
Distance from source [km]	0.50	220.40	7.65
Altitude [m a.s.l.]	125.00	888.00	417.00
Upstream catchment area [km^2]	0.53	7,522.35	16.11
Slope [m km^{-1}]	0.10	85.00	14.02

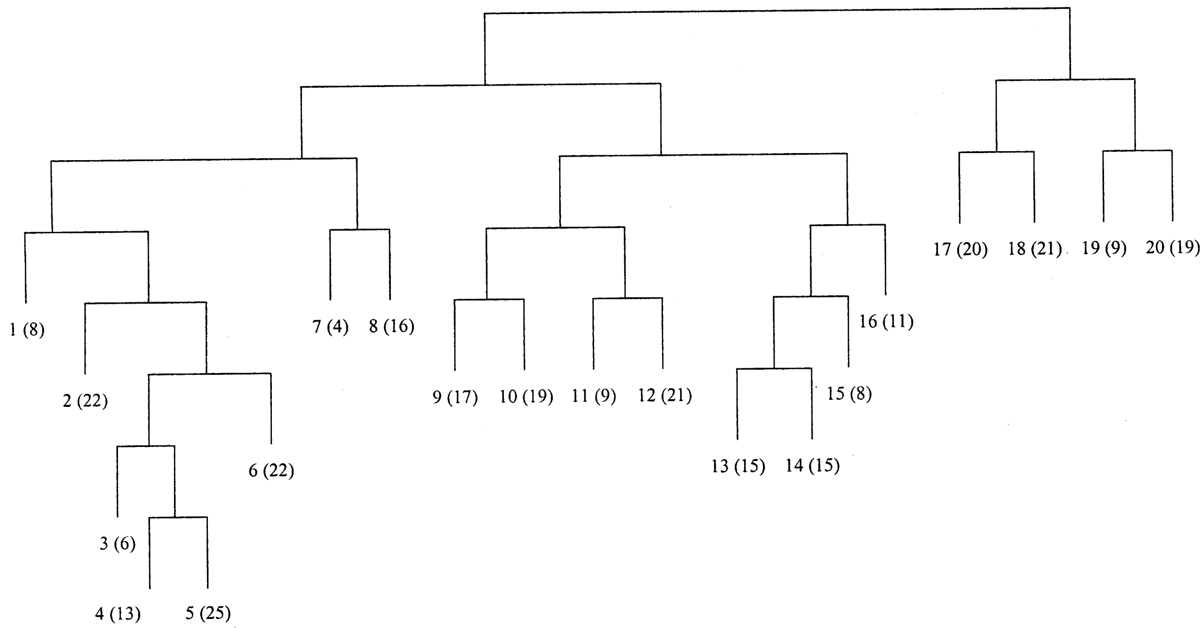

Figure 2. Dendrogram of TWINSPAN classification result – spring, 20 groups.

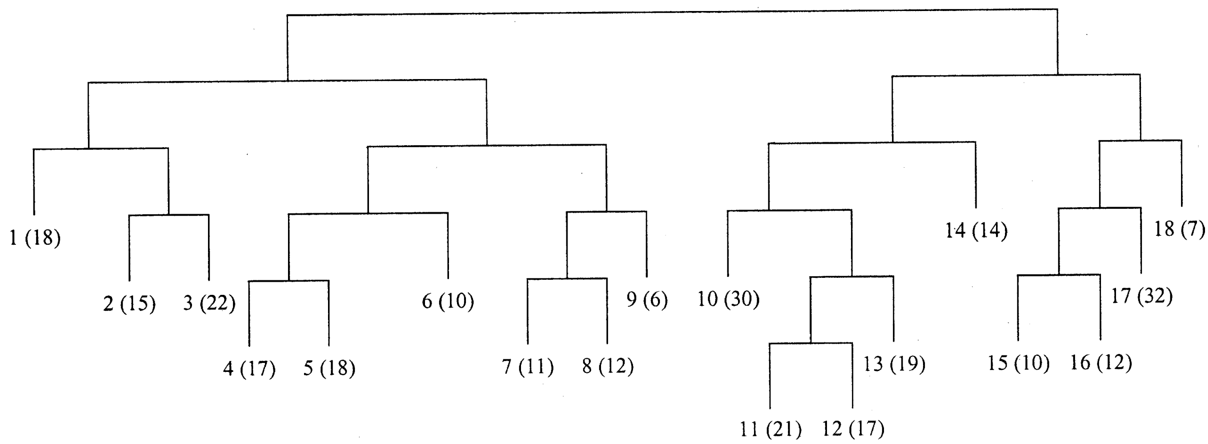

Figure 3. Dendrogram of TWINSPAN classification result – summer, 18 groups.

background of the RIVPACS type prediction model. The SPSS package was used for the computation of discriminant equations and another quantities which are used by software Hobent for the categorization of an observed site into groups of the reference database.

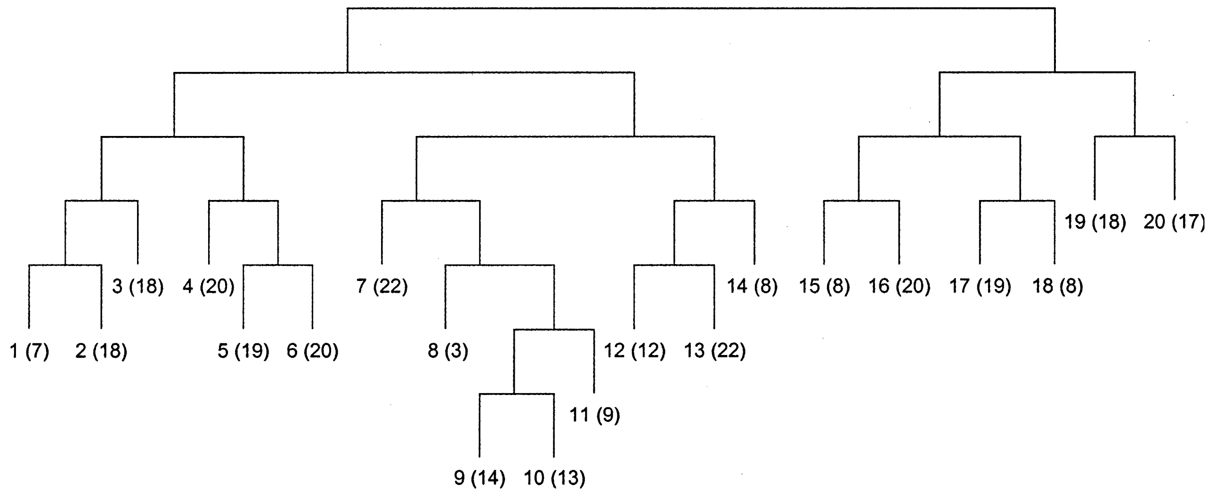

Figure 4. Dendrogram of TWINSPAN classification result – autumn, 20 groups.

Software HOBENT

The prediction is computed by HOBENT software, which was developed at the Water Research Institute (WRI) by Jiri Kokes. The mathematical part of HOBENT uses the same approach as that used in the RIVPACS system (Wright, 1995; Clarke et al., 1996). The software allows the prediction of the target assemblage of benthic macroinvertebrates for any site based on a set of environmental variables (latitude, longitude, distance from source, altitude, slope, catchment area, and stream order) which characterise the site. Then the predicted assemblage is compared with the fauna observed at the same site. The comparison makes it possible to evaluate the extent of disturbance, expressed by index B.

For the computation of the probabilities that the checked site belongs to groups of the reference database, Hobent uses the same formulas as SPSS package (Anonymous, 1997). On the base of discriminant equations and another quantities, which are a part of the reference database, and environmental variables values, Hobent computes discriminant scores and then Mahalanobis distances and uses them for the computation of the probabilities. The sizes of groups (expressed as the prior probabilities, which are also a part of the reference database) are also included in the computation.

Next, for every species of the reference database, the probability of capture at the observed site is computed according to the formula (Clarke et al., 1996):

$$C_{\mathrm{s}} = \sum_{g=1}^{G} F_{\mathrm{sg}} * P_g$$

$$C_{\mathrm{s}} = \sum_{g=1}^{G} F_{\mathrm{sg}} \times P_g$$

s = species, C_{s} = species probability captured at the observed site, g = group, G = number of groups, F_{sg} = frequency of occurrence of species s in group g, P_g = probability which the observed site belongs to group g with. All species are then ordered according their C_{s} and the number of species expected at the observed site is computed as:

$$N_{\mathrm{E}} = \sum_{s=(C_s \geq C_s L)}^{S} C_s$$

$$N_{\mathrm{E}} = \sum_{s=(C_s \geq C_s L)}^{S} C_s$$

N_{E} = number of species expected at the observed site, S = number of species in the reference database, $C_s L$ = optional low limit of C_s (0.5).

Finally, index B is computed as:

$$B = \frac{N_{\mathrm{O}}}{N_{\mathrm{E}}}$$

Table 3. Results of automatic forward selection of environmental variables (Monte-Carlo permutation test, 9999 permutations, CANOCO for Windows)

Marginal effects Variable	Lambda1		
Distance from source	0.23		
Order of stream after Strahler	0.21		
BOD	0.19		
Mean width	0.18		
Mean depth	0.18		
Catchment area	0.16		
Slope	0.15		
COD_{Cr}	0.13		
$N–N0_2$	0.12		
P_{tot}	0.11		
Mean annual air temperature	0.10		
TOC	0.10		
$N–NO_3$	0.09		
Altitude	0.09		
Conductivity	0.08		
total hardness	0.07		
SO_4^{2-}	0.07		
Mean substratum roughness	0.07		
Latitude	0.07		
DO	0.06		
Longitude	0.05		
pH	0.04		
$N–NH_4$	0.02		
Conditional effects			
Variable	LambdaA	*p*-value	*F*-ratio
Distance from source	0.23	0.000	19.69
Conductivity	0.07	0.000	6.64
Order of stream after Strahler	0.06	0.000	5.78
Latitude	0.06	0.000	4.85
BOD	0.04	0.000	4.42
Mean substratum roughness	0.04	0.000	3.73
$N–NO_3$	0.04	0.000	3.46

N_O = number of species with $C_s \geq C_sL$ found at the observed site.

The low limit of C_s is an essential number. The B index computed using the limit is a type of similarity index. When the C_sL is set to zero, only the simple number of taxa is compared and the result is not very useful.

Besides index B and the basic ecological indices, the ASPT, BMWP, saprobic index, EPT, and other indices were incorporated into the software. Their expected values can be predicted. It makes it possible to express these metrics in the form of ecological quality ratios (EQR).

The computation of expected values of some indices, for instance the saprobic index, needs a prediction of abundances. A mathematical method for an abundance prediction does not exist. Hobent, therefore, predicts abundances for each species in each group using pseudorandom numbers as follows:

It generates a pseudorandom value in a range from 0 to 1. If the value is smaller or equal to the probability of occurrence of the taxon in the group (the probabilities are a part of the reference database), taxon "occurs", if the value is higher or the probability is zero, taxon "does not occur". If taxon "occurs", Hobent generates a pseudorandom value in the range from the minimum to the maximum abundance in the group (minimum and maximum abundances of each taxon for each group are also a part of the reference database). The value is "abundance" of the species. By the way, Hobent predicts an "artificial sample" for each group. Consecutively, the saprobic index is computed for each group. Finally, the predicted saprobic index is computed as the sum of products of group indices and probabilities of the observed site that belongs to that group. The procedure is repeated; the number of repetitions is optional. The final predicted index is then computed as an average of all the predicted indices and the EQR_{Si} index as a quotient of the final predicted and observed indices.

The computation of the ecological profile also needs a prediction of abundances, which is done in the same way as in the case of the saprobic index. Computation of the ecological profile follows the method described in Schmedtje (1998), and individual species profiles published in Fauna Aquatica Austriaca (Moog, 1995) are used. The profiles of the two categories (trophic guilds and the biocenotic region) can be computed. Every category has ten subcategories: shredders, scrapers, active filtrators, passive filtrators, detritivores, miners, xylophagous taxa, predators, parasites, and other; and eucrenal, hypocrenal, epirhithral, metarhithral, hyporhithral, epipotamal, metapotamal, hypopotamal, littoral, and profundal. $EQR_{EkoProf}$

Table 4. Results of manual forward selection of environmental variables (Monte-Carlo permutation test, 9999 permutations, CANOCO for Windows

Variable	*p*-value	*F*-ratio	Variance explained by the selected variable
Distance from source	0.000	19.69	0.23
Order of stream	0.000	6.20	0.29
Altitude	0.000	5.01	0.35
Longitude	0.000	4.98	0.40
Latitude	0.000	4.72	0.46
Slope	0.000	2.84	0.49
Catchment area	0.000	2.20	0.51

Variance explained by all variables: 0.85.

for each category is computed as the sum of absolute values of differences between observed and predicted subcategories divided by 2. The index measures a difference between the observed and predicted states, but not the direction of the change.

The differences in the EQR indices in the classification groups were computed using the Kruskal–Wallis nonparametrical analysis of variance (Sokal & Rohlf, 1995).

One of the goals of HOBENT software is easier data treatment. It contains a list of synonyms, computes general indices, and makes data exchange between HOBENT and EXCEL possible.

Discussion

Differences in classification results between seasons

The number of end groups and their composition as results of the classification of biota by TWINSPAN differ slightly in spring, summer and autumn. It is caused, among other factors, by the different number of sites in the seasons and by the absence of Chironomidae in the summer and autumn data sets.

Selection of environmental variables used for the categorisation of sites

During the forward selection of environmental variables, conductivity and total hardness were omitted regardless of their significance. These variables are influenced both by geology and organic pollution. The importance of geological factors is unquestionable, but no relevant information on the geology of the area investigated is available. The geological classification is either very detailed or very rough at present. It is very difficult to distinguish slight organic enrichment from geological influence under these conditions. This is a task that remains to be solved in the near future.

Relations to abiotic stream typology

The HOBENT software and the whole PERLA system were not primarily oriented towards abiotic stream typology. Because Water Framework Directive (WFD) requires abiotic stream typology, this typology was also derived for the Czech Republic (http://heis.vuv.cz/_english/default.asp), and the PERLA dataset was subsequently used for the validation of typology, closely corresponding to typology A of WFD. The WFD A typology leads to many types which are often in a very small number of sites. According to our analysis, the stream types derived by typology A do not agree with the results of classification of benthic macroinvertebrate assemblages (see also Zahrádková et al., in press; Davy-Bowker et al., 2006). The large overlap of environmental variable values in classification groups exists, which is not in concordance with the strict division of environmental variable values in WFD A typology. The prediction models based on the RIVPACS approach are believed to provide a better solution than using abiotic typology, (especially A typology). Discriminant analysis seems to be a better tool for the ordering of a observed site into the groups of the reference database. In fact, the RIVPACS approach also contains a typology, but a more complicated one and not as evident as in the case of WFD A abiotic typology. The concordance of "typology" and groups of benthic assemblages can be easily computed as, for instance, the percentage of correctly ordered sites.

Relations to the multimetric assessment systems and stressor specific approach

The multimetric system is related to the type specific and stressor specific approach, which require the definition of class boundaries for each type and each metric. Dahl & Johnson (2004) stated the major differences between the use multimetric versus multivariate approaches was that the first one requires assumption regarding the expected response of indicator taxa, whilst multivariate approaches require no such a priori assumptions. In the case of a RIVPACS type models based on discriminant analysis, the construction of class boundaries for each group is not necessary and one common class boundary set suffices. It allows for a less complicated interpretation of results. One of the main arguments against the use of multivariate or predictive approaches in bioassessment is that they are consider to be complex to use (required expert knowledge in computer software) and the information is difficult to convey to managers. These shortcomings can be overcome by interactive computer software (Dahl & Johnson, 2004).

The PERLA system is assigned to the site specific and stressor non-specific approaches in principle. Nevertheless, the HOBENT software enables predictions of stressor specific indices like the saprobic index or ASPT; the EQR's of these metrics then also enable stressor specific assessment.

Interrelations with international research projects

Some parts of the PERLA system have interrelations with the STAR project (a research project supported by the European Commission under the Fifth Framework Programme, Contract No: EVK1-CT 2001-00089). The sampling method, sample processing, and assessment of predictive modelling results by HOBENT software were intercalibrated with AQEM-STAR methods within the project. The data of the PERLA system are partially shared by the STAR database.

Conclusion

The PERLA system is a complex of biological methods of ecological status assessment of running waters and interrelated activities in the Czech Republic. It involves (i) a network of reference sites, (ii) a database of reference sites involving both respective biotic and abiotic data, (iii) a prediction model using HOBENT software and iv) TRITON assessment software interrelated to the SALAMANDER information system. The most important tool of this system is the HOBENT software (Kokeš, 2002), which includes the prediction model comparing reference and observed status. The model generally follows the published mathematical principles of RIVPACS (Clarke et al., 1996). Due to this fact, the PERLA system is assigned to the site specific and stressor non-specific approaches in principle. The TRITON software (Jarkovský et al., 2003) represents a multivariate approach (multivariate comparisons based on Gower metric) which is alternative to the HOBENT software and interrelated to SALAMANDER – an information database system developed for the Agricultural Water Management Authority (AWMA). This organisation manages small-sized watercourses; both TRITON and SALAMANDER are restricted to these types of streams.

Methodical support is an inseparable part of the system – an instructional handbook was written (Kokeš & Vojtíšková, 1999); identification courses of benthic macroinvertebrates are regularly organised by Masaryk University and the Water Research Institute; a training course of the sampling method was organised for hydrobiologists participating in the monitoring programmes.

The practical application of the PERLA system started in 2001. Large streams were evaluated by WRI (about 20 sites per year in spring season) (Bernardová et al., 2003) and by AWMA (more than 300 sites a year in spring and autumn season).

The prediction model of the PERLA system enables a more sophisticated evaluation of an observed site than the assessment systems used in the Czech Republic in the past. It cannot be regarded as a universal means sufficient for ecological quality assessment, but as one of the tools which can help to fulfill the demands of the Water Framework Directive.

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