Pol. J. Environ. Stud. Vol. 21, No. 4 (2012), 957-965

Original Research

Polish Investigations on River Hydromorphology

Piotr Lewandowski*

Department of Entomology and Environmental Protection, Poznań University of Life Sciences, Dąbrowskiego 159, 60-594 Poznań, Poland

Received: 1 September 2010
Accepted: 22 March 2012

Abstract

The Water Framework Directive (WFD) introduced the obligation to monitor hydromorphological elements of rivers, including hydrological regime, river continuity, and riverbed morphology. It is estimated that by the year 2015 all uniform water bodies in the EU will be ensured at least very good (class I) or good (class II) ecological status plus good ecological potential. European standards define requirements concerning slightly different quality indices as well as methods of their assessment in such studies.

In Poland, hydrological valuation has been realized since the early 1990s using different research methods. Within the framework of appraisals applied at that time, the requirements of the WFD, adopted later, were not always considered. This paper presents results of an analysis conducted on the basis of the findings of all studies of the hydromorphological status of Polish rivers conducted and published in 1995-2008. From 2,202 km of watercourses, in which scoring was applied for selected quality elements, a total of 1,588 km, uniform in terms of methodology, were selected from 35 rivers. Statistical analysis determined the distribution of results for analyzed quality elements, constituting the foundation for a new method of hydromorphological monitoring of rivers, adapted to the requirements of the WFD. Moreover, our paper also presents a review of developed research methods for the hydrological valuation of watercourses, applied in Poland and Europe.

Keywords: Water Framework Directive, hydromorphology, rivers, lowland, Poland

Introduction

The Water Framework Directive (WFD) 2000/60/EC [1], passed by the European Council and the European Parliament in 2000, has changed the philosophy underlying the perception and management of watercourse resources. Water protection ceased to be understood solely as care for good physico-chemical quality of water, gradually improved in Europe through the construction and modernization of sewage treatment plants. It indicated the significance of physical quality of riparian habitats for the quality of biological elements of watercourses. It requires appraisal of the ecological status of watercourses with catchments larger than 10 km^2 in area, assuming that by the year 2015 all uniform water bodies in the EU member countries will be provided with at least very good (class I) or good (class II) ecological status and good ecological potential (article 4.1. WFD). This leads to the necessity to determine the quality of numerous biological, physico-chemical, and hydromorphological elements of rivers and their surroundings. A score of each element should be expressed in the form of the ecological quality ratio (EQR), which ranges from 0.0 to 1.0. Each member country will specify EQR boundary values of distinguished quality classes for each category of watercourses (natural, heavily modified, and artificial). They are to be determined for all analyzed watercourse elements and indices. The EU member states may introduce their own classification of elements. The most essential aspect is to define boundary values between five classes of ecological status of natural watercourses as well as the ecological potential of heavily modified and artificial watercourses. The boundary value between classes II and

*e-mail: piotrlew@up.poznan.pl

III shows whether the requirement described above, contained in the directive, has been met.

For evaluation of the ecological status of surface waters it is necessary to conduct monitoring of hydromorphological elements. This indicates changes occurring in watercourses, determining habitat conditions for living organisms. Appendix V to the WFD requires an evaluation of the following elements of hydromorphological status: hydrological regime (including the volume and dynamics of flow and the connection of a watercourse with underground waters), watercourse continuity (lack of disturbances), and morphological conditions (variation in river depth and width, the structure and composition of the substrate, the structure of the riverbank zone, substrate conditions, and water flow velocity). The term morphological structure of waters refers to all spatial and material variation in the river bed and its immediate surroundings (the riverbank area), if they influence the hydraulics, morphology, and hydrobiology, and if they are of importance for the ecological functions of the watercourse and the floodplain.

The class of morphological structure of a watercourse is a measure of ecological quality of watercourse morphology and watercourse functionality defined by those structures. The evaluation refers to the present-day potentially natural condition of waters, which would occur in the watercourse and around the watercourse after the present management methods have been discontinued. Such a definition was presented in 2009 in the Report for the EU International Commission for the Protection of the Odra River against Pollution [2].

Hydromorphology as an interdisciplinary science requires knowledge in many fields of research, covering e.g. ecology, hydrology, hydroengineering, geomorphology, water management, and land reclamation [3]. Thanks to this fact it facilitates the identification of the condition of the watercourse environment and its optimal management. However, frequently there is no understanding of the importance of riparian habitat quality for its ecological status. This indicates considerable methodological problems.

Studies on hydromorphological status of rivers have been conducted in Europe starting from the 1980s and in Poland since the early 1990s. Different methods have been applied, taking into consideration regional conditions and disciplines of science, which the authors specialized in.

The aim of this study was to create a unified database including the results of analyses conducted in Poland with the use of the most commonly applied method according to Ilnicki and Lewandowski [4, 5] (a scoring method), which is not adapted to the WFD requirements. This facilitated statistical analyses of results and evaluation of weights of indices included in the appraisal of the hydromorphological condition of rivers. This also created the foundation for the development of a new method of hydromorphological monitoring of Polish rivers, adapted to the requirements of WFD and European standards EN 14614 [6] and EN 15843 [7].

A Review of Methods Used in Poland and Other European Countries

The first studies on hydromorphological valuation in Poland were conducted in the early 1990s [4, 5]. The applied research methods may be divided into two groups. Most authors performed an evaluation of the entire watercourse or at least a considerable part, isolating uniform sections most frequently ranging in length from 100 to 1000 m. Most commonly 8 indices were analyzed, determining the ecological status of each of them within a 5-point scale. Five points were assigned to the most natural watercourse, while a watercourse most severely altered by human activity received a score of 1 point. Starting from the mid-1990s the method by Ilnicki and Lewandowski [4, 5] has been applied most often. This method assumes that the ecological value of watercourse is indicated by the following indices: morphology of the riverbed, a watercourse hydrology, physicochemical properties of water, tree cover of river bank river margins, aquatic vegetation and escarpment vegetation, the layout of the riverbank zone, land use of the river valley, and the scope of area nature protection. Five natural value categories were distinguished on the basis of a mean arithmetic sum of points being scores for all indices.

The other group comprises studies conducted since 2004, using the British method of River Habitat Survey [8]. It consists in the performance of highly detailed studies only on selected 500-m river sections, and not over its entire length. On the basis of scores for 4 or 8 indices, two Habitat Modification Scores and Habitat Quality Assessment indices are calculated, defining respectively the degree of habitat modification due to disturbance and habitat quality on the basis of the presence and abundance of features considered to be beneficial for riverine and riparian wildlife.

In Europe research studies on watercourses (initially referred to as ecomorphological evaluation) were initiated in the 1980s. They were started in Austria and Germany. They included evaluation of as many as 53 different indices [5]. The most frequently evaluated parameters included the course, longitudinal, and transverse sections of the riverbed, substrates collected from the bottom and river margins, structural elements of the riverbed, engineering enforcement of the bottom and river margins, water structures, the volume and velocity of water flow, land use in the river valley, riparian zone vegetation, and tree cover of the river channel. New methods were developed in the 1990s for the evaluation of hydromorphological elements in Austria [9-11], the Czech Republic [12-16], France [17-19], Holland [20], lands comprising Germany [21, 22], Poland [23], Slovakia [24-25], Italy [27], and Great Britain [8]. In many countries (Austria, the Czech Republic, Germany, Slovakia) studies were realized on a broad scale [22, 23]. Procedures applied in Austria and the Czech Republic as well as Slovakia within the framework of cooperation with Denmark were described in detail [28, 29].

The methods applied most frequently [30] included the German LAWA-vor-Ort method [22], the British RHS [8], and the French SEQ-MP methods [17-19]. Some of these were later modified. The basic elements of the watercourse

were characterized using indices. Occasionally weights were used to emphasize a greater or lesser effect of selected indices on the ecological status of the watercourse. None of the methods included abiotic types and watercourse categories (natural, heavily modified, and artificial). Sometimes a significant role was played by the size of the watercourse. No reference conditions were determined for watercourses. It was most frequently assumed that the natural condition of watercourses was found in the first half of the 19th century.

Within the framework of standardization works in 2004 the European Committee for Standardization (CEN) developed a standard EN 14614 [6], while in 2010 it was EN 15843 [7], which partly diverge from the stipulations of the WFD. The complicated structure of the WFD resulted in the implementation of the Common Implementation Strategy (CIS) for WFD [31]. Within this strategy little attention was paid to hydromorphology, focusing mainly on the development of reporting principles [32].

Methods

The investigations were started by collecting and analyzing results of published studies concerning the hydromorphological status of watercourses, conducted in Poland in 1995-2008 in several centers (Kraków, Olsztyn, Poznań, Warszawa, Wrocław). They covered a total of several thousand kilometers of rivers. They concerned 51 rivers with a combined length of 2,202 km.

Within the framework of analyzed methods isolated short sections, uniform in terms of their hydromorphology, were evaluated in each watercourse. Natural watercourses definitely predominated among rivers. The length of analyzed homogeneous river sections varied considerably and most commonly did not correspond to much longer uniform parts of surface water bodies, distinguished later [33].

A vast majority of hydromorphological studies in Poland were conducted using the scoring method by Ilnicki and Lewandowski [5]. Due to the completely different methodology in the further part of this study, the results of investigations conducted by the River Habitat Survey method [8] could not be taken into consideration. It was necessary for the purpose of statistical analysis to isolate from the entire set these watercourses, which were analyzed by applying an analogous selection of indices. This reduced the scope of analyses to 35 rivers. Within their scope different authors distinguished and analyzed, in accordance with method [5], a total of 1,963 uniform sections. They are lowland landscape watercourses, located in the Wielkopolska, Kujawy, Lower Silesia, Podlasie, Mazowsze, Pomerania, and Warmia regions, as well as those of the highland landscape of the Lesser Polish Gorge of the Vistula and the mountain landscape of the Małopolska region. They included fragments of large rivers (the Vistula, Warta, and Noteć) and considerably long (>50 km) sections of medium-sized rivers, i.e. the Ina, Jeziorka, Mała Wełna, Mogilnica, Wełna, Widawa, and Wrześnica rivers.

This made it possible to create a database developed in Excel spreadsheet format. It includes evaluated quality elements of surveyed sections of watercourses. Categories of natural character assigned according to this methodology were later converted into ecological quality ratios, ranging from 0 (the lowest) to 1 (the highest). Calculation of the ecological quality ratio (EQR) was performed by dividing the scores for a given parameter by the maximum potential number of points for this parameter.

The created database constituted the basis for statistical calculations. Statistical analyses were performed by calculating the basic descriptive parameters, e.g. population size, mean, maximum, minimum, standard deviation, distribution of analyzed sections jointly for the section and individual parameters separately. The occurrence of normal distribution for the analyzed scores of the covered parameters was evaluated along with the final evaluation of the section and the investigated watercourse.

Results

A slightly different selection of indices, performed by different authors, made it impossible to create a joint set of data for the results of watercourse hydromorphology appraisals published in Poland. For this reason it was decided to limit the scope of this paper to studies performed on the basis of an evaluation of the same indices. Analyzed sections were classified to uniform water bodies by dividing the set of data into natural, heavily modified, and artificial watercourses. In this way, originally a total of 2,202 km of rivers were isolated (Fig. 1), among which 1,937 km are natural watercourses, 127 km are heavily modified, and 138 km are artificial watercourses. It needs to be stressed that the results used in this study covered the evaluation of solely the main watercourse, neglecting numerous tributaries.

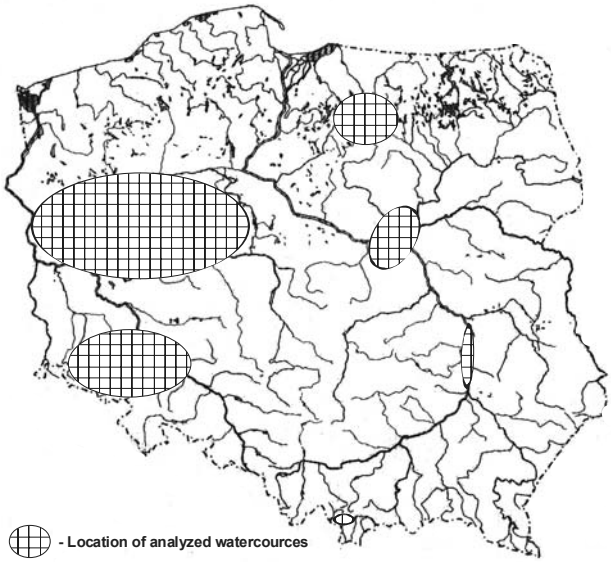

Fig. 1. Distribution of watercourses in which river hydromorfology was analyzed by the field index scoring method.

Table 1. A list of Polish rivers included in the methodologically uniform analyses of hydromorphological status.

River category	Rivers				
	Name	Number of investigated			Length (km)
		Rivers	Water bodies	Sections	
Natural	Cybina, Flinta, Główna, Głuszyna, Gołdapa, Górna Noteć and the Ślesiński Canal, the Książ Canal, Kopla, Korówka, Łyna, Mała Wełna, Margoninka, Męcina, Miała, Mogilnica, Moskawa, Narew, lower Noteć, Sama, Samica, Smortawa, Pisa Warmińska, Warta (below Konin, except for the section from Kopla to Cybina), Wełna, Widawa, Września	26	50	1,733	1,420
Heavily modified	Meszna, Moskawa, Warta (from Kopla to Cybina)	3	4	88	62
Artificial	Górna Noteć, Ślesiński Canal, Główna, Elżbieta Canal, Mosina Canal, Bydgoszcz Canal	6	9	142	106
Total		35	63	1,963	1,588

The study used the results of investigations conducted using the scoring method according to Ilnicki and Lewandowski on watercourses in the Wielkopolska region (the Warta and Noteć rivers and the Bydgoszcz and Ślesiński canals) [5] of 710 km in length, medium-sized rivers in the Wielkopolska region [33] with a total length of 669 km, in the northern part of the Mazowsze region [35, 36] of 86 km, in the mid-Polish Uplands [37] with a length of 80 km, in the Mazury region [38, 39] of 68 km, in Lower Silesia [40, 41] of 141 km, and in the Orawa-Nowy Targ Basin [42, 43] of 17 km. Moreover, analyses conducted using photointerpretation of aerial and satellite photographs [44] on watercourses of 431 km in length also were included in this study.

In the further stage from among the above-mentioned objects these were isolated, on which studies were conducted using uniform methodology. They include 35 rivers divided into 1,963 homogeneous sections with a total length of 1,588 km (72.1% initial joint length of watercourses), including 63 uniform water bodies (Table 1).

An analysis of the role of individual indices for the evaluation of ecological status showed that due to the high water levels in rivers (1,253 sections) and the location of only some of the investigated watercourses within the area covered by natural protection (778 sections), it is not always possible to evaluate all quality elements (Table 2).

The EQR value for the investigated sections ranged from 0.28 to 0.94, while its mean value was relatively high and amounted to 0.61. Taking into consideration the joint score for the isolated sections obtained from the mean of individual parameters, the index of physico-chemical water quality shows that the analyzed rivers are of good or average quality classes. However, it needs to be stressed that both water quality and the specific nature value of the valley may not constitute an element of future methods of hydromorphological evaluation, since they are not included in the WFD or the European standards.

Graphs for the distribution of scores for particular evaluated quality elements are much more varied. Scores for the river channel morphology element follow a fairly normal distribution (Fig. 2). The riparian zone layout (land use) element (Fig. 3) has a less uniform sum of scores in the distinguished natural character classes. It is unimodal with a marked skewness. This is manifested in the predominance of low scores (1-2 points), which indicates a lack of such zones for most rivers. Distributions of natural character classes for the management of the river valley and tree cover of the river channel parameters were not uniform, either. They are characterized by skewness. This fact indicates a considerable proportion of arable land in valleys and the occurrence of numerous watercourses, over whose channels no trees grow.

Table 2. Scoring results for applied indices of hydromorphological status.

Index	n	Mean score (points)	Standard deviation
Morphology of river channel	1963	3.08	0.86
Hydrology of watercourse	1963	3.90	1.16
Water quality	1963	3.32	1.24
Tree cover of river channel	1963	2.83	1.39
Aquatic vegetation and vegetation cover of river margins	1253	2.52	1.35
Riparian zone layout (land use)	1958	2.49	1.22
Management of river valley	1963	2.96	1.26
Specific nature value	778	3.75	0.78
Ecological quality ratio	1963	0.61	0.12

The distribution of calculated ecological quality ratios (EQR) is very close to a normal distribution (Fig. 4). This indicates proper selection of quality elements subject to evaluation. Values of calculated EQR ranged from 0.28 to 0.94, with a mean value of 0.61. The most natural sections of rivers with EQR≥0.90 account for only 0.76% of their

total number. Such sections correspond to the concept of reference (model, natural) conditions. On the other hand, the poorest score (EQR≤0.43) is found in 7.13% of the analyzed sections. This constituted the foundation for the determination of EQR boundary values for five classes of natural character within the framework of the new hydromorphological monitoring of rivers [45].

Discussion of Results

The conducted analyses of results recorded for the watercourses subjected to valuation in Poland covered almost 1,600 km of 35 rivers and canals, constituting 63 uniform water bodies. The common denominator is the applied research method, taking into consideration the evaluation of identical parameters. The resulting set of 1,963 uniform sections comprises the maximum possible number of hydromorphological surveys for the watercourses previously studied in Poland. The presented analysis is based on the published results of studies conducted in different regions of Poland. The surveys mentioned above covered

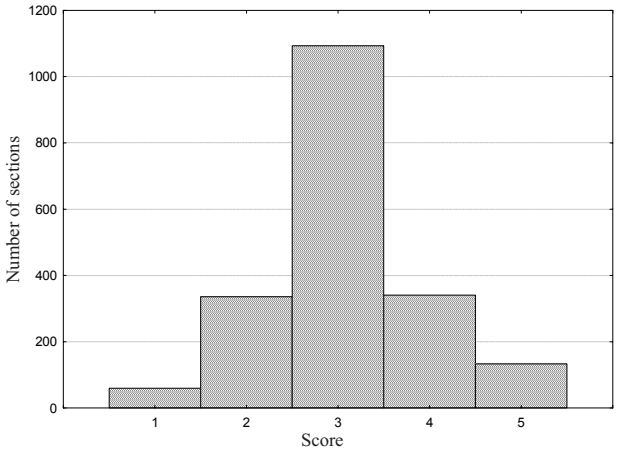

Fig. 2. Distribution of scores for the river channel morphology index.

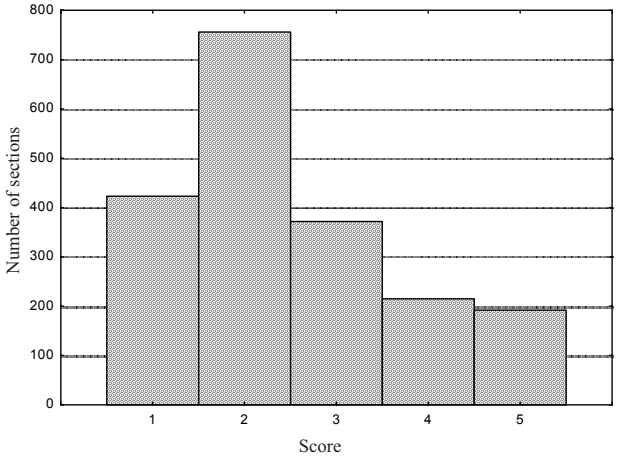

Fig. 3. Distribution of scores for riparian zone layout (land use) index.

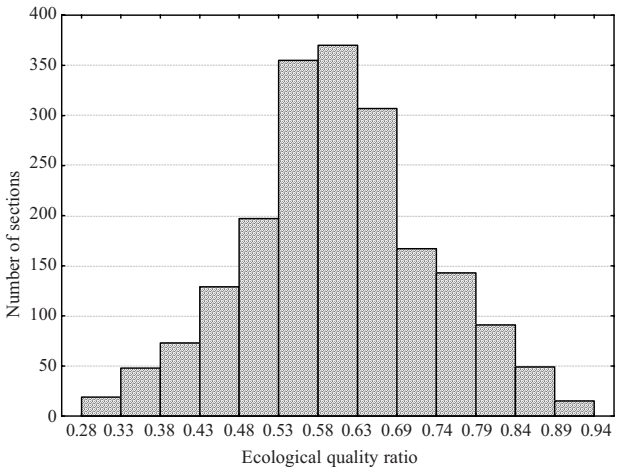

Fig. 4. Distribution of the values of ecological quality ratio in analyzed river sections.

only the main watercourse, neglecting its tributaries. The effect of the considered 7 analyzed indices on the final mean score was determined for a homogeneous section, and thus also its category of natural character. The joint score for the mean of each parameter indicates that the greatest contribution to the high values recorded for the ecological quality ratio is associated with watercourse hydrology, specific nature value of the valley, and morphology of the river channel. The final score was lowered by scores for the occurrence of aquatic vegetation and vegetation of river edges, as well as the layout of the riparian zone.

On the basis of field studies conducted by the authors of this paper in the central Wielkopolska region, constituting a major part of the analyzed data set, it may be indicated that such a situation was either influenced by the occurrence of scarce plant species in the watercourse channel or their complete absence. In the case of the riparian zone layout a decisive role is played by its reduction or even elimination for the sake of permanent pastures or arable land. This pertains particularly to medium-sized watercourses such as the Główna, Moskawa, or Mogilnica. Results concerning their sections constitute a major part of the analyzed set. An opposite situation is found for large watercourses, such as the Warta or Noteć, most frequently having wide and long sections of the riparian zone. A non-uniform distribution is observed for values assigned for management of the valley and tree cover of the river channel. Analyzed watercourses were characterized by a considerable share of arable land in the valley and numerous sections devoid of tree cover.

Relatively high scores were given for water quality, which results from the gradual improvement of physicochemical parameters of flowing waters in Poland. However, it needs to be stressed that both water quality and specific natural value, previously included in the Polish methods of hydromorphological valuation of watercourses, are not required by the WFD.

Values of EQR are essential for the establishment of boundary values of the ecological status of watercourses. At the reported mean of 0.61 they fell within the range of 0.28-0.94. It needs to be stressed here that such high scores of

analyzed watercourses were probably influenced by the slight proportion of heavily modified watercourses (3 objects, 4 uniform water bodies) as well as artificial watercourses (6 objects constituting 9 uniform water bodies). We may mention here the issue of attractiveness of such objects for the realization of research by scientists. However, on the basis of in-situ studies conducted in the Wielkopolska region, we may conclude that some of them, e.g. the confluence fragment of the Mosina Canal, despite its artificial genesis, are undergoing slow processes of self-naturalization [46]. These studies also indicate that a considerable proportion of lowland watercourses in Poland have high and medium ecological status [4, 5, 34, 38-41].

It needs to be stressed here that the WFD imposes the obligation to determine the hydromorphological status of the entire uniform water bodies. This results from studies conducted to date that uniform water bodies of natural and heavily modified watercourses sometimes indicate high variation of continuity, river channel morphology, and river layout. Thus it is required to identify the entire uniform water body, and not just a selected section constituting several percent of its length. Most typically uniform water bodies are long sections ranging in length from several to several dozen kilometers, in which fragmentary modifications of hydromorphology did not play a significant role in the valuation performed using previously applied methods. At the same time the relative "delay" in the channeling of rivers in Poland, observed to date and most frequently resulting from a lack of funds, has contributed to the maintenance of their relatively good hydromorphological status. It needs to be emphasized here that we may never compare Polish rivers with objects located in other parts of the EU. In accordance with the guidelines of the WFD, valuation in each member state may be performed using their own original methodology, adapted to the geographical and historical conditions. Such a stipulation is also incorporated in the act founding the EEC – a protoplast of the EU, i.e. the Rome Treaties (Art. 191, items 2-4) [47].

Thus it is not possible to develop universal boundary values between individual classes of ecological status/ecological potential for the entire EU, which is confirmed in Appendix V to the WFD. It contains very general definitions of each class, where "good ecological status" is defined as a slight deviation from the natural condition, "moderate ecological status" refers to moderate deviation, while "bad condition" – as a state showing very large changes in relation to the reference status, not specifying any measures of this deviation. Each country, for the needs of valuation and classification of their waters, is obliged to present this deviation in numerical form, in the form of the EQR for each valuation index (the so-called matrix). In accordance with the Common Implementation Strategy for the Water Framework Directive, each country individually defines boundary values for quality classes [48]. Guidelines of the CIS-WFD No. 22 of 2009 (p. 21) stipulate that as a result of monitoring, a set of data will be formed, making it possible to determine reference values. However, CIS-WFD documents are not binding legal acts in the EU and allow a different approach.

The WFD does not specify the concept of the natural condition. It should correspond to reference conditions, which for river hydromorphology have not been specified within the framework of intercalibration exercises performed in Europe. The reference condition may refer to the state of the river from the period preceding the Industrial Revolution of the 18th century or intensification of agriculture (mid-20th century), or a pragmatic approach based on the target tangible ecological status.

Realized intercalibration works do not aim at a unification of systems, but only a comparison and harmonization of the results of this valuation between different neighboring countries, which watercourses are located within joint, water ecoregions specified in Appendix XI to the WFD. These groups are formed by countries with similar physico-geographical conditions, under which common types of rivers are found. Each European country has it own typology of waters, developed in accordance with system A or B, described in appendix II to the directive. In this respect the essence lies in the identical interpretation of the definition of classes, particularly good ecological condition, a key concept for the attainment of the directive's objective. Poland in terms of inland waters belongs to the Central Geographical Intracalibration Group. When initiating intercalibration, all countries need to possess already developed systems of valuation and classification of waters, in accordance with the WFD requirements. Problems with the classification of biological elements, which appeared in recent years within the framework of intercalibration work, indicate that such an approach will not make it possible to identify which parts of waters will not be granted good ecological status or ecological potential in the year 2015. We have to remember that the identification of class boundaries, conducted in each country, may be treated as a scientific implementation of an important political decision.

In view of a lack of reference conditions specified in Poland for all abiotic types of rivers, it may be assumed that such conditions will be met by uniform water bodies, which would receive the joint ecological quality ratio EQR = 0.90-1.00. Among the analyzed uniform water bodies, the most natural sections of rivers with EQR≥0.90 accounted for only 0.76% (47.5 m) of their total number. Thus it may be stated that the boundary threshold is high. Boundary values for classes are established on the basis of an arbitrary decision of each member country. In individual countries they will probably vary, which also results from the terms used in the WFD, i.e. "corresponds completely or almost completely to undisturbed conditions" and shows "slight disturbances caused by human activity," which may hardly be considered precise.

At the same time, extensive literature studies indicate that in Central Europe (Austria, the Czech Republic, Poland, Germany) for 43,922 km watercourses subjected to valuation using different methods, averaged boundary values classified 17% rivers to class I, 20% to class II, 22.5% to class III, 27.5% to class IV, and 12.5% to class V. Thus, the requirement of receiving at least good ecological status would be theoretically met by approximately 40% of rivers [49].

The WFD in point 1.3.6 stipulates that methods used in monitoring in relation to the analyzed parameters in terms of hydromorphological parameters should correspond to respective standards, i.e. EN 14614 [6] and EN 15843 [7]. Both standards contain a greater number of parameters recommended for analyses than is the case in the WFD (Appendix V, elements of river hydromorphological status classification include hydrological regime, river continuity and morphological conditions defined based on 5 indices). Standard EN-14614 [6] lists 10 assessment categories that need to be considered in the survey of river hydromorphology and requires identification of five quality classes (different than those in the WFD). It contains guidelines for the evaluation of the hydromorphological status of rivers, distinguishing three elements, i.e. the river channel, banks with the riparian, zone, and the floodplain. It does not include an assessment of the hydrological regime or river continuity. It is based on the principle consisting of the determination of changes in relation to reference conditions. The survey is conducted in homogeneous sections of watercourses (not in uniform water bodies). It does not replace the existing methods used in individual countries. It is emphasized that the performance of the survey makes it necessary to use the expertise of specialists knowing analyzed watercourses and to consider abiotic types of rivers.

Standard EN 15843 [7] presents a method of assessment of 10 core features and 11 subsidiary features and contains boundary values for three and for five quality classes:

1. near natural
2. slightly modified
3. moderately modified
4. extensively modified
5. severely modified

Different names of classes indicate that they are connected with the classification of ecological status according to the WFD. This classification does not distinguish categories and types of rivers.

In contrast to the WFD, the above-mentioned standards include the floodplain, whose evaluation should be included in the new Polish, methodology of hydrological valuation of watercourses. Due to the financial and organizational potential of Poland, hydromorphological monitoring should cover the evaluation of the status only for the main watercourses, comprised in the distinguished uniform water bodies for each watercourse category. It will not be possible to develop separate 27 methods for the distinguished abiotic types of rivers.

Taking into consideration a much wider scope of evaluation of watercourse parameters than is stipulated by the WFD, it is necessary to apply a hierarchical system, comprising numerous attributes, whose evaluation constitutes the basis for the evaluation of the indices, and these in the final stage assess the 4 major watercourse elements, i.e. hydrological regime, watercourse continuity, river channel morphology, and floodplain.

Concluding Remarks

It is difficult to conduct valuation of the ecological status of a river based on river channel morphology, occurring plant communities, management of the river valley, and hydrology. It makes it necessary to consider highly diverse indices and to establish reference conditions as well as determine boundary values for five ecological quality classes of watercourses. A methodology adapted to the requirements of the Directive 2000/60/EC should include major indices applied to date (except for water quality), but it may not be excessively labor-intensive. Thus within a period of 4 years it is necessary to conduct studies on over 50,000 km of rivers. The methodology needs to be based on the evaluation of four major element, i.e. modification of hydrology and hydraulics of a watercourse manifested in the form of a change in the water regime caused by anthropogenic activity (including dammed reservoirs and hydroengineering structures), watercourse accessibility for aquatic organisms and debris, river channel morphology, and the manner of management of the riparian zone and the river valley. Each element should be evaluated on the basis of specifically characterized more numerous features. Evaluation of a given element would be executed based on mean values of features describing it, which would be characterized by selected attributes. This leads to a hierarchical valuation system that results in EQR form.

The selection of quality elements of hydromorphological status evaluation, applied in the method used in the described method by Ilnicki and Lewandowski, ensured an isolation of five natural classes of hydromorphological quality in a manner corresponding to a normal distribution. The selection of indices did not fully meet the requirements of the Water Framework Directive 2000/60/EC, passed later, or European standards EN 14614 and EN 15843.

It is advisable to develop a new method of hydromorphological monitoring of Polish rivers, fully adapted to the WFD requirements. It should be based on the evaluation of four elements (hydrological regime, river continuity, river channel morphology and the floodplain) and characterized with the use of a greater number of quality elements. The result of the evaluation needs to be expressed in the form of ecological quality ratios, classified to five quality classes. When determining boundary thres-holds for the above-mentioned classes, the established normal distribution of the evaluation conducted by the method developed by Ilnicki and Lewandowski will prove helpful.

This does not preclude the application of more specific methods, requiring highly precise recognition of the hydromorphological status of a given watercourse for scientific purposes, or revitalization actions on already modified watercourses.

References

1. Directive 2000/60/EC of the European Parliament and of the Council of 23 Oct. 2000 establishing a framework for Community action in the field of water policy. OJEC L 327/1, **2000**.
2. Report for the International River Basin District Odra on the implementation of the Art. 13 of the Directive 2000/60/WE of the European Parliament and the Council of the 23rd of October 2000 establishing a framework for Community

action in the field of water policy. International Commission for the Protection of the Oder against Pollution. Wrocław **2010** [In Polish].
3. VAUGHAN I.P., DIAMOND M., GURNELL A.M., HALL K.A., JENKINS A., MILNER N.J., NAYLOR L.A., SEAR D.A., G. WOODWARD G., ORMEROD S.J. Integrating ecology with hydromorphology: a priority for river science and management. Aquatic Conserv: Mar. Freshw. Ecosyst. **19**, 113, **2009**.
4. ILNICKI P., LEWANDOWSKI P. Methodological study on the Ecomorphological River Evaluation. Z. Kulturt. Landentwickl. **36**, 255, **1995** [In German].
5. ILNICKI P., LEWANDOWSKI P. Ecomorphological evaluation of waterways in Wielkopolska. Bogucki Wyd. Nauk. Poznań. pp. 1-128, **1997** [In Polish].
6. EN 14614:2004. Water quality. Guidance standard for assessing the hydromorphological features of rivers. European Committee for Standarization CEN Brussel, **2004**.
7. EN 15843:2010. Water quality - Guidance standard on determining the degree of modification of river hydromorphology. European Committee for Standarization CEN Brussel, **2010**.
8. SZOSZKIEWICZ K., BUFFAGNI A., DAVY-BOWKER J., LEŚNY J., CHOJNICKI B.H., ZBIERSKA J., STANISZEWSKI R., ZGOŁA T. Occurrence and variability of River Habitat Survey features across Europe and the consequences for data collection and evaluation. Hydrobiologia. **566**, 267, **2006**.
9. MÜHLMANN H. A handbook for hydromorphological evaluation of actual stock of watercourses with catchments of 10-100 km^2. "Screening method." Bundesamt für Wasserwirtschaft, Institut für Wassergüte Wien, pp. 1-52, **2005** [In German].
10. GZÜV – Surface watercourses (Resolution on monitoring of watercourse status). Realization in 2007-2009. BMLFUW Wien, Bundesamt für Wasserwirtschaft, Institut für Wassergüte Wien, pp. 1-68, **2008** [In German].
11. MÜHLMANN H. A handbook for evaluation of hydromorphological status of watercourses. New version Ferbuary 2010. BMLFUW Wien, Wasser Informationssystem Austria – WISA pp. 1-72, **2010** [In German].
12. LANGHAMMER J. HEM – Hydroekologický monitoring. Methodology of hydromorphological monitoring to determine ecological quality of watercourses. MŽP ČR, Praha, pp. 1-21, **2007** [In Czech].
13. MATOUŠKOVÁ M. Assessment of the river habitat quality within European Water Framework Directive – application to different catchments in the Czech Republik. Geografie – Sbornik České Geografické Společnosti. Charles University Praha, **3/113**, pp. 19-32, **2008**.
14. WEIß A., MATOUSKOVA M., MATSCHULLAT J. Hydromorphological assessment within the EU-Water Framework Directive – trans-boundary cooperation and application to different water basins. Hydrobiologia **603**, 53, **2008**.
15. LANGHAMMER J. Applicability of hydromorphological monitoring data to locate flood risk reduction measures: Blanice River basin, Czech Republic. Environmental Monitoring and Assessment. Springer, **152**, (1-4), 379, **2009**.
16. ŠÍPEK V., MATOUŠKOVÁ M., DOK M. Comparative analysis of selected hydromorphological assessment methods. Environ. Monit. Assess, **2010**.
17. AGENCES DE L`EAU RHÔNE-MÉDITERRANÉE-CORSE Tools for the evaluation of the quality of water courses (S.E.Q.). General principles. Les Etudes des Agences de l'Eau. Etude n° **72**, 1, **1999** [In French].
18. AGENCES DE L`EAU RHÔNE-MÉDITERRANÉE-CORSE. Watercourse quality evaluation system: SEQ EAU. Report on SEQ-Eau presentation (version 1). Les Etudes des Agences de l'Eau. Etude n° **64**, 1, **2000** [In French].
19. SCHMITT L., MAIRE G., HUMBERT J. An hydrogeomorphic typology of rivers: a management model adapted to the physical environment of the south-west watershed of the Rhine rift valley. Géocarrefour, **75**, (4), 347, **2000** [In French].
20. DE WILDE A.J., KNOBE R.A.E. Setting classboundaries for the classification of rivers and lakes in Europe. Final Report. Ministerie van Verkeer en Waterstaat DG RWS – RIZA. Haskoning Nederland BV Water. pp. 1-22, **2002**.
21. AHRENS U. Watercourse structure: mapping and evaluation of watercourses in Schleswig-Holstein. Jahresbereicht Landesamt f. Natur ind Umwelt des Landes Schleswig-Holstein. pp. 115-126. **2006/7** [In German].
22. LAWA. Evaluation of watercourse structure quality in the Federal Republic of Germany. Procedures for small and medium-sized watercourses. Länderarbeitsgemeinschaft Wasser, Berlin, pp. 1-54, **2000** [In German].
23. ILNICKI P., LEWANDOWSKI P., OLEJNIK M. Methods for hydromorphological evaluation of rivers applied in Europe before and after enactment of the Framework Water Directive. Gospodarka Wodna. **10**, 393, **2008** [In Polish].
24. BLAŠKOVIČOVÁ L., MAGULOVÁ R., VELČICKÁ L., DOBIAŠOVÁ M., CHRIAŠTEĽ R., CHYNORADSKÝ P., ADAMKOVÁ J. Establishment of the Protocol on Monitoring and Assessment of the Hydromorphological Elements. Final report (+ 4 annexes). Twinning light Project Slovak Republic-Denmark No TLP 01-29 SR 011001010009, pp. 30 + 37 (annexes), **2004**.
25. ŠPORKA F., MAKOVINSKÁ J., HLÚBIKOVÁ D., TÓTHOVÁ L., MUŽÍK V., MAGULOVÁ R., KUČÁROVÁ K., PEKÁROVÁ P., MRAFKOVÁ L. Methodology for determination of reference conditions and classification schemas for the evaluation of ecological status of waters. C. Hydromorphological elements of quality. VÚVH Bratislava, SHMÚ Bratislava, UZ SAV Bratislava, SAŽP Banská Bystrica, pp. 350-398, **2007** [In Slovak].
26. MAKOVINSKÁ J., KUČÁROVÁ K., TÓTHOVÁ L., HAVIAR M., VALÚCHOVÁ M. Determination of quality of surface water bodies in Slovakia in 2007. Pracovná Skupina 2.3 "Hodnotenie stavu vodných útvarov povrchových vôd a interkalibrácia." SHMÚ Bratislava, pp. 1-70, **2009** [In Slovak].
27. BALESTRINI R., CAZZOLA M., BUFFAGNI A. Characterizing hydromorphological features of selected Italian rivers: a comparative application of environmental indices. Hydrobiologia, **516**, 365, **2004**.
28. ILNICKI P., LEWANDOWSKI P. Hydromorphological evaluation of highland and mountain rivers in Austria. Gospod. Wodna. **10**, 414, **2009** [In Polish].
29. ILNICKI P., LEWANDOWSKI P. Implementation of hydromorphological status evaluation of rivers in the Czech Republic and Slovakia. Wiad. Mel. i Łąk. **1**, 26, **2010** [In Polish].
30. RAVEN J.P., HOLMES N.T.H., CHARRIERE P., DAWSON F.H., NAURA M., BOON P.J. Towards a harmonized approach for hydromorphological assessment of rivers in Europe: a qualitative comparison of three survey methods. Aquatic Conservation. Marine Freshwater Ecosystems. **12**, (4), 405, **2002**.

31. Common Implementation Strategy (CIS) for the Water Framework Directive (WFD) 2000/60/EC Guidance nr 10. River and lakes – Typology, reference conditions and classification systems. WG 2.3. REFCOND. Office for Official Publications of the European Communities, Luxemburg, pp. 1-94, **2003**.
32. EUROPEAN COMMISION – DG ENVIRNONMENT. Technical support in relation to the implementation of the Water Framework Directive (2000/60/EC): A user guide to the WFD reporting schemas. Report Ref: V 4.3, 22 October 2009, pp. 1-216, **2009**.
33. REPORT FOR THE ODER RIVER BASIN from the realization of articles 5 and 6, principles II, III, IV of the Water Framework Directive 2000/60/EC [online] www.kzgw.gov.pl/pl/Raporty-do-Komisji-Europejskiej.html, Ministry of the Environment, Warszawa, **2005** [In Polish].
34. LEWANDOWSKI P. Environmental evaluation of selected watercourses in the Wielkopolska region. Dissert. Agric. Univ. Poznań. Manuscript, pp. 1-215, **2000** [In Polish].
35. OGLĘCKI P., PAWŁAT H. The index method of small lowland river environmental evaluation. Ann. Warsaw Agric. Univ. Land Reklam. **30**, 37, **2000**.
36. OGLĘCKI P. Hydromorphological evaluation of lowland rivers based on the Wkra. Infrast. i Ekol. Ter. Wiej. **4**, (1), 175, **2006** [In Polish].
37. WOLSKI J. Comprehensive (geoecological) method to evaluate natural value of a large river valley based on the Małopolska Wisła River Gap. Ochr. Środ. i Zas. Nat., 23/24, Wyd. IOŚ Warszawa, pp. 125-153, **2002**, [In Polish].
38. GRZYBOWSKI M., ENDLER Z. Ecomorphological evaluation of the Elżbieta Canal. Acta Sci. Pol., Formatio Circumiectus, **4**, (1), 37, **2005** [In Polish].
39. GRZYBOWSKI M. Ecomorphological evaluation of the Pisa Warmińska River in the Olsztyn Lake District. In: Kostrzewski A., Andrzejewska A. (Eds.): Program for Integrated Environmental Monitoring and protection tasks for Natura 2000 areas. Bibl. Mon. Środ. Warszawa, pp. 281-290, **2007** [In Polish].
40. ADYNKIEWICZ-PIRAGAS M., TOKARCZYK T. Ecomorphological evaluation of the Widawa River with an altered runoff regime. Przegl. Nauk Wydz. Mel. i Inż. Środ. SGGW, XIII, **30**, 30, **2004** [In Polish].
41. ADYNKIEWICZ-PIRAGAS M., KRZEMIŃSKA A., TARNOWSKI K., WRÓBLEWSKI T. Characteristics and variation of hydromorphological parameters in a lowland river based on the Smortawa. Infrast. i Ekol. Ter. Wiej. PAN Kraków **4/3**, pp. 17-24, **2006** [In Polish].
42. WYŻGA B., ZAWIEJSKA J., RADECKI-PAWLIK A., AMIROWICZ A. Evaluation of hydromorphological quality of a mountain river based on the Czarny Dunajec. In: Environmental quality of rivers in southern Poland and potential for its improvement - selected aspects. B. WYŻGA (Ed.), Inst. Ochr. Przyr. Kraków, pp. 103-119, **2008** [In Polish].
43. WYŻGA B., AMIROWICZ A., RADECKI-PAWLIK A., ZAWIEJSKA J. Hydromorphological conditions, potential fish habitats and the fish community in a mountain river subjected to variable human impacts, the Czarny Dunajec, Polish Carpatians. Riv. Res. Applic. **25**, 517, **2009**.
44. OLEJNIK M. Evaluation of feasibility of aerial and satellite photographs in hydromorphological evaluation of lowland rivers. Dissert. Agric. Univ. Poznań. manuscript, pp. 1-199, **2007** [In Polish].
45. ILNICKI P., GOŁDYN R., MURAT-BŁAŻEJEWSKA S., SOSZKA H., GÓRECKI K., GRZYBOWSKI M., KRZEMIŃSKA A., LEWANDOWSKI P., SKOCKI K., SOJKA M. Development of monitoring methods and classification for hydromorphological elements of quality in homogeneous river and lakes, in compliance with the requirements of the Water Framework Directive. manuscript, pp. 1-328, **2009** [In Polish].
46. LEWANDOWSKI P., OLEJNIK M., GÓRECKI K. Ecomorphological evaluation of Canal Mosiński with field method. Infrast. i Ekol. Ter. Wiej. PAN Kraków **4/3**, pp. 87-96, **2006** [In Polish].
47. Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union. Information and Notices. OJEC 2010/C 83/01, **2010**.
48. Common Implementation Strategy for the Water Framework Directive (CIS-WFD) 2000/60/EC Guidance nr 10. River and lakes – Typology, reference conditions and classification systems, 2003 and nr 21 Guidance for reporting under the WFD, **2009**. [online] http://circa.europa.eu/Public/irc/env/wfd/library?1=framework_directive/guidancedocuments&vm=detailed&sb=Title.
49. ILNICKI P., GÓRECKI K., GRZYBOWSKI M., KRZEMIŃSKA A., LEWANDOWSKI P., SOJKA M. Ecological quality classes of river hydromorphology in Poland. Journal of Water of Land Development, **14**, 15, **2010**.