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**B** – data collection
**C** – statistical analysis
**D** – data interpretation
**E** – manuscript preparation
**F** – literature search

# Assessment and classification of hydromorphological state of the Breń River

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**Abstract**

The paper presents the classification of the hydromorfological condition of the Breń River according to the River Habitat Survey (RHS). The research of the hydromorphological assessment of the Breń River, which is a right-bank tributary of the Vistula River and almost entirely flows through the area of the Dąbrowa Tarnowska district was conducted in June 2015. The research sites were situated on the border of the Tarnów Plateau and the Vistula Lowland. The Breń River in these sections flows through rural areas used for agricultural purposes with low-density housing. The analysis of qualitative parameters describing the morphological characteristics were based on two synthetic indices of stream quality: Habitat Quality Assesment (*HQA*) and Habitat Modification Score (*HMS*).The calculated numerical values of the two indices proved that the sections of the Breń River correspond with the third and fifth class, which means a moderate (III) and very bad (V) hydromorphological condition.

**Key words:** *catchment, hydromorphological condition, River Habitat Survey method, the Breń River*

## INTRODUCTION

The main assumption of the Water Framework Directive (WFD) 2000/60/EC was to achieve by 2015 a good status of all waters, among others by improving the quality of surface waters and ecosystems degraded by human activities [Directive 2000/60/EC]. The announcement of the European Commission, released at the beginning of 2015 on implementation of the Water Framework Directive in the individual Member States contained a disturbing statement about the risks of failure to achieve the environmental objectives [EC 2015]. While waiting for the report on the assessment of the classification of the ecological potential of surface water body, we need to be aware that it was not always possible to realize the assumptions of the WFD, but further effort should be made to achieve this objective in the future (2021, 2027).

To carry out an appropriate classification of the ecological status of surface water bodies and assess their condition, it is necessary, in addition to the direct assessment using biological elements, to perform an assessment of the intermediate elements related to the course of hydrological phenomena (flows) in the stream during the year, or channel morphology and river valley of water body which influence and significantly support the ecological status of rivers. Currently, Poland does not have an appropriate method of hydro-morphological valorization of natural watercourses. Lack of strict regulations in this field creates the possibility of using one of the methods proposed by various specialists who are concerned with this problem and topic. The most popular in terms of hydromorphological assessment of rivers has become Polish methodology for hydromorphological river surveys (MHR), approved by the Chief Inspectorate for Environmental Protection in Warsaw in December


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2009 [ILNICKI *et al*. 2010] or the River Habitat Survey (RHS) method adapted from the UK in the 1990s, which was adjusted to the conditions prevailing in Poland.The ways of assessment suggested in it allow us to characterize the natural morphological elements of the river channel and banks, land form, the structure of vegetation types and elements related to the transformation of anthropogenic activities in the form of regulation structures and hydrotechnical structures. All this translates to the method's high applicability not only in the Polish research on natural and artificial watercourses, but also in other European countries [ADYNKIEWICZ-PIRAGAS 2006; BOREK, STACHURA 2014; FRANKOWSKI 2011; ŁABAJ, HAMERLA 2012; OSOWSKA 2012; SPIECZYŃSKI *et al.* 2013; SZOSZKIEWICZ *et al.* 2012].

The aim of the study was the assessment and classification of the hydromorphological status made on the basis of three sections in different locations on the Breń River.

## MATERIAL AND METHODS

The Breń River as a right-bank tributary of the Vistula River with the length of 52 km and a catchment area of 717 km$^2$, hydrographically is a 2nd class watercourse. The Breń River is situated in the European Watershed and is part of the catchment area of the Baltic Sea (Fig. 1). The river belongs to the basin of the Upper Vistula and the partial catchment "The Vistula from Nida to Wisłoka" (code 217), administered by the Regional Water Management Board in Kraków. It is a typical small river of the Subcarpathian Valley, characterized by variable water resources, with a predominance of spring high water (after the thaw) and of summer high water (after heavy rainfalls), a variable course of hydrological phenomena related to rainfall and snow melting. The source of the river is located on the slightly wavy slopes in the Tarnów Plateau mesoregion (512.43) near the village of Stare Żukowice (the district of Tarnów, the Małopolskie Province), at an altitude about 240.00 m a.s.l. In its upper reaches the river flows northwards and due to the topography takes the form of a meandering stream typical of the uplands. The river flows here through agricultural lands with low-density housing and a few forested areas. On the length of about 6.5 km the water flows through the urban area of Dąbrowa Tarnowska (the district of Dąbrowa Tarnowska, the Małopolskie Province). At the level of the Swarzów village it flows onto an area of plains in the mesoregion of the Vistula lowland (512.41), and around the village of Wola Mędrzechowska the river changes its direction from north to north-east. Considering the landform, the Breń, having taken numerous tributaries here becomes a typical lowland river flowing through agricultural areas with low-density buildings.

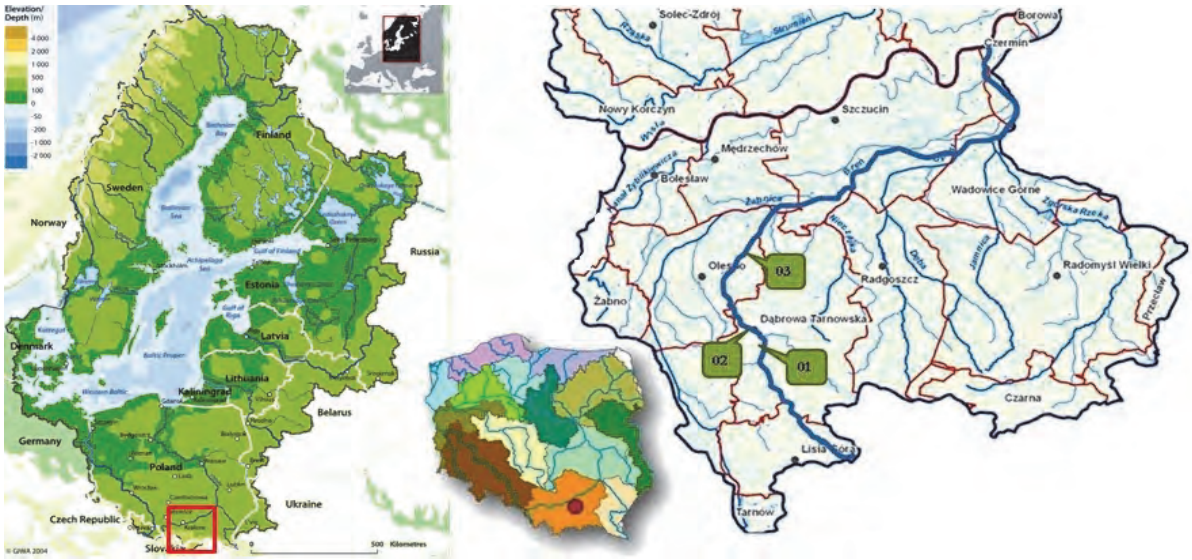


Fig. 1. Location of river catchment and three selections sections on the background of the European Watershead and the Vistula River Basin; source: own elaboration according to Wikipedia [undated] and RZGW Kraków [undated]

The estuary of its recipient, the Vistula River, is located at an altitude of 160.00 m a.s.l., near the village of Otałęż (the Mielec district, the Podkarpackie Province). According to the geographical division by KONDRACKI [2011] both units are included in the macroregion of the Sandomierz Valley (512.4) and the large megaregion which is the Carpathian Region (5). Characteristics of the natural landscape, through which the Breń flows are then related to the geographical location and the geological structure of the specified geographical units. In terms of the typology of surface waters this river upstream belongs to the 17. abiotic type with characteristics of a lowland sandy stream, and downstream it is a lowland sandy-loam type 19 river.

The research of the hydromorphological valorization was carried out in June 2015 in three selected sections of the river flowing through the district of Dąbrowa Tarnowska (Fig. 1). The first of them was located in Żelazówka (01 – Breń–Żelazówka), the second one in the town of Dąbrowa Tarnowska (02 – Breń–Dąbrowa Tarnowska), and the third one was located about 7 km north of the town in the Podborze village (03 – Breń–Podborze). The examined sections belong to the natural surface water body. The assessment was made according to the River Habitat Survey (RHS) method which allows for the collection of a number of parameters defining the hydromorphological conditions of the channel on the length of 500 m, which were assembled in 10 control profiles distant ca. 50 m from each other, and in the synthetic description, which also took into account the elements not registered in the profiles. The hydromorphological properties of the river were determined using the qualitative parameters describing the morphological features and the results were translated into numerical values based on two synthetic indices of watercourse quality:

- Habitat Quality Assessment (*HQA*), which is based on the presence and diversity of natural elements of the watercourse and river valley (for the conditions of Poland taking the values between 15–80),
- Habitat Modification Score (*HMS*), which characterizes the range of transformations in the morphology of the watercourse (in the range of 0–100).

Based on the values of *HQA* and *HMS* the hydromorphological state of the watercourse is determined using a five-grade classification [SZOSZKIEWICZ *et al.* 2012]: I – very good state, II – good state, III – moderate state, IV – poor state, V – bad state.

## RESULTS

### CHARACTERISTICS OF THE RESEARCH SECTION NO. 01 – BREŃ–ŻELAZÓWKA

The predominant substrate of the channel in 7 control profiles was fine gravel (GP), and in the remaining 3 profiles sand (SA) was recorded. In the 10 control profiles smooth (SM) flow type dominated (Phot. 1) – laminar flow, not disturbing the water surface; also upwelling flow type (UP) appeared and at the narrowing of the channel rippled flow type (RP) was observed. There was no channel modification (NO). The right and left banks on a 1-m wide strip are

Phot. 1. Exposed bankside roots. Simple vegetation structure (S). Smooth flow-type (SM) (photo *Ł. Borek*)

Phot. 2. Vegetated mid-channel bar (SU) with sand depo sit (photo *Ł. Borek*)

Phot. 3. Bank modification – reinforced from urban debris (RI) (photo *Ł. Borek*)

Phot. 4. Minor bridge – farm track bridges <10 m wide are recorded as 'minor' (photo *Ł. Borek*)

composed of loose material, predominantly sand (<2.0 mm) (GS). In the field, within 5 m of the banktop semi-continuous scrub and shrubs (SH) were observed, the structure of banktop and bankface vegetation is simple (S) (Phot. 1); there are also ferns and mosses, especially on the branches of trees. No occurrence of water plants the channel was noted. The bank profiles ranged from gentle to steep (>45°). A typical land-use within 50 m of banktop were shrubs (SH), rough unimproved and semi-improved grassland (RP and IG), tall grasses and tilled land (TL). In some cases, the edges of the watercourse approached the buildings and roads (UM). Visible shading of the channel and exposed roots and offshoots on the right and left bank slopes. The natural morphological features of the channel on the 500-m long research section were unvegetated mid-channel bars (MB) and vegetated mid-channel (SU) (Phot. 2), with the active process of debris deposition. Among other morphological features (not related to the flow) observed on that section of the river were marginal deadwater – area of no perceptible flow behind a sand bar and eroding cliffs (Phot. 1). Among the features of special interest observed in the river are the old river bed formed of cut-off meanders (the end of the research section) and the natural tributary of a small stream (next to profile no. 1).

The examined section was characterized by an unobstructed channel; in several places fallen trees still attached to the steep earth bank with their roots were observed.

The anthropogenic transformations observed during field research in the control profiles are mainly bank reinforcements (RI) (Phot. 3). Furthermore, as regards elements registered in the synthetic assessment, we should list the occurrence of small communication structures (Phot. 4). The channel dimensions measured at one location on a straight uniform section of the river showed that the height of the left bank was ca. 1.70 m, and of the right bank ca. 2.20 m. In both cases, the banktop height was not the same as the bankfull height. There were no flood embankments. The bankfull width was about 5.00 m, the water width 3.40 m, and the water depth ca. 0.20 m. The bed material at the site was loose.

## THE CHARACTERISTICS OF THE RESEARCH SECTION NO. 02 – BREŃ–DĄBROWA TARNOWSKA

The material building the bottom of the river bed in research profiles was sand (SA) in places covered with a quite thick layer of silt. In 10 profiles there occurred smooth flow (SM) (Phot. 5) – laminar, not disturbing the water surface, and also upwelling flow-type (UP) (Phot. 7). The river bed and the banks on quite a long stretch of the research section are straight, deepened and profiled (RS) (Phot. 5 and 6). The right and left banks on a 1-meter wide strip are built of loose material, mostly sand (<2.0 mm) (GS) reinforced at the base with a tight wall and on the escarpment with concrete slabs (RI) (Phot. 5, 6 and 8). On the bank escarpments there are scattered tree and shrub clusters (SH) (Phot. 6), the plant structure on the banks tops and escarpment is uniform (U) and simple (S) (Phot. 5). In the river bed no water plants have been identified.

The land on the strips 5 and 50 m from the banks was typically used for town development (SU) (Phot. 6) or covered with shrub clusters (SH) (Phot. 5). There were 2 large bridges (Phot. 7 and 8). In some cases the banks approached the buildings and roads (SU). There was a visible shading of the river bed (Phot. 6). A few outlets of storm drain collectors have been observed (Phot. 8). The bank profile was steep, in some cases anthropogenic transformations could be seen in the form of concrete reinforcement (bridge abutments) (Phot. 7 and 8).

The height of the left and right banks was ca. 3.90 m. In both cases it was identical with the height of the bank water table. There were no embankments. The width of the bank water table was ca. 22.00 m, the width of the water surface 4.00 m, and the depth of water ca. 0.30 m. The subsoil in the examined place was compact. The river bed is unobstructed with only some litter, and the banks get mowed (Phot. 5 and 6).

## THE CHARACTERISTICS OF THE RESEARCH SECTION NO. 03 – BREŃ–PODBORZE

The dominant material building the river bed in 10 research profiles was sand (SA), in places covered with a quite thick layer of silt. In 10 profiles there occurred smooth flow (SM) (Phot. 9), and fast flow (UP) was also noted. The river bed and the banks are straight, deepened and profiled (RS) (Phot. 10). No natural morphological elements have been observed in the river bed or the banks (NV). The right and left banks on the 1-m wide strip are built of clay (CL); at the base of the enscarpment fascine reinforcement (BI) has been noted, protecting the basis of the banks. The plant structure at the bank top and enscarpments is uniform (U) (Phot. 10). On the strips 5 and 50 m from the bank edge a dominant form of land development was tilled land (TL). The occurrence of water plants in the river bed has been observed, mainly emerged broad-leaved plants, submerged broad-leaved plants (Phot. 11), submerged linear-leaved plants and structural algae. The bank profiles are anthropogenically transformed – profiled (RS) and in places reinforced with concrete elements (RI), particularly at the bridge (Phot. 12). Bank modification in the form of embankment at the top (EB). Lack of trees and accompanying elements. The measurements of the river bed made in one representative position have shown that the height of the right and left banks was ca. 3.00 m. In both cases the bank height was not identical with the height of the bank (embankment) water table. The width of the bank water table is ca. 18.00, the width of the water surface 3.00, and the depth of water ca. 0.30 m. The material of the subsoil in the examined place is compact. The river bed is

unobstructed despite abundant greenery on the enscarpments. Visible effects of anthropogenic impact in the form of mowing the enscarpments as well as litter brought by surges from the upper parts of the catchment area. Among the fauna snails and dragonflies occur. Among the plants growing on the banks nettles and knotgrass have been noted, and as regards invasive plants – single specimen of Sosnowsky's hogweed (*Heracleum sosnowskyi*).

Phot. 5. Reprofiled banks profiles (RS). Uniform (U) and simple (S) vegetation structure. Smooth flow-type (SM). Banks mowing (photo *Ł. Borek*)

Phot. 6. Reinforced banks and channel (RI). Urban development (SU) (photo *Ł. Borek*)

Phot. 7. Major bridge with central piers. Upwelling flow-type (UP) (photo *Ł. Borek*)

Phot. 8. Intermediate storm water drainage outlet. Reinforced banks of concrete slabs (RI) (photo *Ł. Borek*)

Phot. 9. Predominant substrate of channel – sand (SA). Smooth flow-type (SM) (photo *Ł. Borek*)

Phot. 10. Uniform bank vegetation structure (U). Resectioned (reprofiled) bank and channel (RS) (photo *Ł. Borek*)

Phot. 11. Submerged broad-leaved and filamentous alga (photo *Ł. Borek*)

Phot. 12. Intermediate bridge without central piers (photo *Ł. Borek*)

The results of the analysis of the hydromorphological condition of the Breń River on three research stretches have been shown in Table 1.

**Table 1.** Classes of hydromorfological condition of the Breń River on the basis of the method River Habitat Survey and indicators Habitat Quality Assessment (*HQA*) and Habitat Modification Score (*HMS*)

| Name of research section | *HQA* | *HMS* | Class |
|---|---|---|---|
| 01 – Breń–Żelazówka | 45 medium natural | 9 medium modified | III – moderate |
| 02 – Breń–Dąbrowa Tarnowska | 20 little natural | 30 significantly modified | V – very bad |
| 03 – Breń–Podborze | 10 little natural | 32 significantly modified | V – very bad |

Source: own elaboration based on SZOSZKIEWICZ *et al.* [2012].

## CONCLUSIONS

As part of the research conducted, three stretches of the Breń River have been evaluated, each 500-m long, in the Tarnów Plateau and the Vistula Valley. In those stretches the Breń flows through rural areas used for agricultural purposes, with scattered building development and through the compact settlement of the town of Dąbrowa Tarnowska. As regards the flows and width the Breń is a shallow watercourse, and gradient-wise it is a small lowland river (0.5–2.0‰). In its longitudinal profile we can distinguish the upper course (the area of the Tarnów Plateau), the middle course and the lower course (the area of the Vistula Valley). The landform in its upper and middle course is typical of a flat-bottomed valley with gentle slopes and river terraces, and in its lower course there is a valley with invisible slopes. The cross-sections of the river bed on the curve tops (its upper and middle course) have a shape similar to asymmetrical triangles of steep inclination with a concave bank, whereas between the curves (on the current passes) the river bed has a symmetrical, almost parabolic shape. In its lower course the river bed shape resembles a trapezium. In the upper stretch the river has a winding course with many meanders. The banks are exposed to erosive effects of the flowing water, particularly with high water levels and fast flow. In the case of concave banks the largest speed and depth of the water is observed. The eroded material carried downstream is composed mainly of sand and small gravel.

On the basis of the research the following conclusions were drawn:

1. The Breń River is a natural watercourse. In its upper course it is characterized by little anthropogenic impact and by moderate diversity of conditions and morphological forms. Its lower course has been significantly transformed and modified as a result of regulation, both as regards the river bed and the banks, which affects the hydromorphological conditions in the valley and the river bed (Tab. 1).

2. As regards the presence of natural hydromorphological elements the river characterized by medium (*HQA* = 45) and a little naturalness (*HQA* = 20 and 10). The largest impact on the values of the *HQA* index was caused by the following categories of parameters: the flow type, the material on the bottom of the river bed, natural morphological elements of the banks, trees and other valuable elements of the river environment.

3. In the case of the anthropogenic modification of the watercourse, a considerable impact on the value of the habitat modification score (*HMS*) was caused by such engineering buildings structures in the watercourse and reinforcing the banks with building waste. On the basis of the values of the *HMS* index the condition of the Breń River appears to be medium modified (*HMS* = 9) and significantly modified (*HMS* = 32 and 30).

4. The hydromorphological condition of the examined stretches of the Breń River determined on the basis of the *HQA* and *HMS* indices and the criteria used in the RHS method is moderate (3$^{rd}$ class) and bad (5$^{th}$ class).

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**Łukasz BOREK**

**Ocena i klasyfikacja stanu hydromorfologicznego rzeki Breń**

STRESZCZENIE

W artykule przedstawiono klasyfikację stanu hydromorfologicznego rzeki Breń z wykorzystaniem metody River Habitat Survey (RHS). Badania oceny hydromorfologicznej rzeki, będącej prawobrzeżnym dopływem rzeki Wisły i niemal w całości przepływającej przez obszar powiatu dąbrowskiego (województwo małopolskie), przeprowadzono w czerwcu 2015 r. Pomiary wykonywano na Płaskowyżu Tarnowskim i Nizinie Nadwiślańskiej. Rzeka Breń na tych odcinkach przepływa przez tereny użytkowane rolniczo z rozproszoną i zwartą zabudową. Analizy parametrów jakościowych opisujących cechy morfologiczne bazowały na dwóch syntetycznych wskaźnikach jakości cieku dotyczących naturalności siedliska (*HQA*) oraz przekształcenia siedliska (*HMS*). Uzyskane wyniki liczbowe dwóch wskaźników pozwalają zakwalifikować badane odcinki rzeki Breń do III i V klasy, co oznacza odpowiednio umiarkowany i zły stan hydromorfologiczny.

**Słowa kluczowe:** *metoda River Habitat Survey, stan hydromorfologiczny, rzeka Breń, zlewnia*