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# Changes in Ecological State and Quality of Rów Wyskoć Waters

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## 1. Introduction

Small watercourses in agricultural landscape are less studied natural ecosystems, although they play significant role in environment. Small water basins and watercourses can be used as retention systems, have economic functions, elevate esthetic value of the landscape and provide habitats for a number of plants and animals. They are part of ecological islands and corridors connecting areas of particular natural importance and stimulate diversity of species (Dudzińska et al. 2016). The river Rów Wyskoć is localized in Wielkopolskie voivodeship and the study sites were selected inside the General Dezydery Chłapowski Landscape Park. The river collects water from smaller watercourses and from the surrounding arable lands and meadows with different intensity of use. The Landscape Park was established in 1992 in order to protect the rural landscape with the characteristic infield afforestations introduced in the $19^{th}$ century by Chłapowski (Uglis et al. 2012). The catchment area of Rów Wyskoć watercourse, similarly as the entire Wielkopolska region, is characterized by low precipitation and water deficits (Kozaczyk et al. 2016). Such a watercourses are very important in water management and freshwater protection, agricultural retention, including the soil and landscape retentions. Increase of the soil retention in the microcatchment of Rów Wyskoć by only 1% would reduce the annual outflow from this microcatchment by 4%, which would make 8.9% of the outflow in the vegetation period (April-September) (Jankowiak et al. 2011).

Analysis of the ecological status of surface waters, including watercourses, apart from other factors, takes into account biological indices based on different tolerance of organisms to environmental variables such as water trophy, pH reaction, salinity, rate of flow and others. A number of indices characterizing the ecological status and trophy of flowing waters is based on the condition of macrophytes. In Poland, starting from 2008 the Macrophyte River Index (Makrofitowy Indeks Rzeczny in Polish, MIR) designed at the Department of Ecology and Environmental Protection in Poznań University of Life Sciences, has been in force and this index was used in our study (Directive of the Minister of Environment 2008, Szoszkiewicz et al. 2010).

## 2. Aim and methods of the study

Studies were undertaken to establish the direction of changes in the ecological state and trophy of Rów Wyskoć on the basis of biological indices and selected parameters describing water quality.

The field study needed for determination of the macrophyte indices were carried out in June and July 2017. The indices determined included the Macrophyte River Index (MIR) used in Poland for evaluation of ecological status (Szoszkiewicz et al. 2010) and Mean Trophic Rank (MTR) used in Great Britain and other countries (Poland, Ireland) for evaluation of trophy of flowing waters (Dawson et al. 1999, Holmes et al. 1999, Szoszkiewicz et al. 2002, Staniszewski et al. 2006, Staniszewski, Jusik 2013). In the field studies carried out along the section of 100 m at each study site, the coverage with particular taxa of vascular plants, ferns and macroscopic algae. Only the plants that have contact with water for over 90% of their vegetation period were taken into account. Each species was assigned with a specific degree of coverage. The MIR and MTR indices were calculated according to accepted procedures (Dawson 1999, Szoszkiewicz 2010):

Macrophyte River Index

$$MIR = \frac{\sum_{i=1}^{N}(L_i \cdot W_i \cdot P_i)}{\sum_{i=1}^{N}(W_i \cdot P_i)} \cdot 10$$

where:
N – the number of species,
Li –index number for a given species,
Wi – weigh coefficient of a given species,
Pi – coverage coefficient.

Mean Trophic Rank

$$MTR = \frac{\sum_{i=1}^{N}(STR_i \cdot SCV_i)}{\sum_{i=1}^{N} SCV_i} \cdot 10$$

where:
$STR_i$ – the trophic index for a given species
(from 1 – hypertrophy to 10 – oligotrophy),
$SCV_i$ – coverage coefficient.

Obtained results were compared with earlier studies, which were carried out in Wyskoć channel (Szoszkiewicz et al. 2006, Gołdyn et al. 2009).

In the sites covered with compact patches of water vegetation of areas greater than 10 $m^2$, the phytosociological releves were taken and the macro-phyte associations were identified (Braun-Blanquet 1928). The trophy of flowing water was evaluated on the basis of concentrations of total phosphorus, dissolved phosphates and nitrate nitrogen, using the Chemical Index of Trophy (CIT) (Staniszewski 2001, Staniszewski et al. 2019).

The catchment area of the Rów Wyskoć river was determined on the basis of the Raster Map of Hydrographic Divisions in Poland (the abbreviation in Polish MPHP) in the scale 1:50000 (2010) supplied by the National Water Management Authority (KZGW). The physiographic characteristics of the catchment was made on the basis of topographic maps in the scale of 1:10000 and the Digital Model of the Land (NMT) offered by Main Centre of Geodetic and Cartographic Documentation (CODGiK) The structure of the catchment area use was described on the basis of the Corine Land Cover Project realized by the General Inspectorate of Environmental Protection (GIOŚ).

The physico-chemical state of water was characterized on the basis of a set of data including 8 parameters describing water quality: dissolved oxygen ($O_2$), BOD5, conductivity at 20°C ($\mu S\ cm^{-1}$), pH reaction, ammonium nitrogen ($N\text{-}NH_4$), nitrate nitrogen ($N\text{-}NO_3$), nitrite nitrogen ($N\text{-}NO_2$) and soluble reactive phosphates ($PO_4$).

The classes of surface water quality were assumed according to the Act of Law in the Journal of Laws of August 5$^{th}$ 2016 on the classification of the state of uniform areas of surface waters and environmental norms of quality for priority substances. The sites of studies were three control sites in villages Racot (1), Wyskoć (2) and Rogaczewo (3) (Fig. 1).

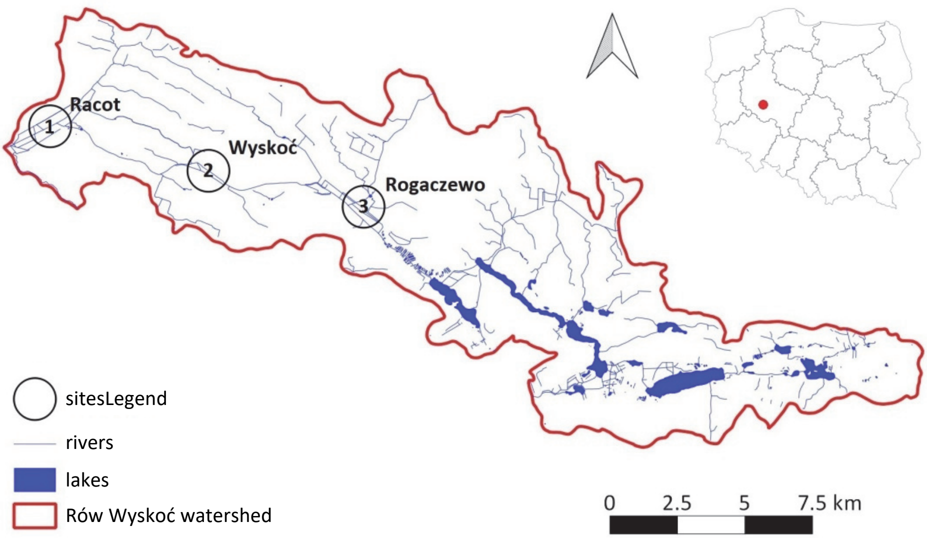


**Fig. 1.** Rów Wyskoć watercourse with marked sites of study

## 3. Characteristics of the study area

The catchment area of Rów Wyskoć spreads at 40 km south of Poznań, to the east of Kościan. It has typical lowland features and belongs to the mesoregion of Równina Kościańska (Kościan Plaine). The area in this part of Rów Wyskoć is under intensive agricultural use, where arable land occupies about 70% of the area, meadows and pastures about 10.5%, forests cover 15.5% (Kędziora et al. 1989).

Rów Wyskoć is the right tributary of the Kościan Channel of the Obra river, its length is 36.6 km and it joins this Channel at the 8$^{th}$ kilometer. The total area of Rów Wyskoć catchment is 174.3 km$^2$. Because of a considerable diversity of the landscape, agricultural use and geomorphology of the area, the catchment can be divided into two parts: region Turew and region Dolsk. The border between them was assumed to be the road connecting the villages Wyrzeka and Jerka. Region Turew (western part) is the area occupied mainly by arable land and has no water basins. This region is entirely within the Kościan Plaine and the area of this part of the catchment is 10 135 ha. Taking into account the administrative division, the whole catchment of Rów Wyskoć belongs to 6 communes. The area that was studied in detail is located within the Kościan commune (Fig. 2).

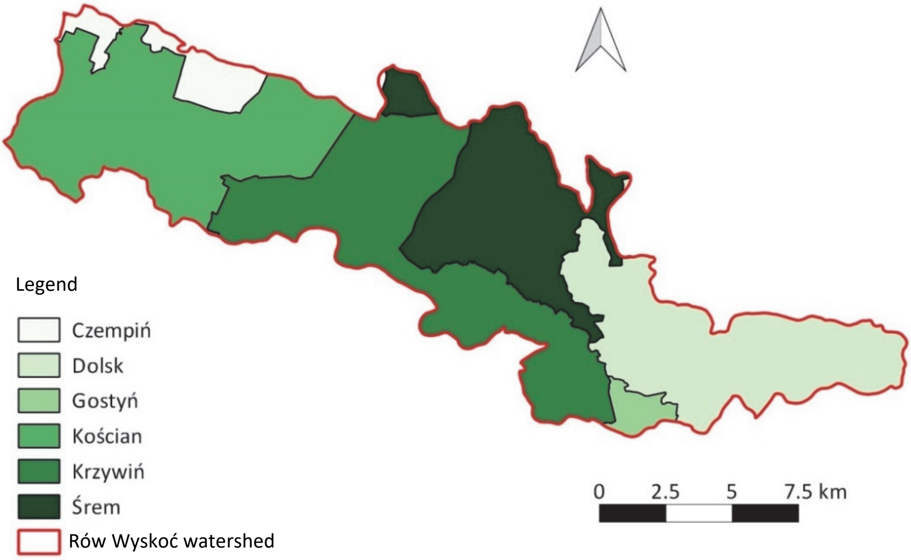


**Fig. 2.** Rów Wyskoć basin on the background of the administrative division

The structure of land use over the analyzed part of Rów Wyskoć catchment area is similar and arable land covered 74% of the area, while forests 14.1% (Fig. 3).

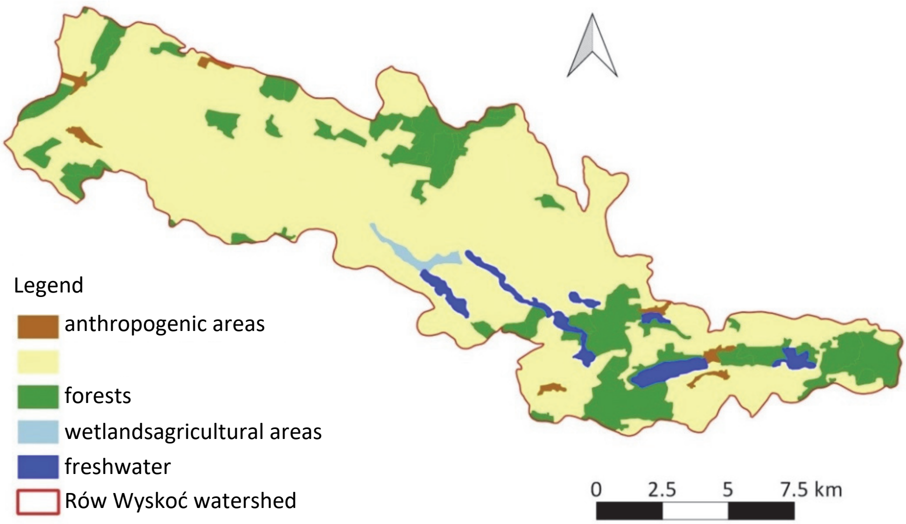


**Fig. 3.** Structure of land use in the Rów Wyskoć watershed

Ecological status of surface waters, including watercourses, was evaluated using a number indices, among others biological ones based on different tolerance of living organisms to different environmental factors such as water trophy, pH reaction, salinity, rate of water flow and others. The presence of aquatic plants (macrophytes) is the basis for biological indices characterizing the ecological state of watercourses.

## 4. Results of the study

The three 100 m long sections of Rów Wyskoć were built of sandy sediments with a certain contribution of the organic fraction (abiotic type 17 – lowland sandy stream) and in the period of study the character of flow in the Rów Wyskoć was observed.

In the year 2017 the level of trophy and ecological state at the three surveyed sites were similar (Table 1-5). The macrophyte indices were diversified however, at site 1 in Racot the trophy was higher and the ecological status was lower than at the other two sites. Moreover, at this site patches of *Urtica dioica* were noted, which suggests existinf of point source of nitrogen (Table 2). At site 1, the structure of water vegetation was studied also in 2003 (Szoszkiewicz et al. 2010) and a similar results were obtained. For site 2 it was possible to compare results with the data collected at four other seasons (Table 3) and each time the results corresponded to a good ecological status, despite the value of MIR decreasing from 42.7 in 1976 to 36.7 in 2017. At site 3 Rogaczewo, an improvement in the ecological status was noted in comparison with the data from 2003 and 2007, up to a good state, however macrophyte index was poorer than in 1976 (Table 3). In 2017, the MIR values recorded at allstudied sites were similar, which was not only a consequence of comparable species composition of water plants but also similar contributions of particular taxa in the total cover. At sites 1, 2 and 3 the number of indicatory taxons identified was 25, 26 and 28, respectively, at a similar total coverage at sites 2 and 3. At site 1 the cover with *Lemna minor* was greater, (cover coefficient $P = 7$), which at the indicative value $L = 2$ gave a lower value of MIR. Trophic conditions of Rów Wyskoć water evaluated in 2017 by the Mean Trophic Rank was similar at the three sites and showed increase of water trophy (Table 4).

In the group of plants mentioned in Table 2, that do not have indicatory MIR values, the majority represented species commonly seen in lowlands near watercourses or ponds, such as *Phragmites australis, Lycopus europaeus, Carex pseudocyperus, Malachium aquaticum* (Kłosowski S, Kłosowski G. 2001, Rutkowski 2006). For instance, reed is found in oligotrophic as well as eutrophic waters so it is difficult to assign to it an indicatory value.

**Table 1.** List of taxa present in studied sites of Rów Wyskoć channel in the year 2017 with cover (*P*), indication value (*L*) and weight coefficient (*W*)

| | 1 | 2 | 3 | L | W |
|---|---|---|---|---|---|
| | P | | | | |
| Algae | | | | | |
| *Cladophora sp.* | 5 | 1 | | 1 | 1 |
| *Chara sp.* | | | 1 | 6 | 2 |
| Pteridophytes | | | | | |
| *Equisetum fluviatile* | | 1 | | 6 | 2 |
| Dicotyledons | | | | | |
| *Berula erecta* | 4 | 3 | 4 | 4 | 2 |
| *Callitriche cophocarpa* | 2 | 1 | | 5 | 2 |
| *Ceratophyllum demersum* | | 3 | 2 | 2 | 3 |
| *Ceratophyllum submersum* | | 1 | 2 | 2 | 3 |
| *Hydrocotyle vulgaris* | 1 | | 2 | 5 | 1 |
| *Lysimachia vulgaris* | 1 | | 1 | 4 | 1 |
| *Mentha aquatica* | 1 | 1 | 1 | 5 | 1 |
| *Myosotis palustris* | 2 | 1 | 1 | 4 | 1 |
| *Nuphar lutea* | | | 1 | 4 | 2 |
| *Polygonum amphibium* | 2 | 1 | 1 | 4 | 1 |
| *Ranunculus circinatus* | 1 | | | 5 | 2 |
| *Rorippa amphibia* | | 1 | 1 | 3 | 1 |
| *Rumex hydrolapathum* | 1 | 1 | 1 | 4 | 1 |
| *Sium latifolium* | 1 | 1 | 1 | 7 | 1 |
| *Veronica anagalis-aquatica* | | 1 | | 4 | 2 |
| Monocotyledons | | | | | |
| *Acorus calamus* | 1 | | 1 | 2 | 3 |
| *Alisma plantago-aquatica* | 3 | 2 | 1 | 4 | 2 |
| *Butomus umbelatus* | 1 | 1 | | 5 | 2 |
| *Carex acutiformis* | 1 | 1 | 1 | 4 | 1 |
| *Carex riparia* | 3 | | 2 | 4 | 2 |
| *Elodea canadensis* | 3 | 1 | 1 | 5 | 2 |
| *Glyceria fluitans* | | | 1 | 5 | 2 |
| *Glyceria maxima* | 4 | 1 | 5 | 3 | 1 |

**Table 1.** cont.

| | 1 | 2 | 3 | L | W |
|---|---|---|---|---|---|
| | P | | | | |
| Monocotyledons | | | | | |
| *Glyceria plicata* | | 1 | | 5 | 1 |
| *Hydrocharis morsus-ranae* | 1 | | 1 | 6 | 2 |
| *Iris pseudoacorus* | 1 | 2 | 1 | 6 | 2 |
| *Lemna minor* | 7 | 3 | | 2 | 2 |
| *Lemna trisulca* | | | 3 | 4 | 2 |
| *Phalaris arundinacea* | 5 | | | 2 | 1 |
| *Potamogeton crispus* | | 3 | | 4 | 2 |
| *Potamogeton natans* | | 1 | 1 | 4 | 1 |
| *Sagittaria sagittifolia* | | 1 | 1 | 4 | 2 |
| *Sparganium emersum* | 2 | 3 | 3 | 4 | 2 |
| *Sparganium erectum* | 2 | 6 | 1 | 3 | 1 |
| *Typha latifolia* | 2 | | 4 | 2 | 2 |

**Table 2.** List of identified taxa without MIR indication value

| Site | Taxa identified also in years 1976-2007 | Other species |
|---|---|---|
| 1 Racot | No data | *Agrostis stolonifera, Eupatorium cannabinum, Lycopus europaeus, Lysimachia nummularia, Malachium aquaticum, Phragmites australis* |
| 2 Wyskoć | *Bidens frondosa, Lycopus europaeus* | – |
| 3 Rogaczewo | *Agrostis stolonifera, Bidens frondosa, Calystegia sepum, Carex pseudocyperus, Lysimachia nummularia, Phragmites australis* | *Urtica dioica* |

**Table 3.** Ecological status of study sites at Rów Wyskoć in the year 2017 on the background of earlier studies (years 1976 and 2007: Gołdyn et al. 2009; year 2003: Szoszkiewicz et al. 2006)

| Site | Macrophyte River Index | | | | Ecological status | | | |
|---|---|---|---|---|---|---|---|---|
| | 1976 | 2003 | 2007 | 2017 | 1976 | 2003 | 2007 | 2017 |
| 1 Racot | - | 33.4 | - | 34.8 | - | moderate | - | moderate |
| 2 Wyskoć | 42.7 | 40.3 | 38.0 | 36.7 | good | good | good | good |
| 3 Rogaczewo | 44.1 | 32.2 | 32.3 | 36.1 | good | moderate | moderate | good |

**Table 4.** Values of MTR index, ecological status and water trophy at the study sites on Rów Wyskoć in the year 2017

| Site | Mean Trophic Rank (MTR) | Ecological status | Trophic status |
|---|---|---|---|
| 1 Racot | 34.8 | moderate | eutrophy |
| 2 Wyskoć | 36.7 | good | eutrophy |
| 3 Rogaczewo | 36.1 | good | eutrophy |

**Table 5.** Concentrations of soluble reactive phosphates, total phosphorus and nitrates in surveyed sites of Rów Wyskoć in June 2017 and trophic status according to Chemical Index of trophy (CIT)

| Site | Soluble reactive phosphates mg $PO_4$ $dm^{-3}$ | Total phosphorus mg P $dm^{-3}$ | Nitrate nitrogen mg N-$NO_3$ $dm^{-3}$ | Trophic status CIT |
|---|---|---|---|---|
| 1 Racot | 0.87 | 0.39 | 0.80 | Meso-eutrophy |
| 2 Wyskoć | 1.17 | 0.43 | 0.00 | Meso-eutrophy |
| 3 Rogaczewo | 0.40 | 0.29 | 1.20 | Eutrophy |

On the basis of the data from three vegetation seasons for sites 2 and 3, it is possible to draw conclusions on some tendencies of changes in the macrophyte species composition. At site 2, the number of indicatory taxa increased from 9 in 1976, to 21 in 2007 and 26 in 2017, while at site 3 the analogous numbers were

26, 17 and 28 taxa. At site 3, in the year 2017 following species were not observed: *Hippurus vulgaris* (prefers water rich in calcium), *Ranunculus circinatus* (eutrophic water, sand-silt substrate) and *Eleocharis palustris* (eutrophic water, sandy substrate). The absence of these species may indicate increased shadowing of the sites and changes in the character of the river sediments. At site 2 in 2017, lackof *Lemna trisulca* was observed (although it is common in the entire country), whereas the appearance of *Ceratophyllum submersum* (scattered sites in Poland), *Polygonum amphibium* (sandy substrate, common in Poland) and *Potamogeton crispus* (eutrophic water, common species) was noted. At the three studied sites of Rów Wyskoć, five associations of water vegetation were identified, four from the class of *Phragimitetea* (*Glycerietum maximae*, *Phalaridetum arundinaceae, Sparganietum erecti, Typhetum latifoliae)* and one from the class of *Lemnetea* (*Lemno-Spirodeletum*).

The syngenetic units of water plants identified in the field studies:

<u>Site 1 (Racot)</u>

*Phragmitetea* (Tx. et Preisg. 1942)
*Phragmitetalia* (Koch 1926)
*Phragmition* (Koch 1926)
*Glycerietum maximae* (Nowiński 1928; Hueck 1931)
*Magnocaricetalia* (Pign. 1953)
*Magnocaricion* (Koch 1926)
*Phalaridetum arundinaceae* (Libb. 1931)
*Lemnetea* (Koch et Tx 1954)
*Lemnetalia (Koch et Tx. 1954)*
*Lemnion minoris* (Koch et Tx. 1954)
*Lemno-Spirodeletum* (Koch 1954)

<u>Site 2 (Wyskoć)</u>

*Phragmitetea* (Tx. et Preisg. 1942)
*Phragmitetalia* (Koch 1926)
*Phragmition* (Koch 1926)
*Sparganietum erecti* (Roll 1938)

<u>Site 3 (Rogaczewo)</u>

*Phragmitetea* (Tx. et Preisg. 1942)
*Phragmitetalia* (Koch 1926)
*Phragmition* (Koch 1926)
*Glycerietum maximae* (Nowiński 1928; Hueck 1931)
*Typhetum latifoliae* (Soó 1927).

The association of *Glycerietum maximae* is typical of eutrophic habitats and shows diverse composition of species (Podbielkowski and Tomaszewicz 1996). It is supposed to play a considerable role in overgrowing of lakes and old river beds. At sites 1 and 3 this association is accompanied with *Lemna minor* (1) and *Lemna trisulca* (3).

The association of *Phalaridetum arundinaceae* forms compact phytocenoses, characteristic of eutrophic waters (Podbielkowski and Tomaszewicz 1996). *Phalaris arundinaceae* can be used as a plant species protecting the banks of rivers and ditches against erosion by strengthening them with root system (Pawłat and Nazaruk 1991). In fast flowing waters, it can substitute reeds. Some patches observed at site 1 included the contributions of duckweed, reed sweet-grass and common frogbit.

The association of *Sparganietum erecti* forms the rush-bed of diverse species composition (Podbielkowski and Tomaszewicz 1996). It has anthropogenic character and can develop at sites exposed by macrophyte cutting (Matuszkiewicz 1981). This association occurs at site 2 (Wyskoć) with a contribution of *Sparganium emersum*.

The association of *Typhetum latifoliae* usually occupies eutrophic sites on organic or organic-mineral substrate. It often forms floristically rich communities of distinct bilayer structure, but at site 3 (Rogaczewo) the species composition was reduced to *Typha latifolia* with a small contribution of duckweed. This association is characteristic for mesotrophic and eutrophic habitats and plays a significant role in detrophication of waters (Rodwell 1995, Podbielkowski and Tomaszewicz 1996).

The association of *Lemno-Spirodeletum* occurs mainly in eutrophic and mesotrophic waters (Podbielkowski and Tomaszewicz 1996). In the studied sites the association covered small areas at site 1, accompanied with *Cladophora* sp. and lesser water-parsnip. The presence of *Cladophora* is a good indicator of eutrophication of surface waters and often correlated with the inflow of phosphates from anthropogenic sources (Parker and Maberly 2000).

Analysis of the physico-chemical state of Rów Wyskoć waters in the vegetation period of 2017 proved, that water was highly oxygenated only at the beginning of the vegetation season (10.6 mg $O_2 \cdot dm^{-3}$). The mean value of dissolved oxygen in the vegetation season 2017 was 6.6 mg $O_2 \cdot dm^{-3}$, which implies that the water quality was below good state. The pH value varied from 8.43 to 8.78, which also classified the water quality below good state. The level of loading with organic pollutants, whose presence contributed to the use of oxygen in the process of self-cleaning, was at a medium level. The value of BOD5 varied from 1.26 to 6.48 mg $O_2 \cdot dm^{-3}$ (the mean value was 3.34 mg $O_2 \cdot dm^{-3}$). The water conductivity varied from 655 to 792, with the mean value of 722 $\mu S \cdot cm^{-1}$. Also these two indicators caused that the water quality was below good state.

According to the level of biogenic substances, the water quality was also classified as below good. The content of phosphates varied from 0.05 to 0.26 mg $PO_4 \cdot dm^{-3}$ at the mean of 0.17 mg $PO_4 \cdot dm^{-3}$. The contents of nitrate nitrogen and nitrite nitrogen were 2.46 mg $\cdot$ $dm^{-3}$ and 0.07 mg $\cdot$ $dm^{-3}$ respectively.

## 5. Summary

Development of agriculture, in particular increased use of chemicals for different purposes, significantly contributed to the elevated level of mineral components in the water discharge from the fields. The consequence was excessive trophy of surface waters accelerating eutrophication. The main sources of pollution were intensification of agricultural production (including excessive fertilization with mineral and organic substances) in the drained areas with increasing amount of households, farmhouses and industrial wastes. Nitrogen compounds occurring in surface water can be of organic or inorganic origin. Almost each chemical form of nitrogen stimulates the process of eutrophication and leads to elevation of biological productivity of waters. The eutrophication of surface waters depends on high concentration of organic and inorganic phosphorus compounds, both soluble and insoluble in water. They originate mainly from the municipal sewage, waters from agriculture (fertilizers, pesticides) and soil erosion caused by landscape changes.

Analysis of the data from monitoring of river water permits evaluation of effectiveness of measures taken to restrict the inflow of pollutants from point and non-point sources of pollution. Results of such a monitoring also support rational management of water resources (Shrestha and Kazama 2007). Evaluation of changes in the ecological state of Rów Wyskoć waters performed on the basis of historical data and confronted with presented studies has shown, that despite a continuous decrease in the macrophyte indices (Table 3), the water at the three study sites was characterized by good or moderate ecological state. At site 1 in Racot, the trophy was the highest and the ecological state the lowest from among the three sites studied. At site 3 in 2017, the ecological state was still good although the values of macrophyte indices were lower than in 1976 (Table 3). The trophy of Rów Wyskoć water in 2017 determined by the MTR method corresponded to eutrophied waters.

Obtained results showed an increase of the number of taxa in comparison to the historical data however, particular species were no longer present. For instance, at site 3 in 2017, lack of *Hippurus vulgaris* (indicator of Ca level in water), *Ranunculus circinatus* (sand-muddy substrate) and *Eleocharis palustris* (sandy substrate) were found. Their absence can indicate increase of shadowing of the site, modification of water chemistry and changes in the physicochemical character of the river sediments. Certain changes in the species composition do not depend directly on the changes in water quality indicators, e.g. at site 2 in a commonly occurring plant *Lemna trisulca* was not found, but other species appeared, like *Ceratophyllum submersum,* which occupies scattered sites all over the country. Actual studies showed, that especially shadowing can play crucial role in limitation of the presence of aquatic taxa (Jusik and Staniszewski 2019).

At the study sites on Rów Wyskoć five associations of water plants were identified, including four from the class of *Phragimitetea* and one from the class of *Lemnetea*. These associations are characteristic of eutrophic waters, often have anthropogenic character and occur near the sites or areas that are the sources of pollutants (Rodwell 1995).

## 6. Conclusions

1. On the basis of values of macrophyte indices it can be concluded that the ecological state of water at the sites in Wyskoć and Rogaczewo was good, while the water at the site Racot was of moderate ecological state.
2. Analysis of macrophyte indices determined at the three sites of study indicated equalization of the ecological state and level of trophy in the water of Rów Wyskoć watercourse.
3. Analysis of physicochemical data characterizing the Rów Wyskoć water in the vegetation season of 2017 showed that the water quality was below good state.

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## Abstract

Studies were were undertaken to evaluate the direction of changes in the ecological state and trophy of Rów Wyskoć on the basis of biological indices and selected indices describing the water quality parameters. The field study needed for determination of the macrophyte indices were carried out in June and July 2017. The indices used in paper were the Macrophyte River Index (MIR) used in Poland for evaluation of ecological status and Mean Trophic Rank (MTR) used in Great Britain and other countries (Poland, Ireland) for evaluation of trophy of flowing waters. In the field studies carried out along the section of 100 m at each study site, the coverage with particular taxa of vascular plants, ferns and macroscopic algae. Only the plants that have contact with water for over 90% of their vegetation period were taken into account. Each species was assigned with a specific degree of coverage.

In the sites covered with compact patches of water vegetation of areas greater than 10 $m^2$, the phytosociological releves were taken and the macrophyte associations were identified. The sites of studies were three control sites in villages Racot (1), Wyskoć (2) and Rogaczewo (3). The trophy of flowing water was evaluated on the basis of concentrations of total phosphorus, dissolved phosphates and nitrate nitrogen, using the Chemical Index of Trophy (CIT)

The catchment area of the Rów Wyskoć watercourse was determined on the basis of the Raster Map of Hydrographic Divisions in Poland (the abbreviation in Polish MPHP) in the scale 1:50000 (2010) supplied by the National Water Management Authority (KZGW). The physiographic characterization of the catchment was made on the basis of topographic maps in the scale of 1:10000 and the Digital Model of the Land (NMT) offered by Main Centre of Geodetic and Cartographic Documentation (CODGiK) The structure of the catchment area use was described on the basis of the Corine Land Cover Project realized by the General Inspectorate of Environmental Protection (GIOŚ).

The physicochemical state of water was characterized on the basis of a set of data comprising 8 parameters describing water quality: dissolved oxygen ($O_2$), BOD5, conductivity at 20°C ($\mu S \cdot cm^{-1}$), pH, ammonium nitrogen (N-$NH_4$), nitrate nitrogen (N-$NO_3$), nitrite nitrogen (N-$NO_2$) and phosphates ($PO_4$). The classes of surface water quality were assumed according to the Act of Law in the Journal of Laws of August $5^{th}$ 2016 on the classification of the state of uniform areas of surface waters and environmental norms of quality for priority substances.

On the basis of values of macrophyte indices it can be concluded that the ecological state of water at the sites in Wyskoć and Rogaczewo was good, while the water at the site Racot was of moderate ecological state.

Analysis of macrophyte indices determined at selected sites of study indicated similarity of the ecological state and level of trophy in the water of Rów Wyskoć. Analysis of physicochemical data characterizing the Rów Wyskoć water in the vegetation season of 2017 showed that the water quality was below the good state.

**Keywords:**
water quality, biological indicators, macrophytes

## Zmiany stanu ekologicznego i jakości wód Rowu Wyskoć

### Streszczenie

Celem pracy było określenie kierunku zmian stanu ekologicznego oraz trofii Rowu Wyskoć. Wykorzystano również wskaźniki biologiczne oraz wyniki analiz wybranych wskaźników jakości wody. Prace terenowe niezbędne do określenia wartości wskaźników makrofitowych przeprowadzono w czerwcu i lipcu 2017 roku. Wykorzystano wskaźnik MIR (Makrofitowy Indeks Rzeczny) używany w Polsce do oceny stanu ekologicznego oraz MTR (Mean Trophic Rank) wykorzystywany w Wielkiej Brytanii i w innych krajach (Polska, Irlandia) w ocenie trofii wód płynących. Podczas prac terenowych prowadzonych na odcinku 100 metrów na każdym stanowisku, odnotowano pokrycie poszczególnych taksonów roślin naczyniowych, paprotników i glonów makroskopowych. Uwzględniono tylko rośliny mające kontakt z wodą przez ponad 90% okresu wegetacji. Każdemu gatunkowi przypisano stopień pokrycia powierzchni cieku. W miejscach, gdzie występowały zwarte płaty roślinności wodnej o powierzchni ponad 10 $m^2$ wykonano zdjęcia fitosocjologiczne i wyznaczono zespoły roślinne tworzone przez makrofity. Wybrano trzy punkty kontrolne, które znajdowały się w miejscowościach Racot (1), Wyskoć (2) i Rogaczewo (3).

Trofię wód płynących określono na podstawie stężeń fosforu ogólnego, fosforanów rozpuszczonych oraz azotu azotanowego z wykorzystaniem Chemicznego Indeksu Trofii CIT.

Zlewnię Rowu Wyskoć wyznaczono na podstawie Rastrowej Mapy Podziału Hydrograficznego Polski (MPHP) w skali 1:50000 (2010) udostępnionej przez Krajowy Zarząd Gospodarki Wodnej (KZGW). Charakterystykę fizjograficzną zlewni określono na podstawie map topograficznych w skali 1:10000 oraz Numerycznego Modelu Terenu (NMT) udostępnionego przez Centralny Ośrodek Dokumentacji Geodezyjnej i Kartograficznej (CODGiK). Strukturę użytkowania zlewni określono na podstawie projektu Corine Land Cover Głównego Inspektoratu Ochrony Środowiska (GIOŚ).

Stan fizykochemiczny wód scharakteryzowano na podstawie zbioru danych, który obejmował 8 parametrów jakości wody: tlen rozpuszczony ($O_2$), $BZT_5$, przewodność w 20°C ($\mu S \cdot cm^{-1}$), odczyn (pH), azot amonowy ($N\text{-}NH_4$), azot azotanowy (N-

$NO_3$), azot azotynowy (N-$NO_2$) oraz fosforany ($PO_4$). Klasy jakości wód powierzchniowych przyjęto zgodnie z Dziennikiem Ustaw z dnia 5 sierpnia 2016 roku w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych.

Na podstawie wskaźników makrofitowych można stwierdzić, że odcinki zlokalizowane w miejscowościach Wyskoć i Rogaczewo mieściły się w dobrym stanie ekologicznym, jedynie odcinek w Racocie wykazywał umiarkowany stan ekologiczny. Wyniki uzyskane przy wykorzystaniu metod makrofitowych wskazują na postępujące wyrównywanie się stanu ekologicznego oraz poziomu trofii pomiędzy badanymi stanowiskami. Analiza stanu fizykochemicznego wód Rowu Wyskoć w okresie wegetacyjnym 2017 roku wykazała, że wszystkie analizowane wskaźniki klasyfikowały wodę tego cieku poniżej stanu dobrego.

**Słowa kluczowe:**
jakość wód, wskaźniki biologiczne, makrofity