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TENDENCIES IN THE DEVELOPMENT OF HYDROMACROPHYTES AFTER THE COMPLETION OF REGULATORY AND MAINTENANCE WORKS IN A RIVER BED

TENDENCJE W ROZWOJU NACZYNIOWYCH ROŚLIN WODNYCH PO WYKONANIU ROBÓT REGULACYJNYCH I KONSERWACYJNYCH W KORYCIE CIEKU

Abstract: The subject of the following study is the analysis of qualitative and quantitative changes in water plants communities after the completion of regulatory and maintenance works in four Lower Silesian rivers. The field research was conducted in vegetative seasons of 2007, 2008 and 2011 in unmodified, maintained and regulated watercourses. It comprised of an identification of a presence of hydromacrophytes species and the level of the bottom coverage by them. Basing on the results of the research agglomerative analysis allowing identification of the study sections was done. Particular sections were similar in the variability of plants communities. An assessment of species variability and similarities between unmodified and modified communities in a result of works was also performed.

Qualitative and quantitative composition of hydromacrophytes communities after completion of maintenance and regulatory works was changing in time. Species similarity to unmodified sections was higher in the first year after the works completion. However, in the later years the direction of these changes depended on the range of performed works. The structure of hydromacrophytes communities on maintained and regulated sections was getting a lot more similar to the communities structure on the sections excluded from the interference.

Keywords: species similarity, watercourses regulation, maintenance works, water plants

Introduction

Water plants are one of biological components supporting an assessment of ecological state of water [1]. They provide organic substance to the water ecosystem creating environmental conditions in the watercourse and they influence hydro-

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chemistry. They constitute habitats for other water organisms providing food to invertebrates, vertebrates and water related organisms. Water plants have beneficial impact on the watercourses ability to self-purification and decrease of water erosion intensity by the bottom and banks substrate stabilization [2–5].

Simultaneously, strongly developed plants in the watercourse cause elevation of the water level in the river bed and they result in decreasing hydraulic throughput of the river bed [6].

In Poland there was no strategy of plants management in waters in relation to their influence on the river bed throughput and ecological state of the watercourse. Most frequently they are removed from the bottom and banks in a result of regulatory and maintenance works. These plants grow extremely fast resulting in later needs for technical interference in the river bed. Therefore, it is necessary to find the compromise between the range of regulation and maintenance of watercourses and technical requirements and environmental protection.

Regulation of rivers and streams most frequently comprises of the change of technical parameters of the river bed and creation of technical buildings constraining damage resulting from waters and enlarging watercourses usability for common usage of water in national economy [7]. Watercourses maintenance influences the river bed less than regulatory works. It includes all the works resulting in correct outflow of water such as: desludging, water plants and scarps mowing, removal of any impediments hampering the outflow [8–11].

Most authors agree that every technical interference in the river bed influences hydromacrophytes communities directly or indirectly. Direct changes result from technical and technological solutions of conducted works extorting complete removal of plants from the watercourse bottom and scarps [8, 12]. Indirect influence is the result of the following activities: standardisation of cross-section dimensions, removal of stone bars and islands, leveling the bottom and banks. Such activities cause decay of the morphological variety in the river bed and loss of the habitat variety in a consequence species impoverishment of hydromacrophytes communities. Water buildings exert direct influence on water plants. They influence water velocity, changes in the water levels and the kind of the bottom material [13]. Creation of diverse ecosystems above and below the tower point is the result of these [14, 15].

Usually the time of regulatory and maintenance does not exceed several months. Also disruptions of environmental relations caused by the river bed modification have temporal character. Ecosystem regeneration follows them [16–18]. Ecosystem regeneration results in the reconstruction of the organisms community. However, in case of hydromacrophytes creation of the community exactly the same as existing before the disruption is very seldom [12].

This process is not well recognized yet. The results presented in the following study show observations of hydromacrophytes communities reconstruction after the completion of regulatory and maintenance works in four small and medium lowland watercourses. The aim of the research is an assessment of the pace and alternations of quality and quantity directions in these communities.

Methods

Field work was conducted in vegetation seasons of the year 2007, 2008 and 2011 on four Lower Silesian watercourses such as: Dobra, Sasiecznica, Zalina and Zurawka (Table 1).

Table 1

Study objects

Watercourse name	River-mouth	Length of the watercourse [km]
Dobra	Widawa	36.1
Sasiecznica	Barycz	43.9
Zalina	Zurawka	10.9
Zurawka	Sleza	27.5

These watercourses were divided into 13 study sections one hundred meters. They were localized in places of approximate climatic, geologic and soil conditions. Adjacent terrain was agriculturally used with the majority of arable lands. In five study sections there was no dimness while in others it was low or medium. Water in study sections was not contaminated with any municipal or industrial wastes.

The range of works in watercourses was diverse. Therefore study sections should be classified into three groups. The first group comprises of three regulated sections located in Dobra and Zurawka bed. The second group includes watercourses where maintenance works were performed. In case of the section located in the bed of Sasiecznica, interference was very mild as it comprised of manual mowing of the banks and water plants. Other sections located in the bed of Sasiecznica, Zalina and Zurawka maintenance works included manual banks mowing, mechanic desludging and scarps strengthening with fascine. The third group consisted of four study sections, one per each watercourse, set in places where no works were done. They constitute the basis for comparatory analyses. The Table 2 shows detailed characteristic of all study sections.

Field work included identification of hydromacrophytes in the study sections and definition of the their degree of the bottom coverage. All hydromacrophytes both embedded in water for at least 90 % of the vegetative period and higher plants, floating freely on the surface or beneath it were taken into account. Braun-Blanquet five degree scale was used to determine the level of plants density in the river bed [19]. Field work in Dobra, Zalina and Zurawka was performed in 2008 and 2011 while in the Sasiecznica in 2007 and 2011. In all cases the first term of the research was the first vegetation season after the completion of technological works in the river bed.

Results of the field work were analized referring to the assessment of:

– qualitative and quantitative alternations in hydromacrophytes community on modified study sections were a result of technical interference in relation to communities in unmodified beds;

– the influence of the time since the works completion on the qualitative and quantitative composition of hydromacrophytes communities in beds with technical interference.

Table 2

Characteristic of the study sections

Study section		Range of works	Bottom width [m]	Water-course depth [m]	Bottom substrate	Use of the littoral area	Degree of shading[a]	The time from the works completion [the number of wedet periods]	
								Year 2007/2008	Year 2011
Dobra	1	Unmodified section	3.0	1.2	sand	meadows	0	—	—
	2	River bed elutriation, bottom and banks mowing, changes in cross-section parameters, modification of scarps incline to 1:2, strengthening the foundation of riverbank with fascine	3.0	1.0	sand	meadows	0	1	4
	3	Watercourse deepening, changes in cross-section parameters, modification of vertical section with horizontal scarps, strengthening banks with gabions	6.8	2.0	sand/stones	farm buil-dings/ meadows	0	1	4
Sasiecznica	4	Unmodified section	6.5	1.5	sand	meadows	1	—	—
	5	Bottom and banksmowing	10.0	1:5	sand	meadows	0	1	5
	6	River bed elutriation, bottom and banksmowing, strengthening the foundation of riverbank with fascine	6.0	1:5	sand	meadows	0	1	5
Zalina	7	Unmodified section	1.5	2.1	sand	arable land	1	—	—
	8	River bed elutriation, bottom and banks mowing, river banks zones mowing, strengthening the foundation of riverbank with fascine	2.0	2.0	organic	arable land	1	1	4

Table 2 contd.

Study section		Range of works	Bottom width [m]	Water-course depth [m]	Bottom substrate	Use of the littoral area	Degree of shading[a]	The time from the works completion [the number of wedet periods]	
								Year 2007/2008	Year 2011
Zurawka	9	Unmodified section	3.0	2.2	sand	arable land	2	—	—
	10	River bed elutriation, bottom and banks mowing, river banks zones mowing, strengthening the foundation of riverbank with fascine	3.3	1.4	sand	arable land	1	1	4
	11		3.0	2.0	sand	farm buildings	1	1	4
	12	Watercourse deepening, changes in cross-section parameters, modification of vertical section with horizontal scarps, strengthening banks with retaining wall	6.0	2.0	sand	farm buildings	1	1	4

[a] Degree of shading: 0 – lack of shade, 1 – low, 2 – medium, 3 – high, 4 – full shade.

In order to group study sections according to the diversification of hydromacrophytes communities agglomerative analysis was performed. An assessment of species diversity and similarity of both modified and unmodified communities following works completion was done.

Agglomerative analysis was performed using the Ward method in Statistica v.9 programme. Euclidean distance was accepted as a measure of the distance. Analyzed data included the number of hydromacrophytes species and the degree of the bottom coverage with them. This served as the basis for the division of modified study sections into homogenous groups with respect to the diversification of water plants communities.

Shannon-Wiener – H indicator was used to assess species variability taking into consideration both the number of species and steadiness of their share in the coverage [20]. It was calculated basing on the following formula:

$$H = -\sum_{i=1}^{s} (N_i \cdot \ln N_i)$$

where: H – species variability indicator,
s – the number of hydromacrophytes species in the study section,
N_i – indicator calculated from the formula:

$$N_i = \frac{Q_i}{Q}$$

Q_i – cube of the value of the bottom coverage by plants of i species,
Q – cube of the value of the bottom coverage by plants of all the species.

Species similiarity Jaccard (P) and structures similarity indicators (w_p) were used to assess the level of water plants similarity between modified and unmodified study sections. Species similarity Jaccard indicator was calculated basing on the following formula [8]:

$$P = \frac{2 \cdot C \cdot 100}{A + B}$$

where: P – similarity index [%],
A – the number of species in unmodified study section,
B – the number of species in maintained or regulated study section,
C – the number of common species in compared study sections.

Similarity of structures in water plants communities found in modified and unmodified study sections was determined basing on the number of species with a certain degree of bottom coverage. The index was calculated using the following formula:

$$w_p = \sum_{i=1}^{k} \min\,(w_{1i}, w_{2i})$$

where: w_p – similarity index between communities structures [%],
w_{1i} – percent share of species in particular classes of the bottom coverage in unmodified sections,
w_{2i} – percent share of species in particular classes of the bottom coverage in modified sections.

Results

Cumulatively 15 species of hydromacrophytes were specified. They included: *Alisma plantago-aquatica* L., *Berula erecta* (Huds.) Coville., *Callitriche* sp., *Ceratophyllum demersum* L., *Elodea canadensis* L., *Glyceria Maxima* (Hartm.) Holmb., *Lemna minor* L., *Myosotis palustris* (L.) L. em. Rchb., *Phalaris arundinacea* L., *Phragmites communis* Trin., *Potamogeton crispus* L., *Potamogeton pectinatus* L., *Sagittaria sagittifolia* L., *Sparganium emersum* Rehmann, *Typha angustifolia* L. Their occurrence and the level of the bottom coverage in particular sections was shown in Table 3.

Data presented in the table shows that in the first vegetation season in 2007 and 2008 13 species of hydromacrophytes were determined together – 8 species in unmodified and 9 in regulated and maintained watercourses. In the vegetation season of 2011 the number of determined species increased to 14.

An increase in the number of species was observed in unmodified sections (13 species) as well as in sections which were maintained and regulated (11 species). The research showed there was a loss of one species (*A. plantago-aquatica*) and two new species of pondweed (*P. crispus* and *P. pectinatus*) appeared. They were not catalogued in the first study season.

Considered watercourses both during the first and second study season showed the most frequent occurrence of *L. minor* and *S. emersum*. Both species were found in 80 % of unmodified sections. In the first season after the works completion these species were present in half of sections under technical activity. In 2011 *L. minor* was found in over 60 % while *S. emersum* in all unmodified sections.

Species which were rarely observed during the field study included: *A. plantago-aquatica* and *C. demersum*. These species were observed only in modified sections while *P. arundinacea*, *P. crispus* and *T. angustifolia* occured in sections without any technical interference.

During the research the most – 8 species of hydromacrophytes were found in unmodified section of Dobra in the second study period and in maintained section of Sasiecznica in the first year of the research. The fewest species were observed in Zurawka section where regulatory work was done. Regulatory works have a very strong level of interferences in the river bed. During the first season after the works completion there were not found any hydromacrophytes in this section. Three years later there was only one species – *S. emersum* found in the section.

Table 3

Hydromacrophytes species and a degree of their bottom coverage in study sections

	Study sections / Aquatic plants	Dobra			Sasiecznica			Zalina		Zurawka				Σ occurrence
		1	2	3	4	5	6	7	8	9	10	11	12	
I study season (2007/2008)	*Alisma plantago-aquatica* L.								1					1
	Berula erecta (Huds.) Coville.	1		1		1								3
	Callitriche sp.		1	1		2			3					4
	Ceratophyllum demersum L.					3								1
	Elodea canadensis L.		5	1	1	2	5							5
	Glyceria Maxima (Hartm.) Holmb.							3						1
	Lemna minor L.	1				2		3	2	3	1	1		7
	Myosotis palustris (L.) L. em. Rchb.	1												1
	Phalaris arundinacea L.	4												1
	Phragmites communis Trin.				5	3	3							3
	Potamogeton crispus L.													0
	Potamogeton pectinatus L.													0
	Sagittaria sagittifolia L.	4				2								2
	Sparganium emersum Rehmann	5	1			2		4	3	4		2		7
	Typha angustifolia L.	3												1
Bottom coverage by all the species		5	5	1	5	3	5	5	4	5	1	2	1	
Number of species		7	3	3	2	8	2	3	4	2	1	2	0	

Table 3 contd.

	Study sections / Aquatic plants	Dobra			Sasiecznica			Zalina		Zurawka				Σ occurrence
		1	2	3	4	5	6	7	8	9	10	11	12	
II study season (2011)	*Alisma plantago-aquatica* L.													0
	Berula erecta (Huds.) Coville.	1	1	1		1	1		1					6
	Callitriche sp.		1			2			4	2		1		5
	Ceratophyllum demersum L.					2								1
	Elodea canadensis L.	1	4	3	1									4
	Glyceria Maxima (Hartm.) Holmb.						1	2			2			3
	Lemna minor L.	1				1	1	2	2	1	2	2		8
	Myosotis palustris (L.) L. em. Rchb.	1					1		1	2				4
	Phalaris arundinacea L.	3												1
	Phragmites communis Trin.				5	4	2							3
	Potamogeton crispus L.									2				1
	Potamogeton pectinatus L.			1						1		1		3
	Sagittaria sagittifolia L.	2	1	1		3			2	1		1		7
	Sparganium emersum Rehmann	4	1	1		1	2	4	3	3	2	3	1	11
	Typha angustifolia L.	2												1
Bottom coverage by all the species		5	4	4	5	5	4	5	4	4	3	3	1	
Number of species		8	5	5	2	7	6	3	6	7	3	5	1	

Conducted research shows that in most cases the number of species after the works completion was higher than in unmodified sections.

Table 3 indicates unmodified sections of watercourses had the highest degree of hydromacrophytes bottom coverage in Braun-Blanquet scale. However, in maintained and regulated watercourses the degree was observed to range between 1 and 5 regardless of the time that has passed from the works completion in the river bed.

Presented data constitute the basis to analysis aiming at regeneration process of hydromacrophytes communities after the completion of regulatory and maintenance works in the bed.

Agglomerative analysis performed to divide study sections into groups of qualitatively and quantitatively homogeneous communities of aquatic plants was done separately for each study period. Watercourses where works were performed were the only to be taken into account. They resulted in a complete elimination of aquatic plants in every section therefore, in starting point they were identical. Agglomerative analysis served as a basis to obtain two dendrograms presented in the Fig. 1a and 1b.

Figure 1a shows that study sections in the first vegetation period after the completion of maintenance and regulatory works create three agglomerates (23 Euclidean distance).

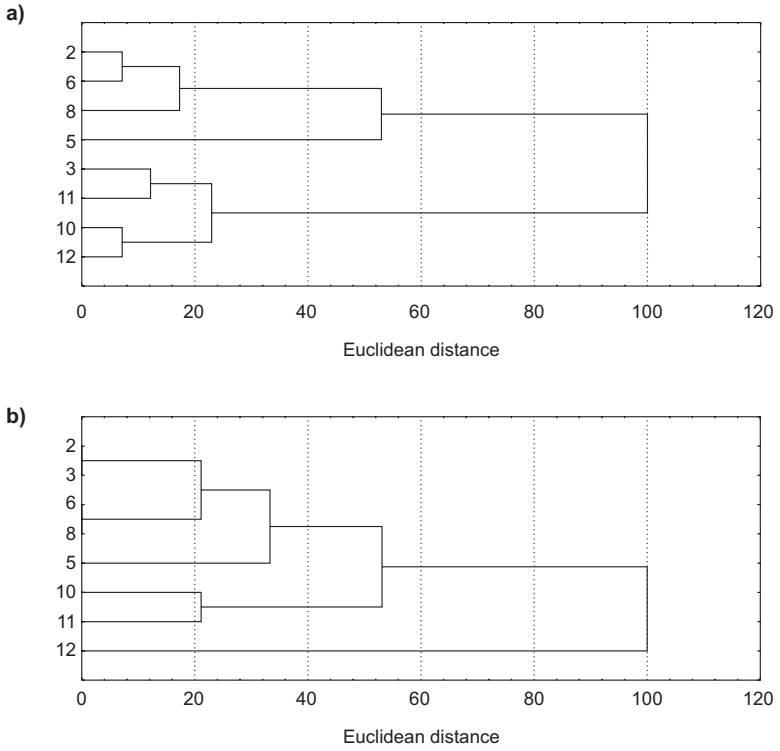

Fig. 1. Classification of modified study sections into homogeneous groups with respect to their qualitative and qantitative composition in hydromacrophytes communities basing on agglomerative analysis: a) – in the I, b) – in the II study period

The first agglomerate comprises two sections where regulatory works were performed (6, 8) and one regulated section (2). Common characteristic of these three sections are scarps strengthened with fascine. Section no. 5 where maintenance works were limited to mowing of scarps and plants in the bottom of the river bed differs distinctly from other study sections and it constitutes separate agglomerates. The third concentration includes both regulated (3, 12) and maintained (10, 11) sections.

Figure 1b suggests that in the later study period variety of the composition of hydromacrophytes has grown and it is possible to distinguish four agglomerates (33 Euclidean distance). The first comprises of two sections located in maintenance watercourses (6, 8) and two other are located in regulated watercourses (2, 3). Section no. 5 similarly as in the first study period constitutes separate agglomerates. Subsequent agglomerate contains two sections located in maintained river bed of Zurawka. Section no. 12 also found in this watercourse but regulated, showed a considerable difference from the other study sections. Euclidean distance of 100 (Fig. 1b) indicates this.

Performed analysis shows that in the first vegetative season after the works completion, qualitative and quantitative composition of aquatic plants communities in the study sections was not linked with the range of conducted works. Regulated and maintained sections such as 2 and 6, 3 and 11, 10 and 12 revealed similar composition of plant communities. The only distinguishing section was section no. 5 with limited range of works. In the later study season a certain tendency might be observed. An increase in the similarity of aquatic plants communities composition in study sections with similar works range was reported (2 and 3; 6 and 8; 10 and 11; 5; 12). In order to understand the following tendency better subsequent analyses were performed separately for each section.

Index of species diversity was calculated for all sections in both study periods. Its values and change tendencies in the study season were shown in the Fig. 2. Vertical axes show Shannon-Wiener values in two study periods while arrows represent particular sections of watercourses. They indicate corresponding values of the indicator itself and its change tendencies.

The analysis of the figure reveals that the indicator of diversity was accepted between 0–1.92. In the two following watercourses: Dobra (sections 1–3) and Zurawka (sections between 9 and 12) higher indicators of diversity occurred in unmodified sections. In compared sections of Zalina river *H* values were approximate. In unmodified Sasiecznica section values of species diversity were lower than in compared unmodified sections.

The highest species diversity was noted in the section no. 5 located in Sasiecznica river in the first vegetative season after the works completion. Four years later significant domination of two species was noted. It resulted in a reduction of Shannon-Wiener indicator. In other sections located in modified river beds values of the diversity indicator during second study period were similar or higher than directly after the works completion.

The lowest values of Shannon-Wiener Index were noted in sections 3 and 12 where vertical, tightly consolidated banks were performed.

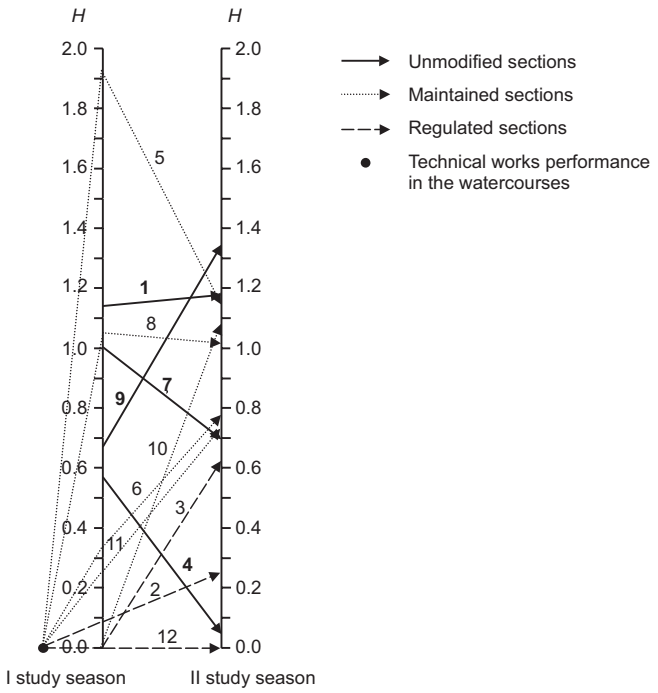

Fig. 2. A tendency in changes of the species diversity indicator in study sections

Presented data suggest that regulatory in comparison with maintenance work had greater impact on changes in species diversity expressed by Shannon-Wiener indicator.

Similarity between communities of hydromacrophytes occurring in sections where regulatory and maintenance works were performed and equivalent of unmodified watercourses were determined basing on species and communities structure (w_p) and indicators of similarity (P). Calculations were done for both study periods. Results of this analysis are presented in Fig. 3a and b.

Fig. 3a shows the diversity in the impact of regulatory and maintenance works on hydromacrophytes communities. While the works were realized regardless of their range, aquatic plants were removed from the bottom of the watercourse completely. Species similarity to unmodified sections was the same in all cases and it amounted to 0 %.

During the first vegetative season after the completion of works some species appeared in watercourses again causing species similarity of compared sections to grow in case of all maintained (5, 6, 8, 10, 11) and two regulated sections (2, 3). The following tendency was sustained during later years only in case of sections where regulatory works were conducted. In all maintained sections species similarity to compared sections revealed significant downward tendency. Perhaps after better identification this characteristic may be used for an assessment of the modification degree of the river bed.

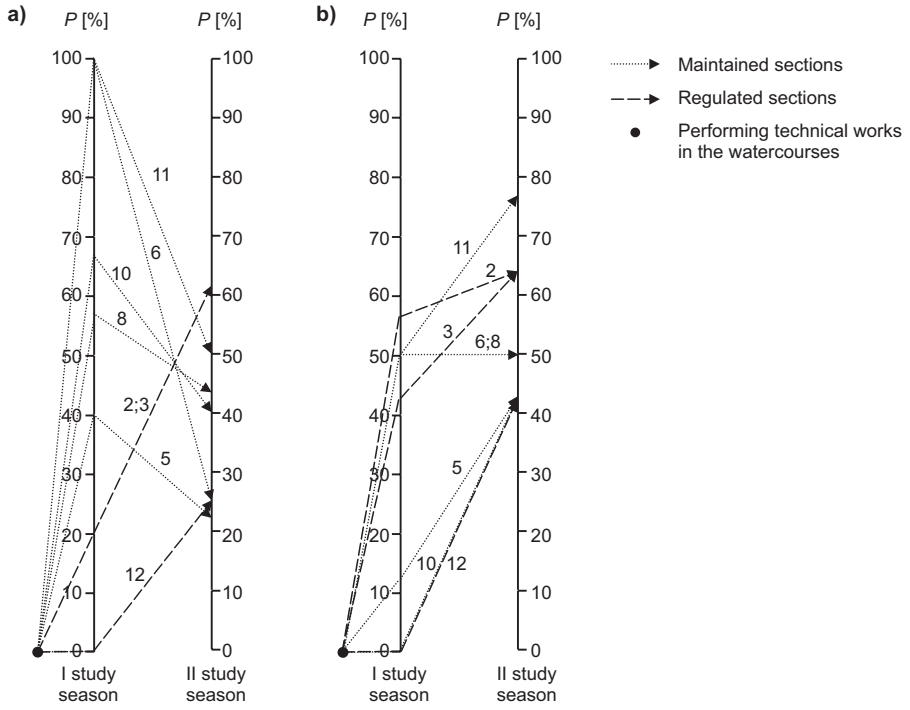

Fig. 3. Species (a) and communities structures of hydromacrophytes (b) similarity in two study periods

Different relation was observed in case of similarity among communities structures. Fig. 3b shows that structure of aquatic plants communities considering the number of species and their share in the coverage in all modified sections was becoming more approximate to the structure of communities in sections not being a subject of such intrusion.

Discussion

In the study sections 15 species of hydromacrophytes were determined altogether. They are ordinarily and commonly found taxons in waters of Polish lowland. The number of species occurring in modified sections as a result of works and unmodified sections was similar. These values are low in comparison with values found by authors conducting similar research [9, 21–23]. Low number of aquatic plants determined during the field work may be caused by the fact that analyzed watercourses were located in scarcely varied agricultural landscape and they were under technical intrusion before.

Agglomerative analysis showed that in the first vegetative season after the works completion qualitative and quantitative composition of aquatic plants communities was not related to their range. It results from the fact that both in maintenance and regulatory

works aquatic plants were removed from the river bed entirely [8, 12] and they developed similarly in the initial period after works completion regardless of the sort of technical activities. An increase in composition similarity of examined communities of sections with the same works range was noted. This may show that the range of works impacted aquatic plants composition after a certain time from their completion.

The highest species diversity was noted in the section maintained during the first vegetative season after the works completion. Removal of plants covering banks, shading river bed and also expansive reed plants resulted in an improvement of habitat conditions for aquatic plants. They could develop steadily which influenced high indicator of biodiversity. It may be a confirmation of many authors' view that correctly conducted maintenance works taking into account ecological requirements may have beneficial impact on environmental system of the watercourse [8, 24, 25].

The lowest species diversity was reported in sections 3 and 12 where vertical, tightly strengthened banks were made. They constituted a barrier for substances influx to the watercourse from its drainage area [26, 27]. Moreover change in cross-section parameters impacted changes in hydraulic characteristics of both rivers. In a consequence it is inevitable to disturb existing dynamic balance of the river and its environment resulting in its ecological threat [25].

Conducted analysis of similarity between species and structures shows the process of the watercourse overgrowing begins very fast after the works completion. In the first vegetative season after their accomplishment an average indicator of similarity in the sections located in both modified and unmodified watercourses was amounted to 50 %. However, an average similarity of hydromacrophytes communities in compared sections was lower and it was measured at 33 %. Similar tendencies were observed by Fox and Murphy [12]. While examining an influence of aquatic plants removal in 4 British watercourses they claimed that each interference of the same kind results in the reduction of plants species biodiversity. In later years species similarity in relation to comparative sections revealed clear decreasing tendency in all sections of maintained watercourses while in regulated sections similarity grew higher. These tendencies as well as the results of performed agglomerative analysis may show that the range of works influences a composition of aquatic plants species after a certain time after their completion. However, plants communities structure of all modified sections was getting approximate to the structure in unmodified sections.

Performed research shows that qualitative and quantitative changes in aquatic plants communities resulting from regulatory and maintenance works in the river bed should be assessed concerning the time indicator. Regardless of the range of works disrupting environmental relations caused by modifications in the watercourse they all led to ecosystem regeneration. The result indicates secondary succession in watercourses not being a subject to assessment. This process was a subject of study for Hearne and Armitage [28], Krebs [17], Lampert and Sommer [18], Falinska [16]. Secondary succession is connected with the fact that most aquatic plants have extremely effective mechanisms of vegetative reproduction and expansion [29, 30]. In a result of secondary succession it is possible for the group of particular organisms to restore plants community inhabiting the watercourse before the works conduction. However, hardy

ever do we observe creation of an ecosystem identical to the previous one [12]. It was confirmed by conducted research.

Conclusions

The following conclusions were drawn from performed research:

1. Field work conducted in four lowland watercourses showed that regulatory and maintenance works had an impact on the qualitative and quantitative composition of hydromacrophytes communities.
2. This composition was changing in time both in modified and unmodified sections.
3. In the first vegetative season after the completion of works in the river bed tendencies in recreation of plant communities were not connected with their range. This relation was observed in the next research period.
4. In modified sections as a result of technical interference, species similarity to unmodified sections was increasing in the first year after the works completion. In maintained sections after 4–5 years from the works completion, species similarity between compared sections was lower than in the first year while in regulated sections a high increase in species similarity was observed.
5. In the course of time from technical interference in the river bed the structure of plant communities in all modified sections was getting closer to the structure of aquatic plants communities in sections not being a subject of interference.

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TENDENCJE W ROZWOJU NACZYNIOWYCH ROŚLIN WODNYCH PO WYKONANIU ROBÓT REGULACYJNYCH I KONSERWACYJNYCH W KORYCIE CIEKU

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Abstrakt: Przedmiotem pracy jest analiza zmian jakościowych i ilościowych w zbiorowiskach naczyniowych roślin wodnych po wykonaniu robót regulacyjnych i konserwacyjnych w czterech ciekach nizinnych Dolnego Śląska. Badania terenowe prowadzono w sezonach wegetacyjnych 2007, 2008 i 2011 r. na ciekach nieprzekształconych, konserwowanych oraz regulowanych. Obejmowały one identyfikację występujących w korycie gatunków naczyniowych roślin wodnych oraz określenie stopnia pokrycia przez nie dna. Na podstawie wyników badań wykonano analizę skupień, pozwalającą na pogrupowanie odcinków badawczych, podobnych pod względem zróżnicowania zbiorowisk roślin wodnych. Dokonano również oceny różnorodności gatunkowej oraz oceniono podobieństwo zbiorowisk nieprzekształconych i przekształconych w następstwie robót.

Skład jakościowy i ilościowy zbiorowisk naczyniowych roślin wodnych po wykonaniu w korycie robót konserwacyjnych i regulacyjnych zmieniał się w czasie. Podobieństwo gatunkowe do odcinków nieprzekształconych wzrastało w pierwszym roku po zakończeniu robót. Natomiast w kolejnych latach kierunek tych zmian zależał od zakresu przeprowadzonych prac. Struktura zbiorowisk roślinnych na odcinkach konserwowanych i regulowanych z czasem stawała się coraz bardziej zbliżona do struktury zbiorowisk na odcinkach nieobjętych tą ingerencją.

Słowa kluczowe: podobieństwo gatunkowe, regulacja cieków, roboty konserwacyjne, rośliny wodne