ASSESSMENT OF THE DEGREE OF SYNANTHROPIZATION OF VEGETATION IN THE URBAN LAKES IN OSTRÓDA (MASURIAN LAKE DISTRICT)

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ABSTRACT

Analyses were carried out of the structural and spatial character of the littoral vegetation in four urban lakes in Ostróda: Jakuba, Morliny, Kajkowskie and Perskie. Phytosociological studies made it possible to distinguish 20 phytosociological units representing plant communities from the classes: Potamogetonetea and Phragmitetea. The extent of anthropogenic changes in the littoral vegetation was examined using synanthropization index calculated for individual lakes. According to the classification proposed in the methods, Lake Morliny was classified as a natural reservoir, Lake Kajkowskie as belonging to the group of synanthropic water bodies (these two lakes were within the series of harmonic development). The other two lakes were classified as anthropogenic, characterised by disharmonic development due to high trophy. These results were confirmed by data on the area occupied in the lakes by particular alliances: Potamogetonion, Nymphaeion, Phragmitetion and Magnocaricton.

KEY WORDS: lake vegetation, phytosociology, anthropopression, lake synanthropization process, urban lakes.

INTRODUCTION

The synanthropization process consists of replacing the given structural elements of a natural system by other elements (Falinski 1972, Rejewski 1981). This process is the subject of many studies, but mostly those concerning communities of land vegetation (Falinski 1966a, b, 1972, 1975, Fukarek 1979, Kornas 1968a, b, 1972, 1981, 1990, and many others).

The methods used to examine and evaluate anthropogenic changes in land vegetation proved to be of little use in the case of aquatic vegetation.

There are many lakes in the town of Ostróda and its vicinity, in which aquatic vegetation and rushes have never been studied.

The aims of the study were: to examine the phytocenoses of phytolittoral in the lakes under study, to determine the area occupied by individual phytocenoses, to assess the anthropogenic changes induced in vegetation of the surveyed lakes.

STUDY AREA

Structural and spatial analyses of aquatic vegetation were carried out in four lakes in the town of Ostróda: Jakuba, Kajkowskie, Morliny and Perskie (Fig. 1, Table 1).

1. Lake Jakuba (Smrody)

This sub-urban lake is located in south-west suburbs of Ostróda. It extends from the north to the south. North part is connected with Lake Drwęckie by means of a short channel. South end receives waters of a stream flowing from Lake Morliny.

Lake Jakuba for many years used to receive a direct discharge of municipal sewage from part of Ostróda town, as well as a discharge of waste waters from a dairy plant. The lake is not used for recreation and tourism due to bad water quality. A busy road runs in the vicinity of the north part.

Lake Jakuba is relatively shallow and does not stratify. Water quality in the lake was established by the Centre of Environmental Surveys and Control (OBIKS) in Olsztyn in spring 1987 (viz. when the lake still received the discharge of pollutants from the dairy plant) and in summer 1987 (when pollution discharge was stopped). The lake is highly polluted; its waters are outside any class of purity, both as regards the purity standards (SOJ) and the regulation issued by the Council of Ministers. Arable lands extending along the east lake shore also add to its bad state. Lake Jakuba is very susceptible to external impacts, so it has been defined as beyond any class of purity.

2. Lake Kajkowskie (Sajmino, Kajkowo)

This lake is elongated, extending from the north-west to the south-east. It has an outflow located in the south-east part, flowing to Lake Sement Mały and then to the Grabiczek River. A municipal bathing site and beach are located at the north-west lake shore, and a little upward, over a sloping embankment, there is an old cemetery.
Lake Kajkowskie is not polluted from any point sources. A road from Ostróda to Olsztyn runs over an embankment along the north lake shore. An overall assessment resulting from the studies by OBiKS in Olsztyn (Cydzik, Kudelska, Soszka 1992) classified the lake into class II of purity according to the official standards of lake classification (SOJJ). On the other hand, more liberal norms for surface inland waters issued by the Council of Ministers would classify this lake as belonging to class I of purity.

Lake Kajkowskie is very susceptible to degradation due to a number of natural features which allocate it into the class III of lake susceptibility.

3. Lake Morliny

The lake is elongated, extending from north-west to south-east, with weakly developed shore line. It has three inflows, the most important of which is the one flowing from south-east and carrying waters from Lake Lichtajny. Outflow is directed northward, through Lake Jakuba to Lake Drweckie. Shores are fairly high, quite steep in places. Some flat areas can be found only at south lake end.

Lake Morliny does not receive any pollution from point sources and is little used for tourism and recreation. There are, however, many places with vegetation treasured in by anglers. Despite low inflow of pollutants, the lake is rich in nutrients and organic substances. Its central part is relatively deep, characterised by thermal and oxygen stratification in summer and winter. Studies on lake quality. Studies on lake quality revealed that its waters belonged to class III of purity according to the regulation issue by the Council of Ministers (if no attention is paid to oxygen index which declassifies the lake) (Cydzik, Soszka, Kudelska 1992). The official standards of water purity (SOJJ) yielded the same result when the analyses were performed in summer. On the other hand, BOD₅ above the bottom is a little over the range for class I of water purity. Still overall assessment places the lake in class III of purity. Coliform titre places it in class II. As regards lake susceptibility to external impacts, it has been classified as belonging to class II.

4. Lake Perskie (Paskiersz)

The lake is situated in the drainage basin of the rivers Drwęca-Vistula, with water surface at the level of 86 m above the sea. It is a suburban reservoir. A district of Ostróda called Osiedle is located at the north-west end of the lake. Lake Perskie is small (Table 1), extending from the north-west to the

TABLE 1. Morphometry of urban lakes in Ostróda.

<table>
<thead>
<tr>
<th>L.p.</th>
<th>Lake name</th>
<th>Lake area (ha)</th>
<th>Max. depth (m)</th>
<th>Lake length (m)</th>
<th>Lake width (m)</th>
<th>Shore line length (m)</th>
<th>Development of the shore line (m/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jakuba</td>
<td>22.8</td>
<td>6.1</td>
<td>1450</td>
<td>200</td>
<td>3250</td>
<td>143</td>
</tr>
<tr>
<td>2</td>
<td>Kajkowskie</td>
<td>29.0</td>
<td>7.8</td>
<td>1350</td>
<td>275</td>
<td>3000</td>
<td>103</td>
</tr>
<tr>
<td>3</td>
<td>Morliny</td>
<td>66.0</td>
<td>19.5</td>
<td>1970</td>
<td>475</td>
<td>4600</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>Perskie</td>
<td>14.3</td>
<td>10.6</td>
<td>750</td>
<td>250</td>
<td>1800</td>
<td>126</td>
</tr>
</tbody>
</table>
METHODS

Phytosociological studies were carried out in 1989–1991, with the phytosociological method commonly used in Middle Europe (Braun-Blanquet 1951), which enables determination of the type of a community comparing floristic composition of the phytocoenoses, both qualitative and quantitative one. Phytocoenoses were analysed using to relevés. One to relevé comprised a list of all plants found within the phytocoenosis, with attention paid to plant abundance (but without estimates of the degree of sociability, as this feature is of little importance in the case of aquatic plants). The to relevés taken in particular community types were synthesized in phytosociological tables (Table 4, 5, 6). The tables present floristic composition of the communities. Constancy, abundance (left column) and coefficient of cover index (right column) were given for particular species constituting components of a given community. Constancy was determined according to the following scale: V – species occurring in 80-100 % of relevés taken in the phytocoenoses of the given plant community; IV – species present in 60-80%; III – species present in 40-60%; II – species present in 20-40%, and I – species present in 0-20% of the pictures. Abundance was determined according to a modified six-degree scale by Braun-Blanquet, in which: + = a few specimens covering a small area, 0.1% on the average; 1 = the given species grows over 1-10% of the area, 5% on the average; 2 = the species covers 10-25%, 17.5% on the average; 3 = the species grows over 25-50%, 37.5% on the average; 4 = the species grows over 50-75%, 62.5% on the average; 5 = the species grows over 75-100% of the area, 87.5% on the average. The overgrowth index was calculated from the equation:

\[
\text{coefficient of cover index} = \frac{\text{sum of average values of the species average number of relevés for a given community}}{100}
\]

Phytosociological units were determined on the basis of dominating species. This method is not consistent with the classical principles of the French-Swiss school, but it complies with the German school and with the real picture of vegetation in water bodies. Totally 20 phytosociological units were distinguished using a systematic arrangement and Matuszkiewicz (1982) nomenclature, with corrections according to Hartog and Segal (1964), Rejewski (1981) and Tomaszewicz (1979).

Maps of real vegetation in the lakes under study were prepared in 1: 5 thousand scale. Phytocoenoses of the littoral and of the shore zone vegetation were marked on the map (they are not presented in this paper due to editorial restrictions). The areas of individual phytocoenoses were identified either directly on the lake (small up to 200 m²) or indirectly in case of larger lakes by delineation of such zones on a bathymetric chart and their planimetric measurement (the bathymetric charts and data of the Institute of Inland Fisheries of Olzyń-Kortowo were used).

In order to examine the synanthropization processes in the aquatic vegetation of the lakes under study, a modified phytosociological method was used (Rejewski 1981, Ciecierska 1994). Composition of the plant cover and the degree of anthropogenic changes were analysed. The method of Rejewski (1981) makes it possible to distinguish between two processes: the succession and the synanthropization. They develop in a similar way although they reflect different direction of changes. “Natural” succession results in more complicated systems, while synanthropization leads to simplified systems. The author of the paper made the supreme assumption that the lake, as an ecosystem, at the moment of origin is oligotrophic and the increase in trophy is a function of time.

The positions of reservoirs in both above mentioned processes are described by two negatively correlated ratios: the index of phytocenotic diversity (H) established according to the Shannon-Weaver function (treated as a specific measure of the aquatic ecosystem development path covered, the value of the ratio increases together with the progress of evolution and reaches the maximum value when the ecosystem reaches its maturity) and the index of colonization (Z) which determines the extent of the trophogenic layer available to macrophytes. The value of the isobath 2.5 m was assumed as constant because, as the studies by Olszewski (1971) indicated, the vegetation in eutrophic lakes is present down to the average depth of 2 m. The value of the isobath 2.5 m was accepted for practical reasons as it is most frequently marked on bathymetric charts.

\[
H = - \sum_{i} n_i / N \times \ln n_i / N
\]

\[
Z = N / \text{isob.} 2.5 \text{ m}
\]

where: H – index of phytocenotic diversity,
\(n_i\) – area overgrown by the given plant community in per cent of the total phytocenotic area,
N – area of the phytocenotic taken as 100 %.

When we want to review the scope of synanthropization simplifications in the vegetation of a reservoir, we should always confront that scope with the current potential for a maximum achievement of its spatial structures (Rejewski, 1981). As a consequence, it is necessary to know the maximum value of the phytocenotic diversity index. This index tends to reach the highest value in the environment lacking factors limiting the possibilities of development of the vegetation in lakes, and its maximum value is reached in the theoretically situation when all plant groups in the littoral zone of a given reservoir are co-dominating, i.e. they occupy the same area.

\[
H_{\text{max}} = \ln S
\]

where: \(H_{\text{max}}\) – maximal value of the diversity index,
S – number of communities of which the given phytocenotic is composed.

The redundancy index (R) is the measure of differences between the potential and real (actual) degree of organization of the analyzed system (aquatic ecosystem).

\[
R = 1 - H / H_{\text{max}}
\]

As a consequence the measure of structural simplifications in the vegetation of lakes taking place under the influence of human pressure is provided by the so called synanthropization quotient-\(I_{\text{syn}}\) ranging from 0 to infinity (Rejewski 1981).

\[
I_{\text{syn}} = R / Z
\]

The modification in Rejewski method was based on development of a new formula describing the anthropogenetic changes in the vegetation of littoral of the lakes. It was necessary to define the maximum limit of the process of synanthropization. In case of so defines a formula (\(I_{\text{syn}}\)) it was
in the Masurian Lake District (Ciecierska 1994 – the majority of reservoirs was of hypertrophic nature). The synanthropization quotient (I_{sa}) was replaced by the index of synanthropization (W_{s}, which is an exponential function) the values of which are within the range of 0-1.

\[ W_{s} = \exp \left( -\frac{H \times Z}{H_{\text{max}}} \right) \]

In calculation of \( W_{s} \), the redundancy index (R) was resigned and replaced by the index of phytocenotic diversity (H / H_{\text{max}}).

New variability ranges were set for individual groups differing in the degree of human pressure (Table 2). The initial four groups of lakes are characterized by harmonious development while the fifth group (anthropogenic lakes) is among reservoirs with disharmonious development as a consequence of significant trophies. The limit values, after exceeding which reservoirs get into disharmonious development, were 1 for the quotient and 0.8 for index of synanthropization.

**RESULTS**

Totally 20 syntaxonomic units ranking as communities were distinguished; their syntaxonomic position and area occupied in particular lakes are presented in Table 3 (Tables 4, 5, 6).

### Table 2. The variability ranges for synanthropization quotient and synanthropization index.

<table>
<thead>
<tr>
<th>L.p.</th>
<th>Groups of lakes according to degree of anthropogenic transformation</th>
<th>Value of the synanthropization quotient index ( I_{sa} )</th>
<th>Value of the synanthropization index ( W_{s} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>natural lakes</td>
<td>0.00-0.25</td>
<td>0.00-0.39</td>
</tr>
<tr>
<td>2</td>
<td>weakly synanthropic lakes</td>
<td>0.26-0.50</td>
<td>0.40-0.59</td>
</tr>
<tr>
<td>3</td>
<td>moderately synanthropic lakes</td>
<td>0.51-0.75</td>
<td>0.60-0.69</td>
</tr>
<tr>
<td>4</td>
<td>synanthropic lakes</td>
<td>0.75-0.99</td>
<td>0.70-0.79</td>
</tr>
<tr>
<td>5</td>
<td>anthropogenic lakes</td>
<td>≤ 1.00</td>
<td>0.80-1.00</td>
</tr>
</tbody>
</table>

### Table 3. Percentage of the communities of aquatic plants and rushes in the phytolittoral of urban lakes in Ostródą.

<table>
<thead>
<tr>
<th>Phytosociological units</th>
<th>Jakuba Lake</th>
<th>Kajkowskie Lake</th>
<th>Morliny Lake</th>
<th>Perskie Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class: Potamogetonetea R.Tx. et Prsg.</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>5.64</td>
</tr>
<tr>
<td>Order: Potamogetonitalia Koch 1926</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>1. Potamogetonetea pectinata Carstensen 1955</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>13.76</td>
</tr>
<tr>
<td>2. Ranunculaceae circinata (Bennema et West. 1943) Segal 1965</td>
<td>.</td>
<td>0.03</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>3. Elodeetum canadensis (Ping. 1953) Pass. 1964</td>
<td>.</td>
<td>.</td>
<td>82.97</td>
<td>2.11</td>
</tr>
<tr>
<td>4. Ceratophyllum demersi Mild. 1956</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>9.28</td>
</tr>
<tr>
<td>5. Potamogetonetea lucetis Hueck 193</td>
<td>.</td>
<td>.</td>
<td>3.66</td>
<td>6.17</td>
</tr>
<tr>
<td>6. Potamogetonetea perfoliati Koch 1926 em. Pass. 1964</td>
<td>.</td>
<td>0.95</td>
<td>0.22</td>
<td>13.13</td>
</tr>
<tr>
<td>Alliance: Nymphaeion Oberd. 1957</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Class: Phragmitetalia R.Tx. et Prsg 1942</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Order: Phragmitetalia Koch 1926</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>Alliance: Phragmitetalia Koch 1926</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>8. Scirpetum lacustris (Allorge 1922) Chouard 1924</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>0.28</td>
</tr>
<tr>
<td>9. Typhetum angustifolii (Allorge 1922) Soó 1927</td>
<td>16.53</td>
<td>0.05</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>10. Sparganium erecti Roll 1938</td>
<td>0.37</td>
<td>.</td>
<td>0.10</td>
<td>0.21</td>
</tr>
<tr>
<td>11. Eleocharitetea palustris Schennikow 1919</td>
<td>.</td>
<td>0.11</td>
<td>.</td>
<td>0.01</td>
</tr>
<tr>
<td>12. Phragmitetum (Gams 1927) Schmale 1939</td>
<td>36.93</td>
<td>0.05</td>
<td>4.09</td>
<td>21.55</td>
</tr>
<tr>
<td>13. Typhetum latifolii Soó 1927</td>
<td>2.19</td>
<td>1.62</td>
<td>.</td>
<td>48.20</td>
</tr>
<tr>
<td>14. Acoretum calami Kobendza 1948</td>
<td>7.17</td>
<td>.</td>
<td>.</td>
<td>5.76</td>
</tr>
<tr>
<td>15. Glyceritetum maximae Hueck 1931</td>
<td>2.01</td>
<td>10.88</td>
<td>10.11</td>
<td>9.73</td>
</tr>
<tr>
<td>Alliance: Magnocaricion Koch 1926</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>16. Thelypteridi-Phragmitetum Kuiper 1957</td>
<td>2.93</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>17. Caricetum ripariae Soó 1928</td>
<td>0.95</td>
<td>.</td>
<td>.</td>
<td>0.02</td>
</tr>
<tr>
<td>18. Caricetum acutiformis Sauer 1937</td>
<td>0.37</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>19. Caricetum paniculatae Wangerin 1916</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>3.81</td>
</tr>
<tr>
<td>20. Caricetum gracill (Graebn. et Hueck 1931) R.Tx. 1937</td>
<td>2.19</td>
<td>.</td>
<td>0.03</td>
<td>.</td>
</tr>
</tbody>
</table>
Adding up the areas of the phytoceneses, a picture of vegetation alliances: Potamogetonion, Nymphaeion, Phragmition and Magnocaricion has been obtained for each lake (Fig. 2).

In order to estimate the extent of anthropogenic changes induced in the lake littoral, synanthropization indices were calculated for the lakes under study (Table 7). According to the

TABLE 4. Communities of the class Potamogetonetea.

<table>
<thead>
<tr>
<th>Community*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cl. Potamogetonetea</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Potamogeton pectinatus L.</td>
<td>III² 4583</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranunculus circinatus Sibth.</td>
<td>I 167</td>
<td>II²-III² 2750</td>
<td>III² 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elodea canadensis Rich</td>
<td>I 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceratophyllum demersum L.</td>
<td>I 3</td>
<td>I² 5</td>
<td>III² 2</td>
<td>I² 3750</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Potamogeton lucens L.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Potamogeton perfoliatus L.</td>
<td>I² 875</td>
<td>III¹-II² 753</td>
<td>I 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuphar lutea (L.) Sibth. et sm.</td>
<td>I 5</td>
<td>I² 100</td>
<td>I² 1750</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Nymphaea alba L.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Myriophyllum spicatum L.</td>
<td>I 250</td>
<td>III¹ 173</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratiotes aloides L.</td>
<td>I² 2</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Potamogeton crispus L.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Cl. Phragmiteetea</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typha angustifolia L.</td>
<td>I² 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phragmites australis (Cav.) Trin. ex Steudel</td>
<td>I² 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 5. Communities of the alliance *Phragmites*.

<table>
<thead>
<tr>
<th>Community*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cl. Phragmitetee</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scirpus lacustris L.</td>
<td>I² 8750</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typha angustifolia L.</td>
<td>I* 10</td>
<td>I³ 6250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spartanium erectum Huds.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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### TABLE 6. Communities of the alliance Magnocaricion.

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* 1 - Thelypteris-Phragmitetum Kuiper 1957, 2 - Caricetum ripariae Soó 1928, 3 - Caricetum acutiformis Sauer 1937, 4 - Caricetum paniculatae Wangerin 1916, 5 - Caricetum gracilis (Graebn. et Hueck 1931) R. Tx. 1937.

Classification presented in the methods (Table 2), the urban lakes of Ostroda were classified (using the index of synanthropicization) into three out of five groups: natural water bodies (Lake Morliny), synanthropic lakes (Lake Kajkowski; these two lakes remain in the series of harmonic development), and anthropogenic water bodies (lakes Jakuba and Perskie; these two lakes are characterised by disharmonious development due to high lake trophy).
TABLE 7. Values of the indices characterising phytocenotic composition of the vegetation in urban lakes of Ostroda.

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<tr>
<th>L.p.</th>
<th>Lake name</th>
<th>Area of 2.5 m isobath (ha)</th>
<th>Area of phytolittoral (ha)</th>
<th>Number of phytolittoral communities</th>
<th>Index of phytocenotic diversity</th>
<th>Index of max. phytocenotic diversity</th>
<th>Index of colonization</th>
<th>Synanthropization index</th>
<th>Anthropogen- pression effect</th>
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<td>1</td>
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<td>9.30</td>
<td>12.06</td>
<td>15</td>
<td>2.19</td>
<td>2.71</td>
<td>1.30</td>
<td>0.35</td>
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<td>2</td>
<td>Kajkowskie</td>
<td>9.30</td>
<td>9.28</td>
<td>9</td>
<td>0.62</td>
<td>2.20</td>
<td>1.00</td>
<td>0.75</td>
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<td>Jakuba</td>
<td>10.90</td>
<td>1.39</td>
<td>13</td>
<td>1.80</td>
<td>2.56</td>
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<td>Perskie</td>
<td>10.00</td>
<td>0.71</td>
<td>7</td>
<td>1.33</td>
<td>1.95</td>
<td>0.07</td>
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<td>anthropogenic</td>
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DISCUSSION

The distinguished communities of aquatic and rush-belt plants are fairly common in Polish waters (Tomaszewicz 1979, Matuszkiewicz 1982).

Taking advantage of the value of the synanthropic indices, lakes Morliny and Kajkowskie were classified as belonging to the group of water bodies with the fitocenosia in a balanced state.

Morliny lake was included in the group of natural reservoirs where, independent of the development stage, the flora develops either without human pressure or such a degree of human pressure which is within the natural categories of influence of the basin and climate (Rejewski 1981). The majority of lakes in the area of Laski in Tuchola Forest (Rejewski 1981) and Wiktorowo lake situated among the agricultural landscape of southern Kujawy region (Samosiej 1987) belonged to that group. Sluza lake from the area of Laski is the most similar one as concerns the value of different ratios for the studied reservoir (S-14 of which 9 phytocenosia were present in both reservoirs, H = 2.02, Hmax = 2.64, Z = 1.35, Ws = 0.35). On the other hand, the nearest surrounding of the reservoir, high banks in their majority occupied by meadows and cultivated fields is closest to the Wiktorowo lake.

Lake Morliny is located at the outskirts of Ostroda, it is not polluted from point sources, and has an almost natural shore zone (only 3% of this area are represented by anthropogenic communities). It is a lake with the least human impacts, mostly because it is not directly affected by the town. This lake is characterised by a well developed zone of submerged vegetation (58.4% of the whole phytolittoral; Fig. 2), composed mainly of the phytocenosia: Ranunculetum circinatii, Potamogetonum perfoliati or Nupharo-Nymphaeetum albae (Table 3). Submerged vegetation is present to the depth of 3.5-4 m. The rush belt is composed mainly of the patches of Phragmitetum and Glycerietum maxima.

Lake Kajkowskie is a eutrophic, synanthropic water body, with the biocenotic systems on the verge of collapsing. This is reflected in the fact that although the zone of submerged vegetation is well developed, it is composed almost exclusively of Elodea canadensis. Mass appearance of this anthropological species suggests advanced anthropopression.

Many reservoirs in the group of synanthropic lakes were identified in Kujawy (Samosiej 1987), but they differed in developed phytolittoral both as concerns the number of phytocenosia and in the expanse of it.

According to the methods, the lakes for which the synanthropization index was equal to or higher than 0.8 were classified as anthropogenic. These lakes were characterised by disharmonic development due to very high trophy. Hence, it is suggested to extend the term anthropogenic lake to include also hypertrophic water bodies, in which high levels of nutrients lead to lake degradation as an ecosystem. Of course it is possible to inhibit or reverse the evolutionary process of an aquatic ecosystem, according to the concept of allogenous succession (Margalef 1975, Rejewski 1981, and many others).

The two other water bodies of Ostroda, lakes Jakuba and Perskie, were included into the group of anthropogenic lakes. These lakes are characterised most of all by a well developed zone of emerged vegetation: in Lake Jakuba 65.2%, and in Lake Perskie 90.5% of the whole phytolittoral (Table 2, Fig. 2). These vegetation are represented most of all by the alliance Phragmition (high rushes and reed), composed of the phytocenosia: Phragmitetum, Typhetum latifoli et or Typhetum angustifoli et. Sedge rushes were poorly developed. They were present only in lakes Perskie and Jakuba. In the latter lake, sedge developed in supralittoral. This was the reason for the presence of many land species from the class Molino-Arrenathereta in the patches of Caricetum phytocenosia (Table 5).

Submerged vegetation was poor in both latter lakes: 4.7% of the submerged zone in Lake Jakuba and 5.6% in Lake Perskie. It was composed in both lakes of pond-weeds: Potamogeton lucens, P. perfoliatus and P. pectinatus (Table 3). The last species is usually characteristic of highly eutrophic waters. Nupharo-Nymphaetum patches developed well only in Lake Jakuba, in a bay on the lake end opposite the town. They formed a zone of nymphaoids (Nymphaeae). Nymphaea alba is connected with fertile habitats of shallow bays, in which thick organic sediments have accumulated (Tomaszewicz 1977, 1979). Nyphar lutea has a very wide ecological amplitude and forms phytocenosia in eutrophic habitats with mineral sediments and flowing water as well as in very shallow mesotrophic habitats with stagnant water. Samosciej (1987) also included a number of lakes in Kujawy into the group of anthropogenic reservoirs. Low residence ratio (from 0.28 to 0.51) and a small number of groups residing in the phytolittoral zone (2-7) were the common features for such lakes. Lubienieckie lake was the only exception with the flora consisting of 13 phytocenosia, which, however, did not form a zoned pattern and were of anthropogenic nature like e.g. Elodeetum canadensis or Acocetum calami. In Jakuba lake also 13 phytocenosia were recorded while in the lakes of Olstyl: Traciki and Skanda, even 14 while the phytolittoral of those reservoirs has always been small (index of colonization was 0.40 and 0.41 respectively).
LITERATURE CITED


OCENA STOPNIA SYNANTROPIZACJI ROŚLINNOŚCI JEZIOR MIEJSKICH W OSTRÓDZIE (POJEZIERZE Iławskie)

STRESZCZENIE


SŁOWA KLUCZOWE: roślinność jezior, fitosocjologia, antropopresja, proces synantropizacji jezior, jeziornie miejskie.