VERTICAL AND SPATIAL DIFFERENTIATION OF PHOSPHORUS CONTENT IN BOTTOM SEDIMENTS OF DEEP EUTROPHIC LAKE IN RELATION TO ORGANIC MATTER CONCENTRATION

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Summary. The vertical and spatial concentrations of total phosphorus against the content of organic matter in the bottom sediments were examined in deep, eutrophic Góreckie Lake. Sediments collected in cores of a length of 25 cm were cut into layers of 5 cm. The examination carried out in July of 2008 comprised 4 stations in both basins of the lake. A decrease in the concentrations of organic matter along with depth was observed within the whole lake area, while in the case of phosphorus the vertical differentiation of the concentrations was higher in the southern basin. A statistically significant differentiation of the studied parameters was recorded.

Key words: bottom sediments, deep lake, eutrophy, phosphorus, organic matter

INTRODUCTION

High phosphorus input to the aquatic environment resulting in eutrophication of all inland surface waters is still the major problem of water management in most European countries [Gelbrecht et al. 2005]. The quality transformation from mineral to organic bottom sediments, which is connected with the processes of sedimentation and accumulation of an excess of matter, is a consequence of the process of eutrophication. A feature of organic sediments is a considerably higher affluence of phosphorus [Joniak et al. 2007] connected both with organic matter as well as with metals [Sobczyński et al. 2002]. Organic sediments to a greater extent, compared with mineral sediments, are responsible for internal phosphorus loading, which may accelerate the eutrophication process...
and be a reason for secondary contamination [Wiśniewski 1995]. There are many mechanisms influencing the exchange of phosphorus between water and sediments, including redox conditions, pH, iron/phosphorus ratio and resuspension [Sondergaard et al. 2003]. As knowledge of the degree of concentration of phosphorus in water provides information regarding the stage of the process of eutrophication, its content in the sediments may predict the potential changes of abiotic features. Phosphorus deposited in sediments is not permanently fixed there. A great part of biologically available P is accumulated in the top layer of the bottom sediments [Sobczyński et al. 1996].

The work presents results of investigations of the total phosphorus content in the bottom sediment in relation to organic matter concentration. The analysis included an observation of the changeability of the concentrations of elements in the vertical gradient of sediments and in the spatial gradient in a lake.

STUDY AREA, MATERIAL AND METHODS

The postglacial channel-moraine Lake Góreckie in the Wielkopolska National Park is a large (surface area 103 ha) and deep (maximal 17.6 m) reservoir. An underwater crosswise projection naturally divides the lake’s arching pan into two basins: the southern (S) and the north-western (N-W). The southern basin is characterised by steep slope and considerable depth (at 1/3 of the area within 10–15 m). There are two 17-meter deepest points in the Lake. The north-western basin is shallower (maximal depth 10 m), with numerous shallows and two islands. During the winter season for a number of years it has provided winter refuge for numerous flocks of wild geese. The mainly forested catchment area of the lake is characterised by a considerable differentiation of relief. Therefore, the direct surroundings of this water body rise steeply above the water level, and these slopes are overgrown by forest; only the north-western parts are flat and are used for agricultural purposes. The lake is supplied from sources and it has an outflow which – due to low water levels – is choked.

The sediment samples were collected in July 2008 from 4 stations in both basins of the lake pan using a sampler with core cutting into layers (5 cm). The content of organic matter (OM) and total phosphorus (TP) were analysed. The sample of fresh sediment was mixed in order to homogenise its content, and later 3 subsamples were established for further analyses. Air-dry samples were homogenised. The concentration of OM was measured with weight method after sample combustion in 550°C. The TP was determined spectrophotometrically after combustion in 550°C and mineralization in HCl (1 : 1). The results were given in g P kg⁻¹ of dry mass. Statistical calculations were made with Statistica 7.0 software.
RESULTS AND DISCUSSION

Physical analysis of the sediment showed a decrease in the hydration along with increasing depth – from a semifluid consistence to the depth of 15 cm into a constant consistence in the deeper layers. The colour of sediments changed in the depth gradient from ginger-brown, through brown to black. The changes of colour which reflect the stages of organic matter decomposition indicate a great participation of the surface layers of sediments of substances at an early stage of decomposition and weakly advanced process of bitumization [Schnitzer 1991].

The concentrations of TP changed along with depth, from the highest in the layer of 0–5 cm to the lowest in the layer of 10–15 cm in the S basin. In the deeper sediment an increase of TP was noted. The layer of 30–35 cm, examined once, contained over 1.5 g P kg\(^{-1}\). In the N-W basin a decrease of concentrations occurred from the surface to the layer of 20–25 cm (Fig. 1). This spatial differentiation may be probably connected with differentiated intensity of anthropogenic pressure in both basins of the lake pan, divided by a natural shallowness.

<table>
<thead>
<tr>
<th>Warstwa (cm)</th>
<th>OM  (g kg(^{-1}))</th>
<th>TP  (g P kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>317.05</td>
<td>1.562</td>
</tr>
<tr>
<td>5-10</td>
<td>280.9</td>
<td>1.2255</td>
</tr>
<tr>
<td>10-15</td>
<td>265.05</td>
<td>1.0005</td>
</tr>
<tr>
<td>15-20</td>
<td>240.8</td>
<td>1.05</td>
</tr>
<tr>
<td>20-25</td>
<td>237.05</td>
<td>1.0815</td>
</tr>
</tbody>
</table>

Fig. 1. Vertical changes of organic matter (OM) and total phosphorus (TP) concentration in bottom sediments of south (A) and north-western (B) basins of the Góreckie Lake.
The southern basin was for many years a recipient of domestic-municipal sewage from the sanatorium in Jeziory Palace, which remained opened until the end of the nineteen eighties. This sanatorium did not have a sewage-treatment plant and the sewage was discharged directly into the lake. As a consequence of this process, eutrophication was accelerated, which is reflected not only in high concentrations of phosphorus and nitrogen compounds during the vegetation season but also in low water transparency, reaching 1.3 m (unpublished data). In the period before 1937 the transparency was not lower than 4.5 m [Brzęk 1948]. However, the waters of the north-western basin are exclusively supplied from spatial sources [Szyper et al. 2001]. On the basis of the conducted research it is difficult to determine the influential role, which has been widely publicized in the local scientific environment, of the acceleration of the process of eutrophication resulting from geese finding winter refuge in this part of the lake.

A feature of sediments was a decrease in the participation of organic matter (OM) along with depth. Considerable differences were noted in the content of OM in particular layers of sediments, and especially in the surface layer (0–5 cm), where much greater amounts were identified in the southern basin compared to the N-W basin (Fig. 1). Taking into consideration the whole vertical profile, the mean content of OM accounted for 260 and 220 g kg\(^{-1}\), respectively. Comparing the present results with data from the mid nineteen nineties [Sobczyński et al. 1997], it can be noticed that the participation of OM in the surface sediment has increased. A statistical analysis of the relationship between the content of OM and the concentration of phosphorus in sediments revealed a significant correlation of these variables in both basins of the lake pan. A feature of the sediments taken from the deeper S basin was their lower value of regression \((r^2 = 0.63, p < 0.006, n = 10)\), compared to the shallower N-W basin \((r^2 = 0.93, p < 0.000, n = 10)\). The reasons for these differentiations could be found in higher concentrations of mineral elements and in changes of the structure of sediments of the southern basin as a consequence of anthropogenic contamination.

CONCLUSIONS

1. A consequence of the differentiated intensity of anthropogenic pressure in the catchment area of the lake in relation to each of the basins is the spatial and vertical differentiation of the concentrations of phosphorus in the bottom sediments. Periodically higher sedimentation and cumulation of mineral matter reaching the southern basin caused dissimilarity in the distribution of concentrations of phosphorus compared to the north-western basin.

2. A decrease in the content of organic matter in sediments along with depth confirms the higher level of its biodegradation which occurs with considerably higher efficiency in the north-western basin where the anthropogenic impacts were lower.
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REFERENCES


PIONOWE I PRZESTRZENNE ZRÓŻNICOWANIE STĘŻEŃ FOSFORU W OSADACH DENNYCH GŁĘBOKIEGO JEZIORA EUTROFICZNEGO W RELACJI DO STĘŻEŃ MATERII ORGANICZNEJ

Streszczenie. Analizowano pionową i przestrzenną zmienność stężeń fosforu całkowitego i materia organicznej w osadach dennych głębokiego, eutroficznego Jeziora Góreckiego. Osady pobierane w postaci rdzeni o długości 25 cm cięto na warstwy 5 cm. Badania przeprowadzono w lipcu 2008 r. obejmowały 4 stanowiska w obu basenach masy jeziora. Stwierdzono spadek stężeń materii organicznej z głębokością w obrębie całego zbiornika, a w przypadku fosforu pionowe zróżnicowanie stężeń w basenie południowym było większe. Wykazano istotną zależność statystyczną badanych parametrów.

Słowa kluczowe: osady denne, głębokie jezioro, eutrofia, fosfor, materia organiczna

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