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Short communications

CHEMICAL COMPOSITION OF THE TOP-LAYER BOTTOM DEPOSITS FROM UNDERNEATH ASSEMBLAGES OF THE SUBTROPICAL SPECIES *VALLISNERIA SPIRALIS* L. IN THE PHYTOLITTORAL ZONE OF TWO HEATED LAKES

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ABSTRACT. The chemical composition of the top-layer bottom deposits in littoral was determined in areas of the phytolittoral zone dominated by *Vallisneria spiralis* L. in Lakes Licheńskie and the Ślesińskie, two heated lakes in central Poland. The lakes differ in terms of water temperature and seasonal patterns in water temperature. The chemical composition of leaves of *V. spiralis* and the periphytic algae growing on them was also determined. The main component of the littoral sediments was silica, comprising from 80.9 to 93.7% SiO_2 d.w. from Lake Licheńskie, and 89.3 to 93.8 % SiO_2 d.w. from Lake Ślesińskie, calcium content ranged from 3.0 to 8.1% d.w., and from 1.5 to 3.7% d.w., respectively. Organic matter content was low and ranged from 0.6 to 4.2% d.w. in sediments from Lake Licheńskie, and from 0.6 to 2.5% in sediments from Lake Ślesińskie. Chemical analysis of leaves of *V. spiralis* revealed that the leaves and the algae growing on them were far more encrusted with calcium carbonate at Lake Licheńskie than in Lake Ślesińskie. The calcium carbonate encrusting the leaves of *V. spiralis* in Lake Licheńskie was deposited as the result of biological decalcification, in which the periphytic flora plays a key role.

Key words: BOTTOM DEPOSITS, PHYTOLITTORAL OF THE HEATED WATERS, *VALLISNERIA SPIRALIS*, SUBTROPICAL SPECIES

Lakes Licheńskie and Ślesińskie are located near Konin in central Poland (Wielkopolsko-Kujawskie Lakeland). For several decades, these lakes have been integrated into the cooling systems of two power plants. From 2001 to 2004, maximum annual water temperatures ranged from 27.2 to 30.0°C in Lake Licheńskie, and from 24.5 to 27.6°C in Lake Ślesińskie (Stawecki et al. 2007). Because of the high water

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temperatures, these lakes support the development of *Vallisneria spiralis* L. (Hydrocharitaceae), a subtropical species that does not occur naturally in Poland. In Lake Licheńskie, *V. spiralis* was first detected at the beginning of the 1990s (Protasov et al. 1994). Since then, it has quickly dominated the phytolittoral zone of the lake, and has almost completely displaced other species of submerged hydrophytes except for *Nuphar lutea* (L.) Sibth. et Sm. (Gąbka 2002, Hutorowicz 2006). *V. spiralis* currently grows to depths of 2.5 m, almost entirely dominating the dense zone of submerged hydrophytes that surrounds the lake. In Lake Ślesińskie, *V. spiralis* was first detected at one site in 2003, and at two more sites in 2005 (Hutorowicz et al. 2006). *V. spiralis* occurs in relative small patches, usually together with other species of hydrophytes. It has never formed extensive, mono-specific underwater assemblages as it has in Lake Licheńskie (Hutorowicz et al. 2006).

In both lakes, water temperatures in the phytolittoral zone are generally lower than in those parts of the lake where heated water from the power plants is directly discharged. Because of this, the phytolittoral zone acts as a refuge for species, which prefer lower water overflow. The leaves of *V. spiralis* are an excellent substrate for periphytic algae (Luścińska et al. 2005). They are also home to specific communities of ciliates and rotifers (Fyda et al. 2006, Ejsmont-Karabin, personal communication). Because the vegetative season in the lakes is prolonged, the leaves of *V. spiralis* and the periphytes growing on them can assimilate large amounts of nitrogen and phosphorus. Nevertheless, the lake water contains high levels of biophilic compounds at least twice during the course of the year. In summer, the rametes of *V. spiralis* undergo intensive regeneration. In late fall and winter the rametes die off, especially in the shallower areas of the phytolittoral zone (Hutorowicz and Hutorowicz 2007).

The levels of some biophilic compounds in the phytolittoral zone can vary widely (Kłosowski and Tomaszewicz 1994, Pełechaty and Kałuska 2003). According to Wiśniewski and Zdanowski (2004), the chemical composition of lake bottom sediments from this zone largely depends on the nature of the surrounding landscape, but the level of organic matter at different sites in the phytolittoral zone of the same hypertrophic lake can vary by a factor of ten (Kowalczewska-Madura 2005).

The aim of this paper was to determine the chemical composition of the top-layer bottom deposits in phytolittoral zone overgrown by *V. spiralis* in Lakes Licheńskie and the Ślesińskie, which differ in terms of water temperature and seasonal patterns in

water temperature. The chemical composition of the leaves of *V. spiralis* and the periphytic algae growing on them was also determined.

In August, 2005, cores of the top layer (10 cm thick) of the bottom deposits were collected with a Kajak tube at a depth of one meter from five sites in Lake Licheńskie, at from three sites in Lake Ślesińskie (Fig. 1). At Site 8, two cores were collected. Core 8_v was collected from directly underneath a dense patch of *V. spiralis*, and Core 8_b was collected from the area adjacent to the patch. At the same time, the leaves of *V. spiralis* were sampled at sites 1 and 2 in Lake Licheńskie, and at site 6 in lake Ślesińskie. The water content and dry matter content of the sediment samples was measured according to the methods of Januszkiewicz (1978). Core samples and leaf samples were dried at room temperature and pulverized in a porcelain mortar. The levels of the following chemical components were determined: silica, calcium, carbonate, organic matter, total nitrogen, total phosphorus, iron, and aluminum. All analyses were carried out in

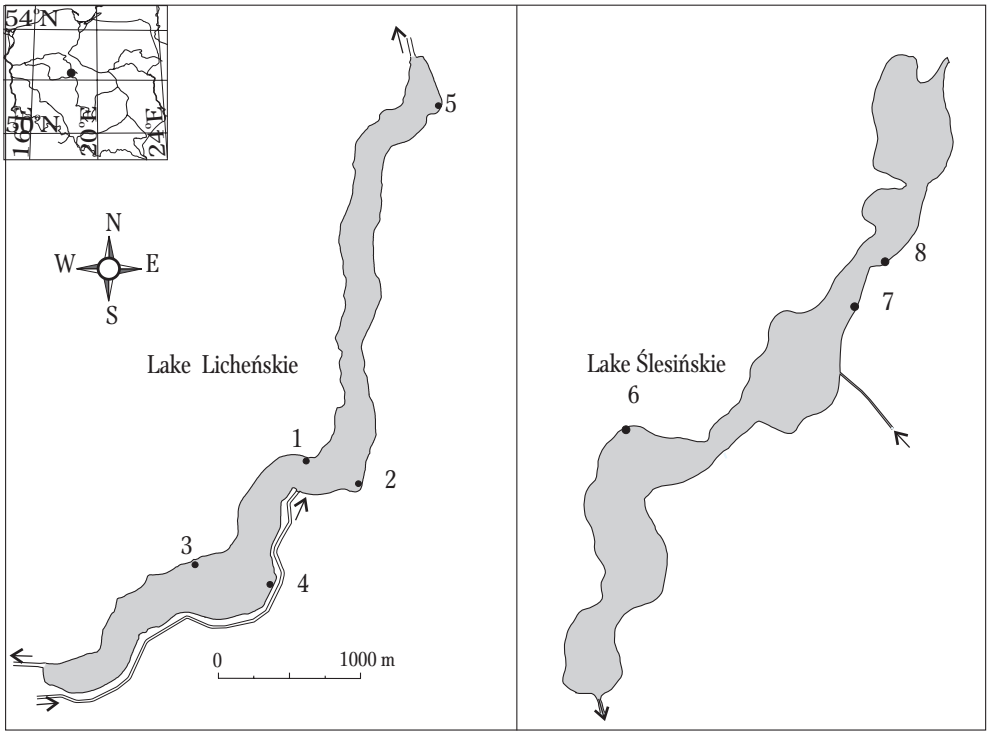

Fig. 1. Location of the bottom sediment sampling stations in lakes Licheńskie and Ślesińskie.

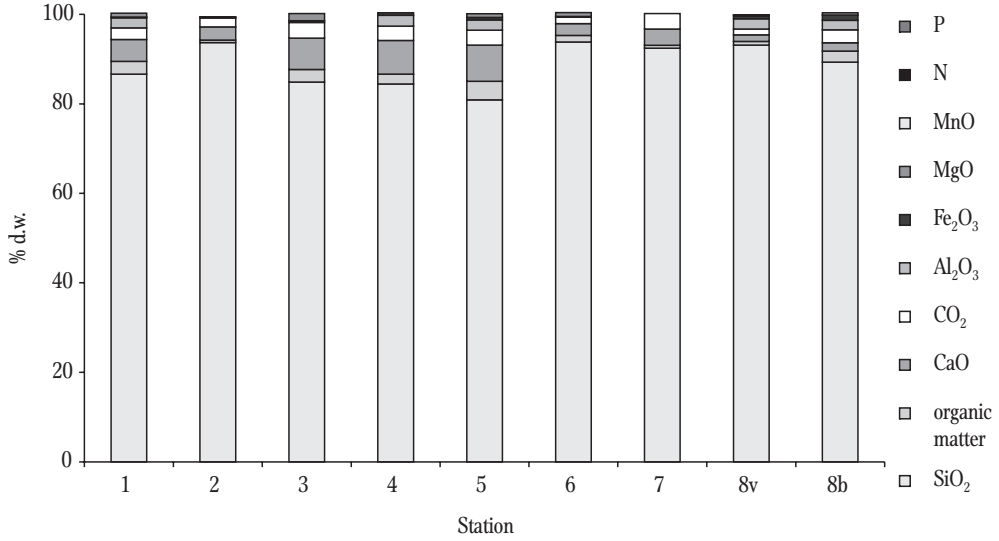

Fig. 2. Chemical composition of the bottom sediments in the littoral zones of the lakes Licheńskie (st. 1-5) and Ślesińskie (st. 6-8). Numbers of the stations correspond to those given in Fig. 1.

accordance with the methods described by Januszkiewicz (1978), except for phosphorus, which was assayed in accordance with the method described by Golachowska (1977). All results were recorded as percentages per dry mass of sediment.

In both lakes, the bottom deposit in littoral on which *V. spiralis* developed was sandy with a water content ranging from 24 to 36%. The dominant component of the bottom deposits was silica. It therefore belonged to the silica type according to the classification scheme proposed by Stangenberg (1938). Silica made up 80.9 to 93.7% SiO_2 in littoral in Lake Licheńskie, and 89.3 to 93.8 % SiO_2 in littoral in Lake Ślesińskie (Fig. 2). Similar contents of silica were measured in littoral sediments from Lake Dejguny in the Mazurian Lake District (Brzozowska et al. 2005). Sediments of this type are frequently found in lakes with exposed shores that are relatively steep, or in lakes in which the sandy shores are periodically exposed due to wide variation in water level (Wiśniewski and Zdanowski 2004).

Organic matter content ranged from 0.6 to 4.2% in bottom deposits from Lake Licheńskie, and from 0.6 to 2.5% in bottom deposits from Lake Ślesińskie. This is comparable to the level recorded in sediments from the littoral zones of Lake Dejguny and Lake Starodworskie, which are highly eutrophic (Gawrońska 1994, Brzozowska et

al. 2005). It is also comparable to the level found in sandy sediment from one site in the littoral zone of Lake Swarzędzkie, which is hypertrophic (Kowalczewska-Madura 2005). The content of organic matter in bottom deposit from the littoral zones of the both investigated lakes was much lower than in sediments from littoral zones of many other lakes, such as Lake Swarzędzkie, which is overgrown with macrophytes (Kowalczewska-Madura 2005). In sediment from the littoral zone of mesotrophic lakes in the Tuchola Landscape Park, the organic matter content ranges from 24.6 to 35.2% (Wiśniewski and Zdanowski 2004).

Total nitrogen content averaged 0.13% in sediments from Lake Licheńskie, and 0.06% in sediments from Lake Ślesińskie. Total nitrogen content was highly correlated with organic matter content ($r = 0.974$, $N = 9$, $P < 0.01$). This indicates that in these lakes nitrogen is deposited together with organic matter, as it is in many other lakes (Brzozowska et al. 2005). Total phosphorus content ranged from 0.017 to 0.067% in sediments from Lake Licheńskie, and from 0.014 to 0.026% in sediments from Lake Ślesińskie. Total phosphorus content was not correlated with organic matter content at either lake. The total nitrogen and total phosphorus levels recorded in lakes Licheńskie and Ślesińskie were typical for lakes that receive little input of these elements from the immediate watershed (Wiśniewski and Zdanowski 2004). Iron content was low, with maximum values of 0.6% in sediments from Lake Licheńskie, and 1.2% in sediments from Lake Ślesińskie. Aluminum content was also low, with maximum values of 2.4% in sediments from Lake Licheńskie, and 2.3% in sediments from Lake Ślesińskie.

Calcium content ranged from 3.0 to 8.1% CaO in sediments from Lake Licheńskie, and from 1.5 to 3.7% CaO in sediments from Lake Ślesińskie. There was little difference in carbonate content in the sediments from the two lakes. Carbonate content ranged from 2.0 to 3.5% CO_2 in sediments from Lake Licheńskie, and from 1.3 to 3.5% CO_2 in sediments from Lake Ślesińskie. Calcium and carbonate are deposited together on the lake bed in the form of calcium carbonate. There should therefore be a strong positive correlation between calcium content and carbonate content (Januszkiewicz and Samulowska 1978). In sediments from Lake Licheńskie, there was a strong correlation between them ($r = 0.96$, $N = 5$, $P < 0.01$). In sediments from Lake Ślesińskie, on the other hand, no significant correlation was found ($r = 0.57$, $P > 0.05$). This indicates that the way in which calcium is deposited beneath patches of *V. spiralis* is fundamentally different in the two lakes. The most important factor involved is the

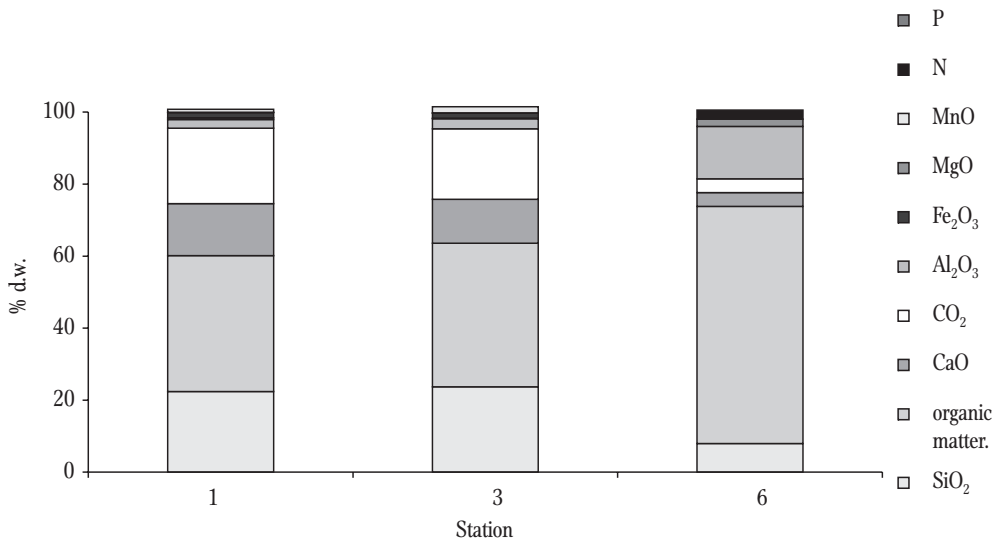

Fig. 3. Chemical composition of the leaves *Vallisneria spiralis* L. growing in lakes Licheńskie (st. 1 i 3) and Ślesińskie (st. 6). Numbers of the stations correspond to those given in Fig. 1.

plants themselves. Leaves of *V. spiralis* and the algae growing on them were visibly more encrusted with calcium carbonate in Lake Licheńskie than in Lake Ślesińskie. As a result, the sediment in the phytolittoral zone of Lake Licheńskie contained a higher amount of calcium. The leaves of *V. spiralis* and the periphytic algae growing on them were far more encrusted with calcium carbonate in Lake Licheńskie than in Lake Ślesińskie (Fig. 3). In dried leaves from Lake Licheńskie, calcium content ranged from 12.2 to 14.4% CaO d.w., and carbonate content ranged from 19.6% and 20.9% CO_2 d.w. In leaves from Lake Ślesińskie, on the other hand, calcium content was only 3.7% CaO d.w., and carbonate content was 3.9% CO_2 d.w. The calcium carbonate encrusting the leaves of *V. spiralis* at Lake Licheńskie was deposited as the result of biological decalcification, in which the very rich epiphytic flora plays a key role (Luścińska et al. 2005, Hutorowicz and Hutorowicz 2007).

Silica content was also much higher in leaves from Lake Licheńskie than in leaves from Lake Ślesińskie (Fig. 3). This was probably because of the higher abundance of diatoms growing on the leaves of *V. spiralis* in Lake Licheńskie (Luścińska et al. 2005).

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CHARAKTERYSTYKA SKŁADU CHEMICZNEGO PODŁOŻA ROZWOJU SUBTROPIKALNEGO GATUNKU *VALLISNERIA SPIRALIS* L. W FITOLITORALU PODGRZANYCH JEZIOR

Celem pracy było określenie składu chemicznego powierzchniowej warstwy podłoża porośniętego przez *Vallisneria spiralis* L. w dwóch, różnie ogrzanych jeziorach (rys. 1). Analizowano również skład chemiczny liści *V. spiralis* wraz z porastającym je epifitonem. Osady litoralowe były zbliżone do typu krzemianowego (rys. 2). Zawartość krzemianów wynosiła od 80,9 do 93,7% s.m., a materii organicznej od 0,6 do 4,2% s.m. (rys. 3). Nieco mniejszą zawartość CaO stwierdzono w osadach litoralowych okresowo podgrzewanego Jeziora Ślesińskiego (1,5-3,7% s.m.) niż całorocznie ogrzewanego Jeziora Licheńskiego (3,0-8,1% s.m.). Analogicznie różniła się zawartość wapnia w liściach *V. spiralis* w jeziorach (rys. 4). Większą zawartość CaO stwierdzono w liściach *V. spiralis* z Jeziora Licheńskiego (12,2-14,4 % s.m.), a niższą z Jeziora Ślesińskiego (3,7% s.m.). Niewątpliwie było to związane z różną obfitością glonów poroślowych (m.in. okrzemek) na liściach *V. spiralis w* badanych jeziorach, a w konsekwencji wpływało na intensywność deponowania wapnia w osadach dennych.