The relationships between environmental factors and the submerged Potametea associations in lakes of north-eastern Poland

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Received 27 December 2004; in revised form 27 September 2005; accepted 2 October 2005

Abstract

A comparative analysis of submerged Potametea communities in lakes of north-eastern Poland was conducted with respect to 16 water chemistry and 14 substrate parameters. The analysis of 187 relevés based on TWINSPLAN clustering showed the existence of 8 aquatic vegetation types. Each of them is characterized by a strong dominance of one of the following macrophytes: Potamogeton lucens, P. perfoliatus, Myriophyllum spicatum, M. verticillatum, Elodea canadensis, Ceratophyllum demersum, Ranunculus circinatus and Hydrilla verticillata. The above vegetation types correspond to the plant associations distinguished using the Braun-Blanquet method (Potametum lucenitis, Potametum perfoliati, Myriophylletum spicati etc.) It was demonstrated that among properties of water analysed, COD-KMnO₄, SO₄²⁻, pH, Na⁺, K⁺, Ca²⁺, total hardness, total Fe, Cl⁻ and colour appear to be most important in differentiating the habitats of the communities studied. In the case of substrates the properties which best differentiated the habitats compared were hydration, organic matter content, total N, PO₄³⁻, K⁺, dissolved SiO₂, SO₄²⁻, Cl⁻ and pH. Most of the aquatic plant communities investigated are distinct with respect to their phytocoenotic structure and ecology and could be good indicators of various types of habitats in lake ecosystems.

Introduction

Aquatic plants and their communities are an important component of the littoral zone in various types of lakes. They form characteristic spatial patterns (Hutchinson, 1975; Spence, 1982; Kłosowski, 1992), which often constitute a transitional boundary between the open water and reedswamp communities. In addition they play an important role in the process of overgrowing of lakes and modify the water and substrate properties, affecting the whole lake ecosystem (Carpenter & Lodge, 1986). It is also recognized that aquatic plants and their communities may be good indicators of the changes occurring in lakes and other water bodies as a result of human-induced acidification (e.g. Grahn, 1977; Roelofs, 1983; Arts et al., 1990; Arts, 2002) and eutrophication (e.g. Lind & Cottam, 1969; Vöge, 1993; Arts, 2002; Nurminen, 2003). The ecology of aquatic plants and their communities was, therefore, the object of interest of many authors in the world (Pietsch, 1972, 1977; Wiegleb, 1978; Pott, 1980; Kadono, 1982; Van Katwijk & Roelofs, 1988; Doll, 1991; Papastergiadou & Babalonas, 1993a, b; Srivastava et al., 1995; Toivonen & Huttunen, 1995; Khedr & El-Demerdash, 1997; Bini et al., 1999; Vastaergaard & Sand-Jensen, 2000; Heegaard et al., 2001; Murphy, 2002). Their findings indicate that macrophytes and their communities (in various regions) could not only reflect the effects of anthropogenic impact but can
be also considered as indicators of various habitat conditions in water ecosystems.

In Poland investigations on the ecology of aquatic vegetation have been carried out for over a period of 25 years (e.g. Klosowski, 1985; Kłosowski & Tomaszewicz, 1989; Szańkowski & Kłosowski, 2001). In the past few years data regarding the ecology of nymphaeid associations (Szańkowski & Kłosowski, 1999) and those obtained for the communities from the class Litto-relleeta uniflorae (Szańkowski & Kłosowski, 2002) have been compiled. The present work aims at summarizing the results of ecological studies conducted among the submerged Potametea communities in lakes of north-eastern Poland. The main objectives of this study were to determine the habitat properties which best differentiated the submerged vegetation in the lakes studied and to define the ecological amplitude and optimum growth conditions for the individual submerged plant communities. I will compare the results of this study with the data reported by other authors.

Material and methods

The survey was carried out in the years 1978–2003 at the height of the growing season (July–August). A total of 187 phytocoenoses of the class Potametea were examined in the study. The criterion of selecting sampling points was the presence of particular dominant species.

In each phytocoenose one phytosociological relevé was recorded by Braun-Blanquet’s (1951) method and water depth was measured in the deepest and the shallowest point of each phytocoenose taking into account the slope of the lake bottom. In each relevé, a list of plant species was made and the abundance of each species was estimated according to modified Braun-Blanquet scale in which + = a few scattered specimens, mean coverage 0.1%; 1 = 1–10% coverage, mean 5%; 2 = 10–25% coverage, mean 17.5%; 3 = 25–50% coverage, mean 37.5%; 5 = 50–75% coverage, mean 62.5%; 5 = 75–100% coverage, mean 87.5%.

In each phytocoenose (within the relevé area) one water and one substrate sample were taken for physical and chemical analyses (187 water and 187 substrate samples together). Both types of samples were collected at the same time as the relevés were performed (July–August). Each year the survey was only carried out at the height of the growing season to ensure the comparability of the data. Water samples were taken from an intermediate depth at which a given phytocoenose occurred and transferred to two 1000 ml plastic containers. Half of the water samples were preserved by the addition of 1 ml H₂SO₄ for NH₄⁺, NO₃⁻, PO₄³⁻, total Fe and COD analyses. Substrate samples were taken from the rhizome-root layer with a tubular bottom sampler and transferred to plastic bags. Each sample was a mixture of three random subsamples taken within a phytocoenose. Both water and substrate samples were stored at 4 °C and analyses were performed directly after the samples were brought to the laboratory.

The following analyses were carried out in water samples: pH (using pH-meter), total and carbonate hardness using Warthy-Pfeifer sodium mixture and by titration with EDTA reagent and ManVer 2 as an indicator, chemical oxygen demand (COD) as consumption of KMnO₄ in acid medium, PO₄³⁻ spectrophotometrically by molybdate method, NO₃⁻ spectrophotometrically with phenoldisulphonic acid, NH₄⁺ by distillation and spectrophotometrically by Nessler’s method, total Fe spectrophotometrically by the rhodanate method, dissolved SiO₂ spectrophotometrically by the molybdate method, SO₄²⁻ spectrophotometrically by the nephelometric method, Cl⁻ by the Mohr’s argentometric method, Mg²⁺ with atomic absorption spectrophotometer, colour spectrophotometrically according to the platinum–cobalt scale, Ca²⁺, K⁺ and Na⁺ with a flame spectrophotometer (concentrations of K⁺ and Na⁺ were determined in 100 ml solutions extracted with 2 ml HCl (1+1) from evaporated and ignited 100 ml samples of water).

In the substrate samples, the following properties were assessed directly: pH, hydration and organic matter content. Concentrations of dissolved SiO₂, NO₃⁻ and Cl⁻ were determined in solutions extracted by addition of 100 ml of demineralised water to a substrate sample containing 1 g of dry matter (water extracts). In the case of solutions used for determinations of total Fe, Ca²⁺, Mg²⁺ PO₄³⁻ and SO₄²⁻ each substrate sample containing 1 g of dry matter was first digested in 20 ml HCl (1+1) within 2 h and then...