Ecotoxicology and Environmental Safety 74 (2011) 558–568

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

The effect of metals accumulated in reed (*Phragmites australis*) on the structure of periphyton

Krystian Obolewski [a], Elżbieta Skorbiłowicz [b], Mirosław Skorbiłowicz [b], Katarzyna Glińska-Lewczuk [c], Aleksander Maria Astel [d,*], Agnieszka Strzelczak [e]

[a] Department of Aquatic Ecology, Pomeranian University in Słupsk, Arciszewskiego Str. 22b, 76-200 Słupsk, Poland
[b] Department of Technological Studies, Technical University of Białystok, Wiejska Str. 45E, 15-351 Białystok, Poland
[c] Department of Land Reclamation and Management, University of Warmia and Mazury in Olsztyn, Plac Łódzki 2, 10-756 Olsztyn, Poland
[d] Environmental Chemistry Research Unit, Pomeranian University in Słupsk, Arciszewskiego Str. 22b, 76-200 Słupsk, Poland
[e] Faculty of Food Sciences and Fisheries, West Pomeranian University of Technology, 3 Papieża Pawła VI Str., 71-459 Szczecin, Poland

ARTICLE INFO

Article history:
Received 23 November 2010
Received in revised form
19 January 2011
Accepted 29 January 2011
Available online 8 March 2011

Keywords:
Trace elements
Periphyton
Reed
Biofouling
Aquatic ecosystems
Greece

ABSTRACT

Studies on trace elements in reed stands and limiting effect of the reed substrate on the periphyton structure were performed in various aquatic ecosystems of Greece during the summer and autumn of 2006. The analysed factors were concentrations of chemical elements (cadmium, lead, zinc, chromium, nickel, copper, cobalt, iron, manganese, potassium, sodium, calcium, magnesium) in reed shoots as well as the density of zooperiphyton and phytoperiphyton taxa. The relationships between metal concentrations and periphyton structure were determined with the use of the multivariate methods Canonical Correspondence *Analysis* (CCA), Detrended Correspondence *Analysis* (DCA) and RDA (Redundancy *Analysis*). The results showed that bioaccumulation of lead and cadmium in the reed had the most negative influence on zooperiphyton species, while low concentrations of alkali metals favoured the occurrence of Cyclopoida, Cladocera (*Chydorus* sp.) and Oligochaeta (*Neis* sp.). A considerable resistance to toxic heavy metals characterised Cyanophyta representatives and, partly, colonial Bacillariophyta. High concentrations of alkali metals supported the presence of unicellular Bacillariophyta but diminished the densities of colonial Bacillariophyta and Chlorophyta of the genus *Scenedesmus*.
© 2011 Elsevier Inc. All rights reserved.

1. Introduction

Common reed *Phragmites australis* (Cav.) Trin. ex Steud belongs to macrophyte species that is the most resistant to environmental conditions, thus it occurs commonly around the world, except for the Amazon river basin (Du Laing et al., 2006). Reed associations (Scirpo-Phragmitetum) are the most important elements of helophyte associations in the internal littoral zone of shallow lakes and other reservoirs due to significant potential to improve water quality (Lakatos et al., 1999). For this reason the reed plays multifold role in nature conservation and environmental protection.

Plant species diversity and their chemical composition may be indicative of the present state and changes in habitat conditions (Hootsmans and Vermaat, 1991). Tissues of *P. australis* show high capacity to accumulate both nutrients and metals (Du Laing et al., 2006; Ye et al., 1997). It supports the use of reed treatment plants in water purification of aquatic reservoirs (Allan, 1998). The amount of accumulated metals depends on the sites, the type of aquatic ecosystem and environmental conditions.

Common reed offers an easily available vertical substrate for a wide group of aquatic organisms, generally referred to epiphytic biotecton. Among the most important factors influencing biofoulers are light, temperature, wavy motion, type of substrate, water quality as well as feeding on periphyton (Allan, 1998; Mihaljević et al., 1998). The effect of other factors has been studied, but there exists scant information on the reed's chemical defence against epiphytic organisms. The released metals can be accumulated in periphyton species which, in turn, are a source of food at the following trophic levels. Nevertheless, biogeochemical relations have been reported in saltwater environments during the development of biofouling (Kirchman and Mitchell, 1981).

Aquatic plants, including reed, release chemical substances containing heavy metals that reduce the density of more sensitive periphyton organisms (Lakatos et al., 1999; Burke et al., 2000). At the same time, selected chemical elements trigger an increase in the density of periphyton taxa. The above has been validated by comparative studies of epiphytic communities on artificial and biotic substrates (Bamforth, 1982; Piesik and Obolewski, 2000;

* Corresponding author. Fax: +48 59 8405 328.
E-mail addresses: obolewsk@apsl.edu.pl (K. Obolewski), eskorbilowicz@pb.bialystok.pl (E. Skorbiłowicz), kaga@uwm.edu.pl (K. Glińska-Lewczuk), astel@apsl.edu.pl (A. Maria Astel), Agnieszka-Strzelczak@zut.edud.pl (A. Strzelczak).

0147-6513/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.ecoenv.2011.01.024

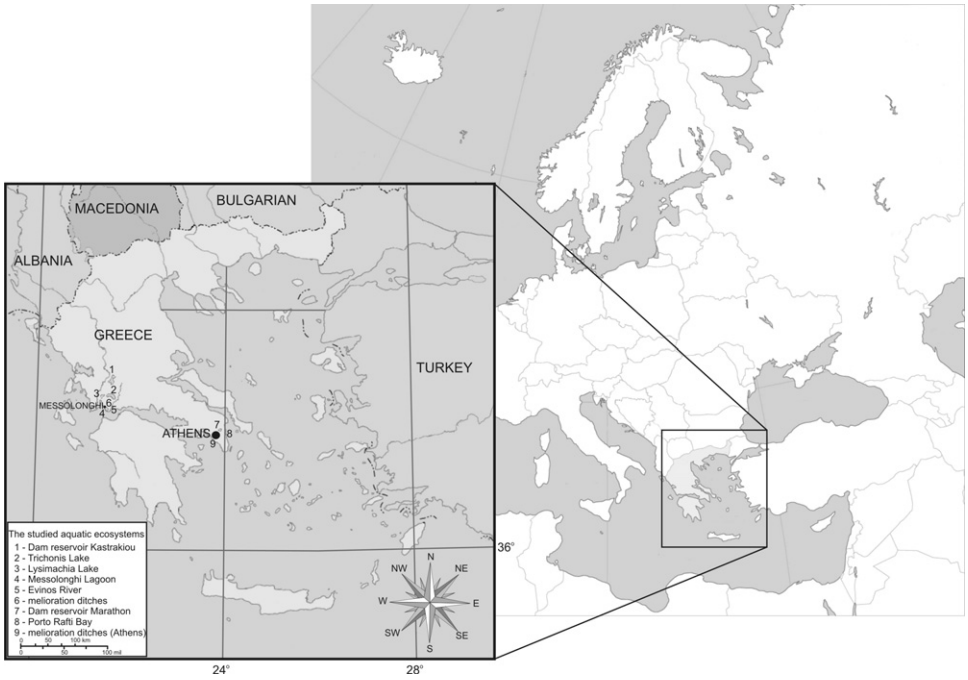

Fig. 1. Location of the studied aquatic ecosystems in Greece.

Obolewski, 2006). The direct impact of biotic substrates' chemical composition on periphyton density is difficult to illustrate mainly due to the overlapping influences of the consecutive factors affecting the overgrowing processes. The periphyton structure, limited by the concentration of chemical elements in plant tissue, needs to be determined to demonstrate the influence of metals on the reed-periphyton relationship.

The emergence of different biofouler groups is spread over time, and it is generally assumed that periphyton formations develop fully in three months (Szlauer-Łukaszewska, 2007). Green, early spring reed shoots are generally weakly overgrown with periphyton, and their ability to accumulate chemical elements is low (Obolewski et al., 2010). According to Lakatos et al., (1999), the level of trace element bioaccumulation increases in particular months of the growing period, and it is accompanied by progressive tissue lignification. The above inhibits the secretion of antifouling substances, and in the autumn, reed becomes covered by a thick layer of periphyton despite its accumulation of vast quantities of metals, including toxic ones (Piesik and Obolewski, 2000). In view of those overlapping influences, field observations of the chemical substrate's effect on biofouling should take place in the summer and autumn.

The aim of our study was to determine the influence of metals (Cd, Pb, Zn, Cr, Ni, Cu, Co, Fe, Mn, K, Na, Ca, Mg) accumulated in submerged shoots of common reed *P. australis* on the density of periphyton in various aquatic ecosystems of Greece.

2. Materials and methods

2.1. Study sites

The studied materials were annual, submerged reed shoots collected in two research seasons (summer and autumn) in 2006 at 45 sampling sites located in Greece in the prefecture of Aetolia–Acarnania and in the area of Athens. In Greece, common reed inhabits aquatic reservoirs in the central part of the country. The following aquatic ecosystems were investigated: Trichonis and Lyssimachia freshwater lakes, saline Messolonghi Lagoon, Kastrakiou and Marathon dam reservoirs, drainage canals in Athens and central Greece in the vicinity of the city of Messalonghi, the Evinos River and the Porto Rafti sea bay (Fig. 1). The study sites were carefully selected against a permanent water table as well as differences in hydrological conditions (letic or lotic ones) and the salinity level (chlorides concentrations).

These locations represent different hydrological types, including stagnant water reservoirs (lakes, lagoon, dam reservoirs, sea bay) and flowing bodies of water (channels, river). They are marked by a different chemical composition, including brackish water (lagoon, sea bay, canal in Athens) and fresh water (lakes, drainage canals, river). Detailed characteristics of the aquatic ecosystems studied in Greece are depicted in Table 1.

2.2. Chemical analysis

Reed material purified of periphyton was subjected to chemical analyses. The collected reed shoots were dried at 80 °C (Peng et al., 2008; Mazej and Germ, 2009) and then homogenised samples were mineralised using pressure Microwave Accelerated Reaction System MARS-5 (CEM Corporation, Matthews, Nortn Carolina, US) in a mixture of H_2O_2 and HNO_3 under high temperature and pressure (Vymazal et al., 2007). According to Du Laing et al. (2006), microwave destruction and destruction using a combination of HNO_3 and H_2O_2 are the most suitable methods for determination heavy metals in reed.

The obtained material was analysed for metal concentrations with flame atomic absorption spectrometer SPECTRA-100A (Varian, Australia). In order to assess measuring errors, the obtained concentrations were compared to the results reported for two certified plant materials (mixture of herbs and tea leaves): INCT-MPH-2 and INCT-TL-1. The calculated measuring error did not exceed 5% of the certified value. The concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn, K, Na, Mg and Ca were given in mg per 1 kg of dry mass (d.m.).

2.3. Periphyton analysis

Five sampling reed stands inhabited by periphyton were set up in each analysed ecosystem. Experimental material was sampled through the direct collection of reed from the substrate or together with the substrate. Three current-year shoots of *P. australis* were sampled from each site. Three sections were removed from each shoot, producing a total of 9 sections from one sampling site. A section of 7–5 cm was cut out from the upper (15 cm below the water table), middle and above-deposit part of every reed shoot.

The collected substrate samples were fixed in 8% formalin or 98% ethanol solution. The length, width and surface area of substrate samples was measured in a laboratory. At the next stage, periphyton was scrubbed off with a brush, rinsed through a plankton net, mesh size 60 μm, and placed in a graduated cylinder with the capacity of 25–100 ml, subject to the density of the analysed material. Substrate was mixed thoroughly in the cylinder, three sub-samples of 1 ml each were collected with a pipette and placed in a plankton chamber. Samples were

Download English Version:

https://daneshyari.com/en/article/4421430

Download Persian Version:

https://daneshyari.com/article/4421430

Daneshyari.com