INVESTIGATION OF THE LEACHING DYNAMICS OF A SUBMERSED MACROPHYTE (*MYRIOPHYLLUM SPICATUM*) IN THE AREA OF LAKE BALATON

Brigitta Simon, Szabina Simon, Angéla Anda, Tamás Kucserka*

University of Pannonia, Department of Meteorology and Water Management

Keszthely 7 Festetics Str H-8360 Hungary

*simonbrigitta.georgikon@gmail.com

Abstract

The concentrations of the different nitrogen and phosphorus forms are key parameters in the ecological system, which can affect the aquatic organisms and the whole ecological balance in natural waters. In this study, from 22 September to 16 November 2017, we investigated the dynamics of nutrient dissolution during the degradation process of *Myriophyllum spictatum*, which is a dominant macrophyte in Lake Balaton. Glass bottles containing plant material and distilled water were incubated at natural temperature from which at specified intervals the liquid phase was removed. We measured the pH, conductivity, NO_3-N, NH_4-N and PO_4-P content of the water samples. The results showed that the NO_3-N and PO_4-P concentrations and the pH were the highest in the first 8 hours while the NH_4-N concentration reached the maximum on day 7. After the 14th day, all the tested parameters became permanent, only the conductivity was observed with greater variability. At the same time sampling was carried out from Lake Balaton and the change of these parameters was monitored.

Key Words: *Miriophyllum spicatum,* Lake Balaton, leaf litter decomposition, leaching

Összefoglalás

Az ökológiai rendszerben a különböző nitrogén- és foszforformák kulcsfontosságú paraméterek, amelyek hatással lehetnek a vízi élőlényekre és a teljes természetes ökológiai egyensúlyra. Kísérletünkben a Balatonban domináns hínárfaj, a *Myriophyllum spicatum* lebontási folyamata során végbemenő tápanyag kioldódás dinamikáját kísértük figyelemmel 2017. szeptember 22 és november 26 között. A növényi anyagot és vizet tartalmazó üvegpalackokat természetes hőmérsékleten inkubáltuk, melyről meghatározott időközönként a folyadékfázist eltávolítottuk. Mértük a víz pH-ját, vezetőképességét, NO_3-N, NH_4-N és PO_4-P tartalmát. Eredményeink azt mutatták, hogy az NO_3-N és PO_4-P koncentráció, illetve a pH az első 8 órában volt a legmagasabb, míg az NH_4-N koncentráció a 7. napon érte el maximumát. A vizsgált paraméterek a kioldódásának üteme egyenletessé vált a 14. napot követően, csupán a vezetőképességnél figyeltünk meg nagyobb változékonyságot. A mintavételekkel egy időben a Balatonból is vízmintát vettünk és figyelemmel kísértük e paraméterek alakulását.

Kulcsszavak: *Miriophyllum spicatum*, Balaton, avarlebontás, kioldódás

Introduction

When macrophytes die, the resulting decomposition processes can, in turn, substantially regulate the recycling of nutrients in fresh water ecosystems over an extended period of time (Pieczynska 1993, Shilla et al. 2006). The importance of each factor in regulating decomposition varies between ecosystems. During mineralization, organic nutrients, such as phosphorous and nitrogen are transformed into inorganic forms, which increases the internal nutrient loads (Ward et al. 2013). The growth of phytoplankton has been regarded as P-limited in many lakes worldwide (Schindler 1977, Correll 1998, Schindler et al. 2008). Shifts in N:P ratios can also shift the composition of phytoplankton species with flow-on effects (Elser et al. 2000).

The examination of the rate of nutrient leaching is important for the quality of the water in Lake Balaton.

Components released from the decomposition litter can contribute to the natural contamination of the water. In this study, the aim was to investigate the nutrient release from macrophyte litter (*Myriophyllum spicatum*) in Lake Balaton.

Materials and Methods

The study was conducted in Lake Balaton, which is a shallow, freshwater lake that lies in the southwestern Hungary. The sample site was in Keszthely Bay, in the littoral zone of the lake, 5 meters far from the bank (17°14'46.3" E and 46°43'32.1" N).

The leaching dynamics of the submersed macrophyte (*Myriophyllum spicatum*) were studied from 22 September to 16 November 2017, using the method of Gaudet and Muthuri

(1981). Release of nutrients during decomposition of the macrophyte litter was investigated *in situ* in Lake Balaton using 0.5 liter of volume glass bottles into which 0.45 liter destilled water and 25 g of oven dried macrophyte material were placed. The bottles were incubated *in situ* to 1 m depth in the water.

The changes in nutrient content of each bottle were analyzed after 0.4, 1, 3, 7, 14, 28 and 56 days by taking 450 ml of water from the triplicates for the determination of phosphorus, ammonium, nitrate, pH and conductivity. These parameters were also determined from the water samples taken from Lake Balaton. The physical andchemical variables (pH, conductivity, NO_3-N, NH_4-N and PO_4-P) were determined using a spectrophotometer (Lovibond MultiDirect) and pH and conductivity were determined with Neotek-Ponsel Odeon Digital Meter.

Results and Discussion

A decreasing trend was observed in the nitrate concentrations in the bottles (Figure 1.). The decrease in the first 14 days in the incubated bottles could be registered either due to the microbial utilization of nitrates by microbes for protein production or due to ammonia volatilation (Reddy and Sacco 1981), which was also evidenced by higher pH values recorded during the incubation in the bottles (Figure 4.). Subsequently, a slow increase in nitrate concentration was observed. The figure shows that nitrate dissolution (29.7 mg L^{-1}) is the fastest in the first 8 hours, and it is consistent from the seventh day (8-11 mg L^{-1}). Tamire et al. (2017) observed a similar tendency in the nitrate dissolution from *Arundo donax*, *Echinochloa colona*, *Potamogeton schweinfurthii*, *Cyperus articulatus*, *Typha latifolia*, *Cyperus papyrus* and *Nymphaea lotus*. In the littoral zone of Lake Balaton nitrate was not detectable (under 1 mgL^{-1}).

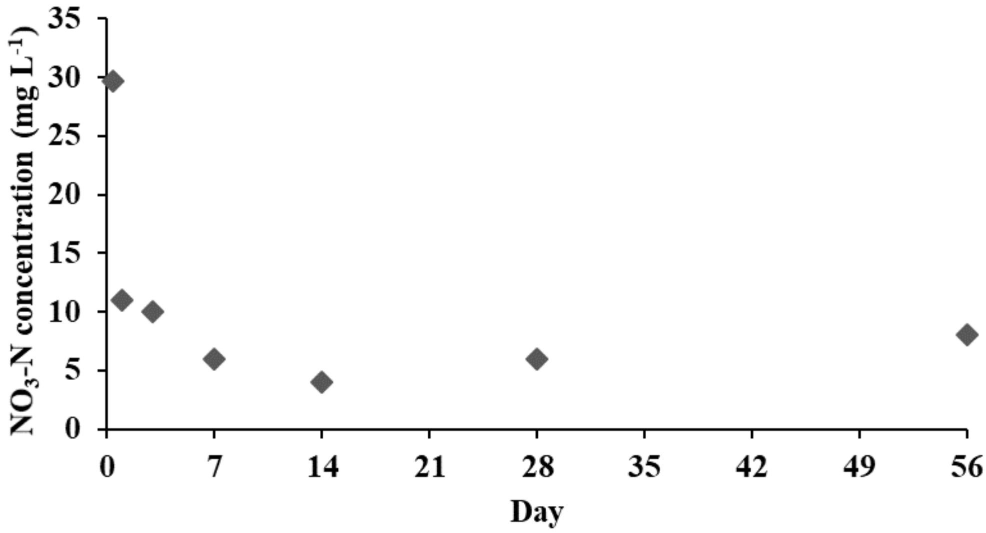

Figure 1. Change in NO_3-N concentrations in the water of the incubated bottles during the experimental period in Lake Balaton

The dissolution rate of ammonia is inversely proportional to nitrate. The concentrations of ammonia at each sampling time are shown in Figure 2. The concentration of ammonia increased intensively, peaked on the seventh day, which was followed by a sudden decrease. The average concentration of ammonia was 0.2±0.1 mg L^{-1}in Lake Balaton during the study period. The rapid increase of NH_4-N concentration at the beginning stage was mainly derived from releasing of the decomposition process, and the subsequent decrease was probably attributed to nitrification by nitrifying bacteria in the water. Wu et al. (2017) also observed a similar tendency . As well as their investigations showed that higher NH_3-N was obtained with higher dosage of the plant litter, for example, NH_3-N in the water increased from 2.58 to 14.30 mg L^{-1} when the dosage of *Eichhornia crassipes* litter increased from 0.1 to 1.0 g L^{-1}.

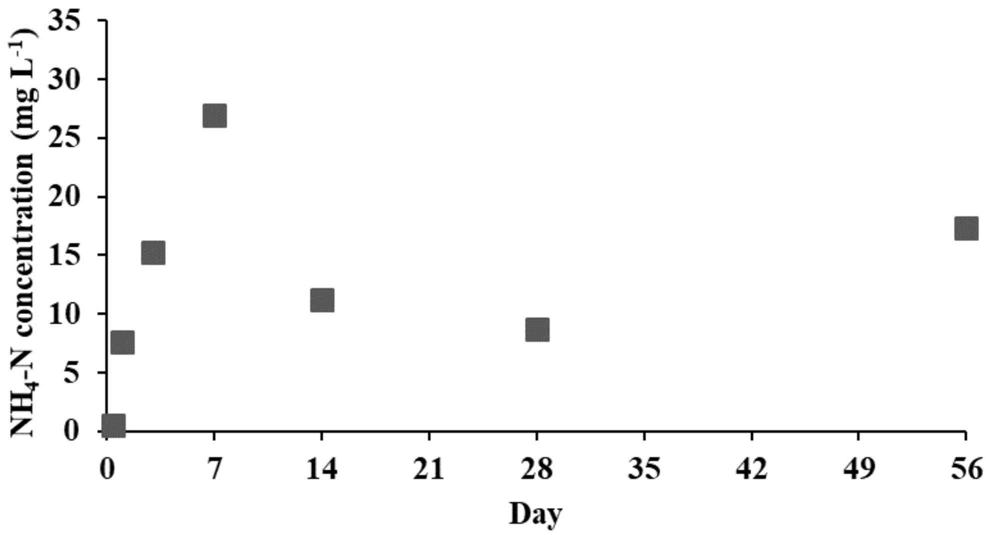

Figure 2. Change in NH_4-N concentrations in the water of the incubated bottles during the experimental period in Lake Balaton

Landers (1982) investigated the nutrient release of the submerged macrophyte, *Myriophyllum spicatum* during its annual dieback, and also demonstrated a greater impact on water column P than N. Park and Cho (2003) have reported that the leaching process of phosphorous from aquatic macrophyte litter can provide considerable contribution to the eutrophication of some aquatic ecosystems. According to our results, phosphorous concentration from the decomposition of macrophytes appears to be low in Lake Balaton (Figure 3.). The rate of phosphorous leaching is decreasing. The highest concentrations were measured on the first day (47.3 and 40.3 mg L^{-1}), from the 14th day degree of dissolution decreased by half (24.0-21.4 mg L^{-1}). The concentration of phosphorus was low (0.23±0.1 mg L^{-1}) in the littoral zone of the Lake Balaton from September to November. The change in the phosphorous concentration during the experiment was narrow. The increment in phosphate during this study, where the increase was from 21.4 to 47.3 mg l^{-1} in bottles, was much higher when compared with the experiment of Tamire et al. (2017) (with similar submerged macrophyte (*Potamogeton schweinfurthii*), where 3 g of dried macrophyte was incubated into 1 liter of water. They observed an increase from 35 µg L^{-1} to 160 µg L^{-1} of phosphate in Lake Ziway (Etihopia). Gibtan and Abera (2012) reported much higher phosphate concentration (212 µg l^{-1}) at the mouth of River Bulbula, than recorded in Lake Ziway.

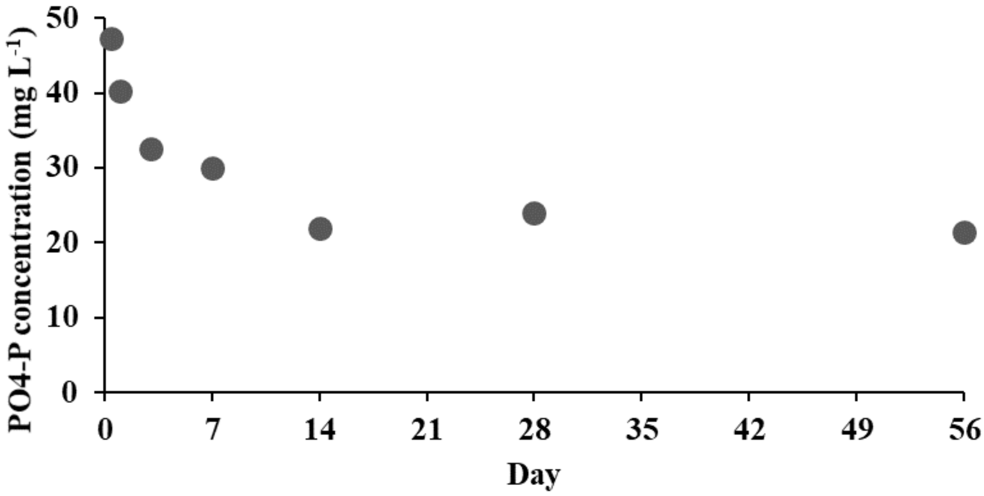

Figure 3. Change in PO_4- concentration in the incubated bottles water during the experiment period in Lake Balaton

The pH values of the water samples taken from the glasses are shown in Figure 4.a. At the first day, pH of the water grew rapidly and reached the maximum (pH=7.67), followed by the gradual decrease (1-7 day) and finally reached a stable value (14-56 day, pH= 6.3-6.5). The pH increment was probably due to the consumption of the organic acids by the microorganisms in the water (Gaudet & Muthuri, 1981). Later, pH became stable at the decomposition stage, it was likely that decomposition process was slowed down by lower leaching acids at this stage. The seasonal average of pH in Lake Balaton was 8.4±0.5 in the in investigation period.

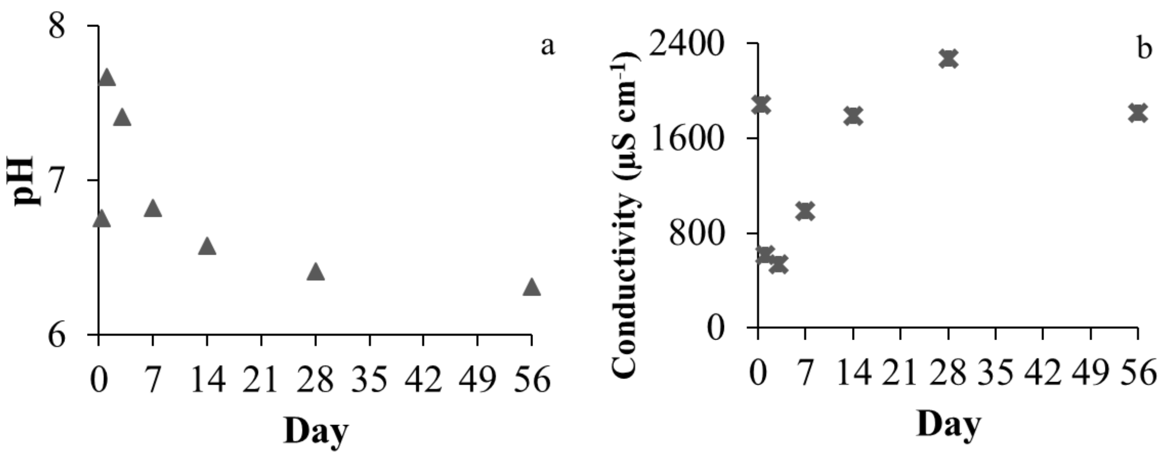

Figure 4. Change in pH (a) and conductivity (b) in the incubated bottles during the experiment period in Lake Balaton

Figure 4.b. shows the conductivity in the bottles. The high conductivity measured after the first sampling was followed by a sudden decrease in the first and third days, and after the third day it shows an upward trend. Dahroug et al. (2016) investigated the existence of temporal fluctuations of limnological parameters during *Eichhornia azurea* decomposition. The study showed that the conductivity significantly correlated with the density of water and bacterial biomass. According to Esteves (1988), conductivity values are related to the trophic state of the water. Thus, increased nutrient concentrations from the decomposition and subsequent release of ions affected the conductivity. The conductivity measured at natural conditions in Lake Balaton was 671.5±41.3 µS cm^{-1} during the investigation period.

Conclusions

In this study, decomposition processes of *Miriophyllum spicatum* litter were studied to determine the influence in aquatic environment, including pH, conuctivity, NH_4-N, NO_3-N, PO_4-P. In conclusion, this study showed that macrophyte species could release significant concentrations of nutrients when desiccated and rewetted. The relative high pH (8.4±0.5), low conductivity (671.5±41.3 µS cm^{-1}) and low NO_3-N (underrange), NH_4-N (0.23±0.1 mg L^{-1})

and PO_4-P (0.2±0.1 mg L^{-1}) concentration of the littoral zone of the lake could show the absence of significant effect of decomposition of the macrophyte on the water quality parameters of Lake Balaton in autumn.

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