The role of submerged macrophytes in the regulation of internal nitrogen and phosphorus release

Jing Wan (Wuhan University, PR China; Hubei Academy of Environmental Sciences , PR China), Hong Peng, Xu Zhang, Wanshun Zhang* , Xiaomin Chen (Wuhan University, PR China)

Introduction

In aquatic systems, excessive N and P often leads to rapid production of phytoplankton thus deteriorates the water quality. Reducing the external N and P loading could not always render a prompt recovery from eutrophication, as in some cases, N and P stored in sediment as the internal source would become main sources for eutrophication. Such delayed responses typically stem from the positive feedback between internal N and P release, which highlights the importance of internal N and P releasing processes at the water-sediment interface.

Sediment is vital in determining the concentration and vertical transport of N and P. Internal cycling involves the movement of N and P into or out of the sediment as a result of biological, physical and chemical processes that are affected by factors including temperature, redox conditions, pH, dissolved oxygen, sediment resuspension and benthic biological community. Nitrogen and phosphorus deposition may be remineralized as inorganic N and P and released to pore water, which can flux out into overlying water.

Nitrogen and phosphorus can be released from sediment through a variety of mechanisms. Among several possible processes, N and P release at the water-sediment interface in the regulation of submerged macrophytes is important, and further research is needed to clarify how N and P release from sediment affected by submerged macrophytes. In this study, we aim to have a better understanding of sediment N and P release under the growth of submerged macrophytes.

Materials and Methods

Microcosms and Experimental Design

To have a better understanding of N and P release processes under the growth of submerged macrophytes, N and P release simulation was conducted in microcosms. Two commonly used submerged macrophytes in eutrophicated water purification in China, *V. natans* and *M. verticillatum*, were selected as the experimental plants. Sediment and overlying water used in the ecological microcosm experiment were collected from Xinghu Lake in Wuhan University, China (30° 31'47″N, 114° 21'10″E).

Filling 72 L 1.2-cm-thick glass tanks with 20-cm-thick sediment. Black cloths were wrapped around the glass tanks to exclude light from the tanks' sides. The collected water was fully mixed and slowly added to the glass tanks until the water depth reached 35 cm, respectively. Leave the microcosms for 48 hours to be stabilized before planting. Before transplanted into glass tanks, plants of these two submerged macrophytes were washed carefully with water to remove impurities and then transplanted in glass tanks, separately. The average height of these submerged macrophytes was about 20 cm. The ecological microcosm experiment was conducted with and without submerged macrophytes. Three treatments were designed which included the control (without planting submerged macrophytes), V treatment (treatment with *V. natans*) and M treatment (treatment with *M. verticillatum*). Each treatment had three replicates.

To simulate outdoor temperature, the ecological microcosm experiment was conducted under laboratory conditions without any artificial heat preservation. Glass tanks were placed in the greenhouse of the College of Resources and Environmental Science, Wuhan University, China.

Sample Collection and Analysis

Water samples were collected at intervals of 5 cm, 15 cm and 30 cm at equal volume (10 mL). In order to prevent the sediment disturbance, sediment samples were collected by a sediment core sampler with 2-cm-diameter cross section. The average height of *V. natan* and *M. verticillatum* was measured by tape when water and sediment sampled.

Results

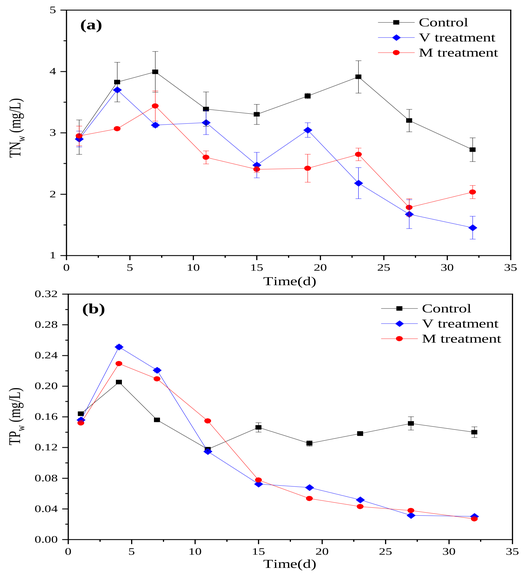

Figure 1. Temporal variations of (a) total nitrogen concentrations in overlying water (TN_w) and (b) total phosphorus concentrations in overlying water (TP_w) during the ecological microcosm experiment (mean ± SD, n=3).

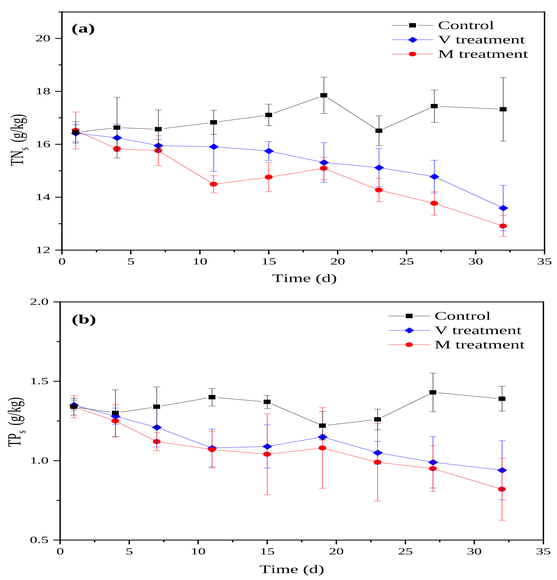

Figure 2. Temporal variations of (a) total nitrogen concentrations in sediment (TN_s) and (b) total phosphorus concentrations in sediment (TP_s) during the ecological microcosm experiment (mean ± SD, n=3).

Table 1. The average N and P release rates at the water-sediment interface during the ecological microcosm experiment.

Treatment	Variable	Average release rate ($mg \cdot m^{-2} \cdot d^{-1}$)
Control	R_N	-2.25
	R_P	-0.26
V treatment	R_N	-15.81
	R_P	-1.38
M treatment	R_N	-10.02
	R_P	-1.37

Note: R_N-N release rates at the water-sediment interface; R_P-P release rates at the water-sediment interface .

- **TNw in the control were higher than that in the V and M treatments. TNw in the V treatment at the end of the ecological microcosm experiment were lower than that in the M treatment. TPw in the control fluctuated, and that in the V and M treatments increased in the first 4 days and then decreased rapidly. TPw were significantly reduced at the effect of submerged macrophytes.**
- **TNs and TPs were significantly influenced by the treatments ($P < 0.05$). TNs and TPs were reduced with the presence of V. natans and M. verticillatum, whose values were arranged as M treatment < V treatment < control. TNs and TPs in the V and M treatments had a gradually decreased trends over time.**
- **The absolute values of R_N and R_P in the V and M treatments were obviously larger than that in the control, and arranged in the order of V treatment > M treatment > control. Thus, V. natans and M. verticillatum which are mainly wetland plants can accelerate the deposition of N and P in overlying water, and have differences in controlling internal N and P release.**

Conclusions

- ✓ **TN and TP concentrations in overlying water and sediment decreased under the effect of V. natans and M. verticillatum. The study revealed that the decreased release rates of N and P would be presented under the growing of submerged macrophytes.**
- ✓ **The R_N and R_P in all treatments were negative, and the descending order of their absolute values was V treatment, M treatment and control.**

References

Lu, J.; Bunn, S.E.; Burford, M.A. 2018, Science of The Total Environment.

Diepens, N.J.; Arts, G.H.P.; Focks, A.; Koelmans, A.A. 2014, Environmental Science & Technology

*** Corresponding author. Tel.: +86 13971480859, E-mail: wszhang@whu.edu.cn**