USE OF BIOENGINEERING TECHNIQUES IN RIVER RESTORATION FROM A FUNCTIONAL PERSPECTIVE: UNDERSTANDING DRIVERS OF NITROGEN REMOVAL

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INTRODUCTION

Many bioengineering techniques involve the use of helophytes to reduce soil erosion and increase landscape stabilization. However, helophytes can influence carbon (C) quality, water residence time and biogeochemical rates, and thus they can also play a relevant role on in-stream nitrogen (N) removal (Peipoch et al., 2013). Therefore, these bioengineering techniques could be successfully applied in stream reaches downstream of wastewater treatment plant (WWTP) effluents which usually exhibit a high capacity to nitrify ammonium but a low capacity to permanently remove N via denitrification (Ribot et al. 2012). In this study, we tested the effect of helophytes on net N removal by using flumes receiving treated water from a WWTP. Furthermore, we added a labile C source to the flumes to test whether the low C quality of the treated waste water can limit N removal, and in particular denitrification.

MATERIALS AND METHODS

Experimental approach:

In a set of 12 artificial flumes with sub-surface flow, fed with water from a WWTP effluent, we defined 4 different treatments: 3 gravel-bed flumes with *Iris pseudachorus*, 3 flumes with *Scirpus holoschoenus,* and 3 flumes with *Phragmites australis;* finally, 3 flumes were left unvegetated and served as controls (Fig. 1). At each flume, we examined longitudinal variation of dissolved inorganic nitrogen (DIN) concentration in sub-surface water (5 sites along each channel) to estimate net DIN uptake rates before and after a 3-days addition of a labile carbon source from a waste product of beer production.

Parameter calculations and statistical analysis:

Net DIN uptake rates (U_{net}, mgN min^{-1} m^{-2}) were estimated as the difference in DIN load (concentration and flow rate) between two adjacent sampling locations divided by the surface area between the two sites (2 x 0.6 m^2). For each flume, U_{net} was the average of the rates estimated at the 4 subsections. To compare U_{net} among flume treatments, we used a one-way ANOVA with repeated measures with the type of channel as fixed factor (n = 4) and U_{net} estimated within each channel (n = 4) as repeated measures. For each flume treatment, we also compared the effect of the C addition on U_{net} using a one-way ANOVA with repeated measures with absence/presence of C as fixed factor (n = 2) and U_{net} estimated within each channel (n = 4) as repeated measures.

RESULTS AND DISCUSSION

We found that artificial flumes have a remarkable capacity to biogeochemically process DIN along sub-surface flow paths as indicated by $U_{net} \neq 0$ in most cases (Fig. 2), but we did not observe a predominance of N removal ($U_{net} > 1$) over N release ($U_{net} < 1$) processes. Furthermore, the large variability observed in U_{net} within each treatment, resulted in no significant differences between the control flumes and those with helophytes (one-way ANOVA, p-value = 0.891). In addition, despite some variability in U_{net} before and after the C addition, results from the one-way ANOVA indicated no significant effect of the C addition on U_{net} for any treatment (p-value ≥ 0.200), suggesting that either DIN removal is not limited by C availability or that the C addition was not long enough to clearly enhance N removal in the systems.

Figures

Fig. 1. General view of the flumes at the Urban River Lab experimental platform where the study was conducted (www.urbanriverlab.com).

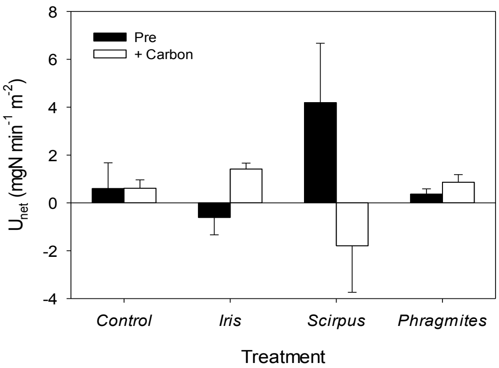

Fig. 2. Net DIN uptake rates (U_{net}) on the flumes for the 4 treatments: control (unvegetated) and the 3 different species of helophytes before (Pre) and during C addition (+ Carbon). Data are the mean ± SE of 12 values (4 values at each of the 3 flumes for each treatment). Positive and negative values denote net removal and release of DIN within each channel, respectively.

CONCLUSIONS

Helophytes used in bioengineering practices may contribute to the net removal of DIN in sub-surface water of streams; however the high variability in U_{net} at local scale overwhelms potential differences among flume treatments studied. Furthermore, labile C does not seem to limit rates of net N removal in the study system.

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