THE EFFECTS OF A GOLF COURSE ON LEAF LITTER BREAKDOWN RATES IN A GEORGIA PIEDMONT STREAM

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Abstract. Golf courses apply heavy loads of fertilizer and a variety of pesticides, including fungicides, herbicides, and insecticides, to maintain both impeccable greens and aesthetically pleasing fairways and fringes. The primary purpose of this study is to determine if these practices have an impact upon leaf litter breakdown rates in a stream draining a suburban Atlanta golf course. *Liriodendron tulipifera* leaf packs were placed in a reference reach upstream of the golf course and in a study reach, just below a tributary draining a green. Mass of leaf material remaining in leaf packs was determined incrementally, and the logarithmic leaf breakdown rate (k) was calculated for each reach. Fine sediment accumulation in packs, and concentrations of NO_3, NH_4, soluble reactive phosphorous (SRP), chlorothalonil, and its metabolite in the water were measured. Similar leaf breakdown rates were found for each reach, although the study reach had somewhat higher concentrations of NO_3-N and OH-chlorothalonil.

INTRODUCTION

Leaf litter breakdown is a vital process in stream ecosystems. Aside from photosynthesis, the breakdown and recycling of allochthonous inputs is the major energy and nutrient source for the entire ecosystem. Leaf litter decomposition is largely facilitated by hyphomycetes (Webster and Benfield, 1986), which are more closely associated with leaves in the early phases of decomposition than bacteria (Weyers and Suberkropp, 1996).

Leaf litter breakdown rates have been shown to vary with different land usage (Paul 1999). Golf courses are among the most highly managed systems in the world today, with extremely high loads of both fertilizers and pesticides required to maintain a pristine area for play. A typical southern Piedmont golf course may apply upwards of 300 lbs of pesticides per acre each year, including as many as twenty different insecticides, herbicides and fungicides (Armbrust, in press).

Golf course pesticides could contaminate streams via runoff or by leaching into ground water. The entrance of these toxins, particularly fungicides, may kill or hinder the aquatic hyphomycetes necessary for leaf decomposition, thereby slowing leaf breakdown. Despite the recent increase in studies considering the impacts of golf courses on lakes, streams and marine sediments (Cohen et al, 1999, Miles et al, 1992,Ryals et al, 1998), the possible effects on leaf breakdown rates have been neglected. The purpose of this study is to evaluate the impact of a southern Piedmont golf course on the leaf litter breakdown rate in a suburban stream.

METHODS

Study Site

The study is being conducted in Camp Creek at the Golf Club of Georgia, located in Alpharetta. The study reach is a 75 m stretch located just downstream from a small tributary that drains the thirteenth hole. The reference reach is approximately 1 km upstream of the study reach, and just upstream of the point where Camp Creek enters the golf course.

Leaf Pack Assemblage and Placement

Liriodendron tulipifera leaves were collected as they fell from various trees in Athens, GA . After drying at room temperature for two days, the leaves were assembled into 8g packs. On November 7, 2000, 36 packs were placed in each reach. Packs were placed to minimize variation of physical parameters such as depth, velocity, canopy density and distance from bank. Three packs were temporarily placed in the stream and removed on day 0 to control for mass loss due to handling in the field.

Leaf Pack Removal and Processing

Three or four packs were removed from each reach on six dates between November 14, 2000 and January 31, 2001. Packs were collected from separate stakes within each reach with a small mesh net to capture insects and fine particles dislodged during the removal process. Packs were individually placed in plastic bags, stored on ice, and brought back to the lab (two hours away). Depth and velocity were measured where each pack was anchored.

On each sampling date, a water sample was taken from each reach, and filtered for nutrient analysis. NO_3, NH_4 and soluble reactive phosphorus (SRP) were measured using standard analytical techniques (4500 NO_3-H, 4500 NH_4-H, 4500 P-F in Greenberg et al., 1992). A grab sample was taken from each site on two dates (August and October 2000) and analyzed for pesticide content (methods found in Armbrust, in press).

In the lab, the leaf packs were rinsed free of sediment over a 250 µm mesh sieve and a sediment collection bucket. A sub-sample from the bucket was dried and weighed to determine the mass of fine sediment accumulating in packs.

Leaf packs were dried at 60°C, weighed, and a sub-sample ashed at 500°C to determine ash free dry mass. A natural log regression was used to determine the breakdown rate for each reach (Webster and Benfield, 1986).

RESULTS AND DISCUSSION

Although concentrations of NO_3-N and NH_4-N were higher in the study reach than in the reference reach on all dates, only the nitrate concentrations were significantly different ($p<0.05$, see Table 1). Higher nitrate concentrations in the study reach are probably caused by runoff of fertilizers from the golf course. Leaf packs in the study reach accumulated somewhat less fine sediment per pack; however, the difference was not statistically significant ($p>0.05$), probably due to high variability within each site (several packs from each reach were completely buried, and therefore had much higher sediment loads). Higher nutrient concentrations and lower sedimentation should result in more rapid leaf decay in the study reach, yet the two breakdown rates were not significantly different because their 95% confidence intervals overlapped (Table 1). High variability within the data set resulted in wide confidence intervals, which in turn deemed the breakdown rates to be equal.

Table 1: A comparison of the leaf breakdown rates (slope +,- 95% confidence limits), sediment accumulation (mean and standard error of 20 samples), and nutrient concentrations (mean and standard error of 3 samples taken over the course of the study period) and OH-chlorothalonil taken from a grab sample in August, 2000.

Parameter	Reference Site	Study Site
K (d^{-1}) with confidence	0.0113 (0.0054)	0.0074 (0.0056)
Sediments (standard error)	1.63 g (0.07)	1.18 g (0.05)
NO_3N(mg/l)	0.155 (0.007)	0.279 (0.007)
NH_4N(mg/l)	0.040 (0.020)	0.061 (0.010)
SRP (mg/l)	0.006 (0.0005)	0.006 (0.0005)
OH-chloro-thalonil	3.26 ppb	5.23 ppb

The breakdown rate within the golf course was slightly lower than what has been previously reported for *Liriodendron tulipifera* in a southeastern headwater stream, while the upstream reference was approximately equal to it (0.01/day in Webster and Benfield, 1986). A higher concentration of the degradation product of the fungicide chlorothalonil was found in the study site on one sampling date (Table 1). OH-chlorothalonil was not detected in the second sample taken in October, 2000. This metabolite has low activity in terrestrial systems but has not been tested with aquatic hyphomycetes (Armbrust, in press).

Slow leaf breakdown rates have negative implications for the stream ecosystem. They imply that energy is entering the food web at a slower rate, which could affect invertebrates and fish in the stream. Breakdown rates measured in this study were somewhat lower in the golf course, but our ability to detect differences between sites was limited because of within site variability. We are continuing to monitor leaf breakdown at these sites. Measuring breakdown over a longer period of time should enable us to reduce the variability associated with these rates and determine if the lower breakdown rate suggested by the golf course data is real.

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LITERATURE CITED

Armbrust, K.L. (in press). Chlorothalonil and chlorpyrifos degradation products in golf course green leachate. *Pest Management Science.*

Cohen, S., A. Svrjeck, T. Durborow and N. L. Barnes (1999). Ground water quality. *Journal of Environmental Quality*, 28: 798 – 808.

Greenberg, A.E., L.S. Clescori and A.D. Eaton (1992). *Standard Methods for the Examination of Wather and Wastewater, 18th edition.* American Public Health Association, Washington, D.C.

Miles, C. J., G. Leong and S. Dollar (1992). Pesticides in marine sediments associated with golf course runoff. *Bulletin of Environmental Contamination and Toxicology*, 49: 179 – 185.

Paul, M. J. and J. L. Meyer (1996) Fungal biomass of 3 leaf litter species during decay in an Appalachian stream. *Journal of the North American Benthological Society,* 15: 421 – 432).

Paul, M. J. (1999). Stream ecosystem function along a land-use gradient. PHD disseratation.

Ryals, S. C., M. B. Genter and R. B. Leidy (1998). Assessment of suface water quality on three eastern North Carolina golf courses. *Environmental Toxicology and Chemistry*, 17: 1934 – 1942.

Webster, J. R. and E. F. Benfield (1986). Vascular plant breakdown in freshwater ecosystems. *Annual Review of Ecology and Systematics*, 17: 567 – 594.

Weyers, H. S. and K. Suberkropp (1996). Fungal and bacterial production during the breakdown of yellow poplar leaves in 2 streams. *Journal of the North American Benthological Association*, 15: 408 – 420.