EFFECTS OF ACIDIC PRECIPITATION ON LEAF DECOMPOSITION RATES, MICROBIAL BIOMASS, AND LEAF PACK MACROINVERTEBRATES IN SIX STREAMS ON THE ALLEGHENY PLATEAU OF WEST VIRGINIA

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Abstract: We studied the effects of acidification on leaf litter decomposition in six headwater streams in the Monongahela National Forest. These streams differed in underlying geology and mean baseflow pH (3.99, 4.24, 6.13, 6.47, 6.59, and 7.52). We placed 10-gram leaf packs of white oak, red maple, and yellow poplar in each stream, and retrieved them after two days, two weeks, and then at 4-week intervals from November 1993 to February 1994. Leaf packs were analyzed to determine changes through time in leaf decay rate, invertebrate composition, density, and biomass, and microbial biomass (ATP concentration). The mass loss rate coefficient, k, ranged from -0.0128 to -0.0052 for poplar, -0.0120 to -0.0047 for maple, and -0.0059 to -0.0018 for oak. The acidic streams had significantly lower decay rates. The acidic streams had higher invertebrate densities but lower biomass than the more alkaline streams. ATP concentrations were lower in the acidic streams than in the more alkaline streams. In streams that are vulnerable to acidification, pH depression may reduce energy and material availability to stream macroconsumers.

INTRODUCTION

Allochthonous leaf litter may constitute as much as 90 percent of a stream's energy budget (Anderson & Sedell 1979; Fisher & Likens 1973). Decreased leaf litter processing rates have been observed in acidified aquatic systems (Burton et al. 1985; Griffith & Perry 1993; Mulholland et al. 1987). Decreases in processing rates have been attributed to direct toxicological effects of high H^+ concentrations, increased solubility of metals, particularly aluminum, and decreased microbial activity.

We placed three species of leaf packs in six streams of different mean pH. Mass loss rates, invertebrate community structure, and ATP concentration (microbial biomass) from each stream were compared in order to determine the effects of acidification on detrital processing.

METHODS

Site Descriptions

We sampled six streams: Freeland Run (FR), Engine Run (ER), South Fork of Red Run (SFR), Wilson Hollow (WH), Hickman Slide Hollow (HSH), and Camp Hollow (CH). All are in or near the Monongahela National Forest, Tucker County, West Virginia. Mean baseflow pH for the streams were 3.99 (ER), 4.24 (SFR), 6.13 (WH), 6.47 (FR), 6.59 (CH) and 7.52 (HSH).

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Field Procedures

Nylon mesh bags (3-mm) were filled with 10g of either white oak, red maple or yellow poplar leaves. During the first week in November 1993, we placed 42 bags of each species in the center of each stream channel. After 2, 14, 28, 56, and 84 days, five bags of each species were randomly selected and removed. On each sampling day, stream pH and conductivity were measured, and a grab sample for measuring water chemistry was collected. Water temperature was continuously monitored with a Ryan model J thermograph in a pool of each stream.

Laboratory Procedures

Three replicates of five leaf disks were cut from each leaf pack using a 10-mm diameter cork borer, two for ATP analysis, and one for ash-free dry weight determination.

Invertebrates in the leaf packs were separated from the organic matter, identified to the lowest possible taxa, and enumerated. They were then dried, and weighed to estimate biomass. ATP was extracted from two replicates from each leaf pack using H_2SO_4 and assayed using a luciferin-luciferase bioluminescence assay (Suberkropp & Klug 1976).

RESULTS

Water chemistry and temperature

Streamwater pH was highest in HSH (7.52), lowest in ER (3.99) and SFR (4.24), and intermediate in WH (6.13), FR (6.47) and CH (6.59). Daily mean stream temperatures decreased as the study progressed from 7°C at the start of the study to 2°C at the end.

Leaf pack processing rates

During the 12-week study, AFDW of the leaves decreased from a mean initial weight of 8.60 g/bag at all sites for all species to values ranging from 3.02 g/bag to 7.25 g/bag. Decay rate coefficients ranged from -0.0018 for oak in ER to -0.0128 for poplar in CH. The decay rates for the acidic streams were significantly lower than both the neutral and alkaline streams for all leaf species ($p<0.01$). The decay rate for the alkaline stream was not different from the circumneutral streams for oak and poplar, but was significantly lower for maple ($p<0.01$).

Microbial biomass

ATP concentrations were significantly lower in the acidic streams than in the neutral or alkaline streams for maple ($p<0.01$) and for oak ($p<0.05$). There were no significant differences in ATP concentrations on poplar leaves among streams.

Shredder densities and biomass

The acidic streams supported significantly higher densities of invertebrate shredders than the neutral streams, which in turn supported significantly higher numbers than the alkaline stream. Based on ANOVA results, there were no significant differences in shredder biomass among the three pH groups. The shredder communities of the two acidic streams (ER and SFR) tended to be dominated by *Leuctra* and *Amphinemura,* and the communities of the other streams included significant numbers of *Pycnopsyche*, *Peltoperla*, *Paracapnia*, *Lepidostoma*, and *Gammarus*.

DISCUSSION

The AFDW loss rates measured in this study, were lower in the low pH streams than in the more alkaline systems. This has been demonstrated by other investigators (Burton et al. 1985; Kimmel et al. 1985; Mackay & Kersey 1985;

Mulholland et al. 1987; Griffith & Perry 1993). The lower rates of decomposition in ER and SFR appear to be at least partially the result of lower microbial biomass. Our analysis of ATP concentrations showed that the acidic streams supported significantly less microbial biomass than the higher pH streams. This is consistent with the results of other studies which have examined the microbial communities of acidified systems. Rao and Dutka (1983) found that bacteria populations and densities were nearly an order of magnitude less in acidified lakes than in neutral lakes. Palumbo et al. (1987) found that epilithic microbial biomass was significantly correlated with pH in Tennessee and North Carolina streams. We found a trend towards larger numbers of smaller species of macroinvertebrates in acidified waters and fewer numbers of larger species in neutral waters. Other researchers have found similar results at sites with low pH (Hildrew et al. 1984; Mackay & Kersey 1985; Mulholland et al. 1987).

In summary, our results suggest lower rates of leaf mass loss in streams with pH <4.0. The lower rate of leaf mass loss was accompanied by significantly lower ATP levels, significantly higher shredder densities, and lower shredder biomass. This suggests that decomposition rates in these acidic streams are depressed by a decrease in microbial biomass and the altered shredder community. Continued acidification of headwater streams in this area may result in further reductions in decomposition rates, less microbial biomass, and altered macroinvertebrate communities.

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