Litter Decomposition in a Chihuahuan Desert Playa

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ABSTRACT.—Mass loss rates were compared for several types of litter in a flooded desert ephemeral playa. Most nonwoody types of organic matter, including black grama grass, creosotebush leaves and rabbit feces decomposed rapidly. Creosotebush twigs and wood decomposed slowly. About 25% of the mass was lost due to abiotic leaching. Predator exclusion significantly increased decomposition of creosotebush leaves, but reduced mass loss rate of creosotebush twigs and black grama grass. Decomposition rates were within the range of those found in lakes, and much lower than rates typical of streams. Our data suggest that organisms have little effect on mass loss of debris transported into a desert playa.

INTRODUCTION

Thousands of ephemeral freshwater ponds and small lakes, called playas, are located throughout the desert SW of the United States (Sublette and Sublette, 1967). These un-drained desert basins vary in area from several square meters to over hundreds of hectares and in depth from a few centimeters to a few meters. Some are regularly filled by runoff water from rain events while others are filled rarely at irregular intervals. For some playas the interval between flood events may be as long as 10 years (e.g., MacKay et al., 1990). The longevity of a playa is dependent on the frequency, intensity and duration of a rain event and the size of the drainage area. Once a playa becomes flooded, there is a rapid increase in activity of invertebrates from aestivating eggs or from adults of a large diversity of organisms (Cole, 1968; Crawford, 1981). These organisms must grow and complete their life cycles while the playa is flooded.

Playas that are surrounded by native vegetation receive large quantities of organic debris transported by overland flow from the watershed into the basin. Organic debris may include large pieces of wood, twigs, leaves, rabbit feces and particles of plant and animal material in various stages of decomposition, depending upon the intensity of the rainfall and velocity of overland flow. This material represents a considerable input of carbon and nutrients into the decomposer subsystem of the playa and may serve as an energy source for the playa food web. Data from other aquatic habitats indicate that decomposition rates in lakes (Saunders, 1976) are much lower than in streams (e.g., Suberkropp et al., 1975; Stout, 1980; Oberndorfer et al., 1984). The ephemeral nature and patchiness of playas could restrict the presence or growth of organisms that play a role in organic matter decomposition in these systems.

We hypothesized that rates of decomposition in a playa lake would be similar to those in other lakes as they are both nonflowing bodies of water. We further hypothesized that the presence of invertebrate detritivores would increase the rate of mass loss from organic debris. Therefore most decomposition would be accounted for by biotic processes.

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METHODS AND MATERIALS

Several types of organic matter were placed in a playa which flooded in May 1984. The playa was on the Jornada Long Term Ecological Research Site located 45 km NE of Las Cruces, Dona Ana County, New Mexico. Litter included rabbit (Lepus californicus) feces, black grama grass [Bouteloua eriopoda (Torr.) Torr.] and creosotebush [Larrea tridentata (DC) Cov.] leaves, twigs (<1 cm diam) and wood (>1 cm diam). These materials are common on the surrounding watershed and are carried into the flooded playa in large quantities.

Ten grams (dry mass, 3 days at 60°C) of each litter type were placed in bags of two mesh sizes; standard fiberglass window screen with mesh size 1 mm and undyed nylon stockings with mesh size approximately 50 μ. In addition, we placed weighed 10 cm (ca. 10 g) pieces of dead creosotebush wood in the playa. Groups of litterbags and wood were tied to pieces of construction rebar with monofilament line and submerged in the water. As the playa dried, the samples were lowered in order to keep them submerged. Samples were collected at 14-day intervals, washed to remove mud and sediments, dried to constant mass at 60°C (3 days) and weighed. We also evaluated the effect of abiotic leaching of creosote leaves on mass loss. Two pre-weighed litterbags were placed in water in 1 qt Bell canning jars, autoclaved and sealed. Thirty-six replicates were established and the bags were removed at 14-day intervals. Litter was subsequently dried at 60°C (3 days) and weighed to determine mass loss.

RESULTS

Nonwoody debris decomposed rapidly (Figs. 1, 2, Table 1), whereas wood and creosotebush twigs lost little mass during the 8 wk the playa contained water (Fig. 1). Mass loss rates for black grama grass were high, although mass increased after 6 wk, which may have been due to increased growth of an epiphyte community and sediment accumulation (Christian, 1984). Temporary increases in biomass are common in decomposition studies (Stout and Cooper, 1983).
Mass loss rates for rabbit feces were lower than expected (Fig. 2) because fecal pellets remained intact. We assumed that when fecal pellets became wet they would break apart and expose a large surface area to decomposer organisms, and that part of the material would pass through the mesh of the bags. Mass loss rates for creosotebush leaves were very high (Fig. 2). However, some of the mass loss was due to abiotic leaching. Laboratory studies showed an initial mass loss of 25.3% (±2.07 SD) within the 1st 2 wk. There was no significant change in mass at 4 and 6 wk.

The effects of mesh size varied with the five litter types (Table 1). We predicted that the smaller mesh would exclude invertebrates that graze on microflora and as a result the mass loss would be higher for this material. It should be noted that there are no important shredders in the playa (Mackay et al., 1990). Analysis of covariance demonstrated no effect of mesh size on mass loss in rabbit feces (Table 1) (no significant differences between slopes or intercepts). However, mass loss of creosote litter was significantly higher in the fine mesh than in coarse mesh bags. Rates of decomposition of twigs and black grama grass were significantly higher in coarse mesh bags. Since the slopes were positive for Larrea twigs and Bouteloua grass in fine mesh bags, it is possible that fine mesh excluded microbial grazers, allowing periphyton assemblages to accumulate on the substrate. This was not due to increased fungal growth, which only uses nutrients already in the wood and thus shows no net increase in mass of the substrate.

**DISCUSSION**

Most knowledge concerning detrital processing in bodies of water has come from studies of artificial leaf packs used to simulate natural leaf accumulations (Barlocher et al., 1978; Oberndorfer et al., 1984; but see Ganning and Wulff, 1969). The few studies done on lakes have shown decomposition is much slower than in streams (Saunders, 1976; Barnes et al., 1978; Briggs and Maher, 1983; Carpenter et al., 1983). This is unexpected as the processing in littoral lakes may be similar to streams (Barnes et al., 1978) and the temperatures in
<table>
<thead>
<tr>
<th>Litter type</th>
<th>Mesh</th>
<th>K†</th>
<th>Mass loss</th>
<th>Slope</th>
<th>Intercept††</th>
<th>r††††</th>
<th>F values</th>
<th>Homogeneity of variances</th>
<th>Slope</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbit feces</td>
<td>coarse</td>
<td>−0.0062 ns</td>
<td>0.70</td>
<td>−2.11</td>
<td>68.02</td>
<td>0.56*</td>
<td>2.25 ns</td>
<td>(7,7)</td>
<td>0.06 ns</td>
<td>1.89 ns</td>
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<tr>
<td></td>
<td>fine</td>
<td>−0.0044*</td>
<td>0.58</td>
<td>−1.79</td>
<td>69.44</td>
<td>−0.71**</td>
<td>(9)</td>
<td></td>
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<td></td>
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<td>Creosote leaves</td>
<td>coarse</td>
<td>−0.0082**</td>
<td>1.10</td>
<td>−1.58</td>
<td>50.95</td>
<td>−0.65*</td>
<td>1.39 ns</td>
<td>(27,27)</td>
<td>0.09 ns</td>
<td>10.94****</td>
</tr>
<tr>
<td></td>
<td>fine</td>
<td>−0.0066**</td>
<td>1.17</td>
<td>−1.14</td>
<td>45.06</td>
<td>−0.58*</td>
<td>(29)</td>
<td></td>
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<td>Creosote twigs</td>
<td>coarse</td>
<td>−0.0005 ns</td>
<td>0.07</td>
<td>−0.96</td>
<td>85.90</td>
<td>−0.40*</td>
<td>1.06 ns</td>
<td>(26,26)</td>
<td>10.49***</td>
<td>0.32</td>
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<td></td>
<td>fine</td>
<td>+0.0011*</td>
<td>0.02</td>
<td>+1.08</td>
<td>75.12</td>
<td>+0.42</td>
<td>(28)</td>
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<td>−0.0029 ns</td>
<td>0.79</td>
<td>−0.76</td>
<td>54.50</td>
<td>−0.29</td>
<td>1.61 ns</td>
<td>(8,8)</td>
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<td></td>
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<td>+0.0115*</td>
<td>0.41</td>
<td>+3.36</td>
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<td>+0.73</td>
<td>(10)</td>
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<td>Creosote wood</td>
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<td>−0.0007**</td>
<td>0.09</td>
<td>−0.72</td>
<td>82.62</td>
<td>−0.47**</td>
<td>(39)</td>
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</tbody>
</table>

† Based on daily changes of untransformed data. The asterisks indicate the level of significance of the correlation coefficients
†† Calculated from arcsine √p regression lines and converted to untransformed values
†††† Arithmetic scale intercept is in parentheses
††††† n is in parentheses
ns = not significantly different; * = P < 0.05; ** = P < 0.01; *** P < 0.005
lakes are often higher than those in streams (Saunders, 1976). Perhaps litter in streams is simply subjected to more battering by the water, although this would not be true in the littoral zone of a lake, where organic debris often accumulates. Saunders (1976) summarized information on decomposition rates in streams. Slowly decomposing leaves lose 0.2–0.75% d⁻¹, those with medium rates lose ca. 1% d⁻¹ and rapidly decomposing leaves lose from 1 to 1.75% d⁻¹. The values of K from exponential models of the data range from −0.003 to −0.061 (Short et al., 1980; Stout and Cooper, 1983). In contrast, soft rush in a fresh water marsh loses about 0.2% d⁻¹ (Boyd, 1971) and the K values for uncontaminated lakes vary from −0.0032 to −0.027, depending on the litter type. The K values for litter used in our study (Table 1) were in the range of those found in lakes and much lower than those typical of streams. Percent mass loss per day of creosote and black grama grass in the coarse mesh bags were in the medium ranges. The mass loss of twigs and pieces of wood were very low.

A large proportion of the mass loss of litter in aquatic systems is due to physical-chemical mechanisms and abiotic leaching (Saunders, 1976), primarily of soluble carbohydrates and polyphenols (Carpenter et al., 1983), although biotic mechanisms may be the most important (Saunders, 1976). Mass loss occurs within the 1st 24 h and ranges from 5–27% (Peterson and Cummins, 1974; Briggs and Maher, 1983; Carpenter et al., 1983). Our abiotic experiments with litter showed a mass loss of 25% within the 1st 2 wk. Heating in the autoclave may have enhanced leaching of solubles. After the initial leaching, fungi develop in and on the leaf material, reaching a maximum population density, and then decrease, which is probably due to exhaustion of easily metabolized substrate (Saunders, 1976). Fungi may rely only on leached substances or use the litter as a hold-fast and derive nutrients from the surrounding water (Chamier and Dixon, 1982).

The invertebrate fauna of playa lakes appears to differ from that of permanent lakes in that the species are primarily filter-feeders (Whitford, pers. observ.). The only effect of filter-feeders on litter would be mechanical fragmentation. Anuran tadpoles are the organisms most likely to cause fragmentation as they move along the substratum. Tadpole shrimp Apus longicaudatus may also cause fragmentation. However, our data demonstrate that the detritus-fungal grazer/filter-feeders have minimal effect on mass loss debris transported into a desert playa.

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Literature Cited


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