Biolife
AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES
2(3):900-904
ISSN (online): 2320-4257
www.biolifejournal.com
BIOLIFE RESEARCH ARTICLE

LEAF LITTER DECOMPOSITIONAL PATTERN IN A TROPICAL LAKE OF SOUTH INDIA

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ABSTRACT

The effects of leaf toughness and C/N ratio on decomposition rates of three riparian plants were examined using a litter bag assay of three litter types (soft, medium and hard) during 35 days exposure at the unpolluted tropical lake of India. Decomposition rate was affected by both litter type and chemistry. However, litter types accounted for the most variation in decomposition rates. Soft litter type decomposed more quickly than medium and hard litter types. The time taken for 50% weight loss of hard, medium and soft litter types would 20 days, 18 days and 1 day, respectively. The C/N ratio was decreased in hard and medium litter types and increased in soft litter type.

Key Words: Decomposition, C/N ratio, leaf litter, litter type.

INTRODUCTION

Leaf litter from riparian plants provides an important source of nutrients, energy and shelter in freshwater ecosystems (Henderson and Walker, 1986; Wallace *et al*., 1997). Leaf litter decomposition is a complex process that is regulated by physical, chemical, and biological processes. The rate of decomposition has been related to the chemical quality of the litter and to the environmental conditions where the process occurs (Webster and Benfield, 1986). The litter-bag assay (Boulton and Boon, 1991) is the most common approach for evaluating litter decomposition in the field and involves enclosing a known mass of plant litter in mesh bags, incubating them in the field, and later retrieving the litter bags to determine the amount of litter that has decomposed over time. The litter-bag assay has done much to advance understanding of organic-matter decomposition, nutrient cycling, carbon storage, and detrital food webs (Tiegs *et al*., 2009; Imberger *et al*., 2010).

Several studies on litter decomposition related to litter types, chemistry, assimilation and colonization of macroinvertebrates have been carried out in streams of temperate and tropical regions (Cortes *et al*., 1997; Pettit *et al*., 2012; Tiegs *et al*., 2013). Few such studies have done in India, especially streams that leaf litter retention, transport, decomposition and colonization of macroinvertebrates (Krishnankutty *et al*., 2003; Anbalagan *et al*., 2012a, b; Sridhar *et al*., 2013). Recently, breakdown of leaves and macro-invertebrate colonization in an a static pond was studied in South India (Dinakaran *et al*., 2008) and no other study has conducted in lakes of India. Therefore, to understand the decompositional pattern of three types of leaves from riparian plants in a tropical lake was investigated in the present study.

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MATERIALS AND METHODS

Study area:

The study was carried out in an unpolluted suburban lake. Thenkal lake is situated in Tiruparankundram, Madurai, Tamil Nadu province, India (Latitude: 9°53’13’’N, Longitude: 78°4’24’’E) between September and October 2013. The lake receives water only through the rainfall. This lake is the principal source of water for the paddy cultivation in the nearby areas of Vilachery, Muthupatti and Tiruparankundram. Along the banks of the lake are shallow stands of trees, shrubs and grasses.

Experimental design:

Leaf decomposition was measured by the litter bag method (Petersen and Cummins, 1974). In the study area, bank of the lake is consisting of eight riparian plant species. The leaf type was measured for eight riparian plant species based on their toughness/strength by using Penetrometer and they were classified into hard, medium and soft type. Of the eight plant species, hard leaves from *Millettia pinnata* (Fabaceae), medium leaves from (*Syzygium cumini* (Myrtaceae) and *Morinda tinctoria*: Rubiaceae) were taken for the present study. Freshly fallen leaves of each litter type were collected under the respective plant species along the bank of the lake. The collected leaves were incubated to overnight, then weighed into portions of 1g of each leaf type, and placed in mesh bags (pore size -1mm; size - 10 x 10 cm). 75 bags were taken. Of these 15 bags were used to convert air dry mass to oven dry mass (1 x leaf species (3) x sampling date (5)); 15 bags were used to determine handling losses (1 x leaf species (3) x sampling date (5)) and 45 bags were used to study the decomposition rate of three different leaf species (3 x three leaf species (3) x sampling date (5)). Replicates of three bags of each litter type were collected at 7, 14, 21, 28 and 35 day intervals. Following the collection and transport of litter bags to the laboratory, remaining litter in the bags was washed, dried (4 days at 37°C), weighed, ashed (3h at 500°C) and re-weighed to obtain estimates of AFDW remaining for each collection date. An average correction factor D was calculated as follows D = (oven- dry mass) / (air-dry mass). The initial oven dry mass of each leaf pack brought to the lake is estimated by multiplying the measured air-dry mass by the average correction factor, D. A second set of bags was recovered immediately upon exposure in the lake water. This allows an estimate of losses due to initial handling. To analyze C/N ratio, the carbon and nitrogen content of each litter type were estimated according to Gupta and Varshney (1997).

Statistical Analysis:

Mass loss as a percentage of original mass was expressed after correction for humidity and handling (100% = mass after corrections). Decay co-efficient (-k) estimated by regression analysis. (a) A linear regression with the original data (Time = independent variable; % Mass remaining = dependent variable). (b) A non-linear curve fitting program (exponential decay; provide an estimate of ***a*** and ***k***). (c) Transform (% Mass remaining) to ln (% Mass remaining) and run a linear regression (Time = independent variable; ln (% Mass remaining) = dependent variable. Pair-wise comparisons of regression slopes were made with a Student‘t’ test ($p<0.05$) (Zar, 1984).

RESULTS

Decompositional pattern:

The physico-chemical parameters are given in Table 1. The mean water temperature and pH were 28.3ºC ± 1.17, 6.9 ± 0.0 respectively. The dissolved oxygen (mgL^{-1}) was gradually increased during the experimental periods and mean dissolved oxygen ranged from 10.4 to 11.4. There was no variation of total dissolved solids and conductivity during the sampling period. Weight loss due to leaching of hard, medium and soft leaves were 49%, 31% and 99% respectively during the first week in mesh bags. The fast rate of decomposition and 95% mass loss was observed within the first week of

Table 1: Physico-chemical parameters of Thenkal lake of Tiruparankundram during sampling period.

Interval days	0	7^{th} day	14^{th} day	21^{st} day	28^{th} day	35^{th} day
Air temperature (ºC)	31	31	32	31	29	33
Water temperature (ºC)	29	28	30	30	27	29
pH	6.9	6.9	6.9	6.9	6.9	6.9
Dissolved oxygen (mgL^{-1})	10.1	10.4	10.8	11.2	11.6	11.4
TDS (mgL^{-1})	120	120	120	120	120	120
Conductivity (µmhos)	0.21	0.21	0.20	0.20	0.21	0.21

exposure in soft type of litter. This might be due to the association of macroinvertebrates. The large number of *Aelosoma* sp. (Oligochaetes) was observed in the mesh bags containing the leaves of *M. tinctoria* of the present study, which indicates that *M. tinctoria* leaves may quickly leached by macroinvertebrates with or without the leaching of microbes (Dinakaran *et al*., 2008).

Table 2: Decay coefficients (-k) and days to 95% AFDM loss (± SD) for three litter types. Coefficients of determination (*r*²) are presented.

Litter type	r^2	-k ± 95% CI	Days to 50% loss	Days to 95% loss
Hard	0.88	0.020	20.1	38.1
Medium	0.77	0.018	17.7	33.6
Soft	0.65	0.001	1.3	2.4

The gradual weight loss was observed for the first three weeks in hard type of litter, but there was a hike in weight loss during the fourth week of exposure, whereas the steady reduction of biomass was observed in medium type of litter. It is evident to study of Benner and Hodson (1985) and Valiela *et al*. (1985) that the three discrete phases occur during decomposition as leaching, decomposer and refractory. In the leaching phase, water action removes soluble substances from the litter, the decomposer phase is slower, various detritivores and microbial decomposers control organic matter losses, and the final phase, decomposition occur at a slower rate than the other two because the remaining components are much more refractory. Prediction through regression analysis revealed that there would be a weight loss of 50% of hard, medium and soft litter types may be taken 20, 18 and 1 days respectively, while 95% of mass loss in hard, medium and soft litter type will take 38, 34 and 2 days, respectively (Table 2). Our results show that litter type (toughness) was the important factor in determining the decomposition rate.

This finding supports to the studies of Webster and Benfield (1986) and LeRoy and Marks (2006) that leaf litter diversity has the capacity to affect on decomposition rates and aquatic

Table 3: **Percentage of carbon, nitrogen and C/N ratio for three litter types during decompositional period.**

Day	**Carbon %**			Nitrogen%			C: N ratio		
	Hard	Medium	Soft	Hard	Medium	Soft	Hard	Medium	Soft
0	25.0	21.0	6.0	5.42	4.48	1.82	4.61	4.7	3.3
7	25.0	21.0	6.0	5.41	4.49	3.65	4.62	4.7	1.64
14	24.0	27.0	9.0	4.84	5.32	1.34	4.96	5.1	6.72
21	28.0	33.0	10.0	6.21	8.12	1.26	4.51	4.1	7.94
28	38.0	35.0	16.0	5.43	8.694	0.98	7.0	4.0	16.3
35	38.0	39.0	20.0	4.21	6.41	0.98	9.03	6.1	20.4

macroinvertebrates, but that these effects depend on both litter quality and water characteristics. Moreover, this result suggests that soft leaves with our without leaching by microbes, while, medium and hard leaves first leached by fungi, which converted non-palatable into palatable litter and then attraction of macroinvertebrates occurs for further leaching. It is widely known that the microbes associated with leaves during decomposition provide a higher quality food resource for macroinvertebrates (Cummins and Klug, 1979; Suberkropp, 1992). Different fractions of litter tissue (*e.g.*, soluble sugars, cellulose, and lignin) differ in decomposition rates with soluble sugars exhibiting the highest rate and lignin the lowest rate (Minderman, 1968).

C/N ratio:
Carbon and nitrogen contents were gradually increased during the decomposition period in all litter type. The percentage of carbon and nitrogen values were higher in hard leaves followed by medium and soft leaves. The C/N ratio tended to decrease in hard and medium leaves, whereas C/N ratio increased in soft leaves (Table 3). This may promote greater decomposition by invertebrates and microbial communities as well as increase leaching of N (and probably other nutrients), thus stimulating the growth of microorganisms and thereby increasing the rate of leaf breakdown (Mathuriau and Chauvet, 2002). In addition, these changes were associated with the almost complete skeletorization of the litter during the first week, followed by loss of carbon form and the poor nitrogen residue. This is in agreement with results of Aerts *et al*. (1995) who compared changes in C/N ratios and in potential decay rates of *Cartex* litter in N limited and non-N limited systems treated with $10 gNm^{-2}y^{-1}$. The relationship between plant decomposition rates and litter carbon and nitrogen concentration found here accounted for most (91%) of the differences in the decomposition rates of litter derived from three types (hard, medium and soft). These results highlight, therefore, the importance of the nutrient balance (C/N) of litter in regulating decomposition rates. Similarly, Prescott (1996) reported an inverse relationship between litter decomposition rates and the C/N ratio of the forest floor, and direct relationship between decomposition rates ad the amount of extractable N in the forest floor. In summary, our findings suggest that the decomposition rate differed with toughness and chemistry (C/N) of litter in the tropical lake. Further work is required to understand the relationship between microbes and macroinvertebrates during decomposition in the tropical lake.

ACKNOWLEDGEMENT

This work was supported by Science & Engineering Research Board (SERB), DST-Fast Track Young Scientists project, Government of India (Ref. No: SB/FT/LS-102/2012).

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DOI: http://dx.doi.org/10.17812/blj2331
Received: 11 July 2014;
Accepted; 23 August 2014;
Available online : 12 September 2014

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