

## Studies on the Decomposition of Leaf Litter of *Polyalthia Longifolia* (Sonner.) Thw. and *Rhododendron Arboreum* Sm. at High and Low Altitude Forest Stands of Meghalaya



### Botany

**KEYWORDS :** Decomposition, *Polyalthia longifolia* and *Rhododendron arboreum*

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### ABSTRACT

Leaf litter decomposition of *Polyalthia longifolia* (Sonner.) Thw. and *Rhododendron arboreum* Sm. were studied at high and low altitude forest stands of Meghalaya using Bocoek *et al.* (1960) litter bag method for a period of one year. Results showed that the rate of decomposition of both the leaf litter was higher at the high altitude forest stand than that at the low altitude forest stand. Of the two leaf litters, the rate of decomposition of *P. longifolia* was faster than that of *R. arboreum*. Significant positive correlations among moisture content, pH and the various chemical constituents of decomposing leaf litters were observed at both the forest stands.

### INTRODUCTION

The decomposition is a natural process of breaking down of dead plant and animal tissues as well as dead microbial cells thereby releasing locked up nutrients into the system. A large amount of plant litter is added annually to the soil through leaf fall and death of plants. As the plant materials fall on the ground, they are immediately attacked by various groups of soil microorganisms and soon after, the process of decomposition is initiated. Thus, decomposition is important in terms of returning nutrients to an ecosystem. The result of decomposition is that the building blocks required for life can be recycled.

Leaf litter production and its decomposition are the main processes and form an important nutrient pool and play a significant role in regulating structure and function of forest ecosystem in a variety of ways. The ground litter production is the dominant pathway joining the living biological component to the non-living soil of the ecosystem through organic matter decomposition (Meentemeyer *et al.*, 1982). The majority of the litter consists of structural components of plants such as cellulose, hemicelluloses and lignin, all of which are broken down relatively slowly. Cellulose, a widely distributed polysaccharide is a vast replenishable resource and is recycled by the microbes. Lignin remains closely associated with cellulose and hemicelluloses (Lundquist *et al.*, 1980).

The extent to which organic residues decompose depends on environmental conditions and the chemical composition of decomposing materials; environmental factors (primarily moisture and temperature), climatic conditions, litter chemistry and structure and the abundance, functional type and activity of soil organisms and substrate nutrients (Prescott, 2010). Leaf litter generally decompose faster than expected in its environment of origin, owing to specialization of litter and topsoil decomposer communities to break down litter encountered most often (Freschet *et al.*, 2012).

Decomposition of leaf litter, by which organic matter and nutrients are returned to the forest soil has received considerable attention for sustainable soil fertility (Moretto *et al.*, 2001). In most ecosystems, more than 90% of the available nitrogen and phosphorus and more than 60% of mineral elements come from plant litter cycling (Chapin *et al.*, 2002). Foliar tissues generally decompose on the soil surface where they are directly exposed to rainfall (Silver *et al.*, 2010).

Understanding decomposition processes and the influence of soil micro flora in changed environmental conditions is important in maintaining long-term productivity in forests of Meghalaya. No comprehensive study has so far been made on the leaf litter decomposition particularly in the broad leaved forests of northeast India. Therefore, the present investigation was carried out to determine if identical leaf litters decompose differently at different altitudes under changed environmental conditions.

### MATERIALS AND METHODS

The two common tree species in the two selected forest stands of Meghalaya- *Polyalthia longifolia* and *Rhododendron arboreum* were selected and the following parameters were taken into account:

#### Rate of leaf litter decomposition

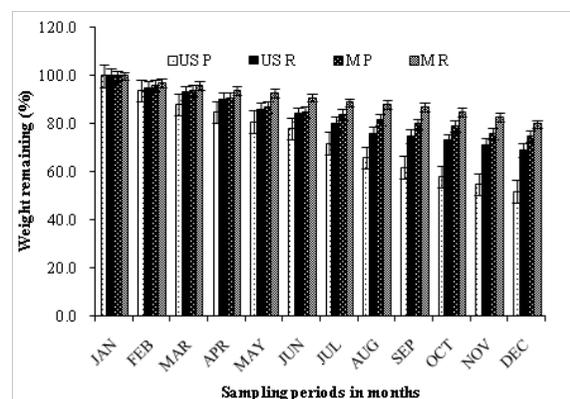
Litter bag technique (Bocoek *et al.*, 1960) was followed to study leaf litter decomposition in the field condition. The rate of litter breakdown was estimated by percentage weight remaining method. Change in chemistry of decomposing litter was estimated by following the method of Peach and Tracy (1955). Moisture content and pH was estimated by following standard methods.

### RESULTS

#### Rate of leaf litter decomposition

The rate of leaf litter decomposition of *P. longifolia* and *R. arboreum* was higher at the high altitude forest stand than at the low altitude forest stand. Of the two leaf litters, the rate of decomposition of *P. longifolia* was higher than that of *R. arboreum*. At the end of decomposition at the high altitude forest stand, the weight remaining was 52.00% in *P. longifolia* and 69.00% in *R. arboreum*, whereas, at the low altitude forest stand, it was 75.00% in *P. longifolia* and 80.00% in *R. arboreum* (Fig. 1).

**Fig. 1: Percentage weight remaining of both the decomposing leaf litter at the two forest stands during the study period.**



**Note: US P= *P. longifolia* in Upper Shillong; US R= *R. arboreum* in Upper Shillong; M P= *P. longifolia* in Mawkyrdep; M R= *R. arboreum* in Mawkyrdep**

#### Moisture content and pH

Moisture content of decomposing leaf litter was higher at the high altitude forest stand than at the low altitude forest stand.

It was also higher in decomposing leaf litter of *P. longifolia* than that of *R. arboreum* (Fig. 2).

During the study period at the high altitude forest stand, moisture content of decomposing leaf litter of *P. longifolia* ranged between 52.20-69.40% and 53.10-69.00% in case of *R. arboreum*, whereas, at the low altitude forest stand in *P. longifolia*, it ranged between 47.00-65.60% and 45.00-65.00% in case of *R. arboreum*.

pH of decomposing leaf litter was slightly more acidic at the high altitude forest stand than at the low altitude forest stand (Fig. 3).

During the study period at the high altitude forest stand, pH of decomposing leaf litter of *P. longifolia* ranged between 4.16-5.70 and 4.36-5.67 in case of *R. arboreum*, whereas, at the low altitude forest stand in *P. longifolia*, it ranged between 4.00-5.38 and 4.12-5.78 in case of *R. arboreum*.

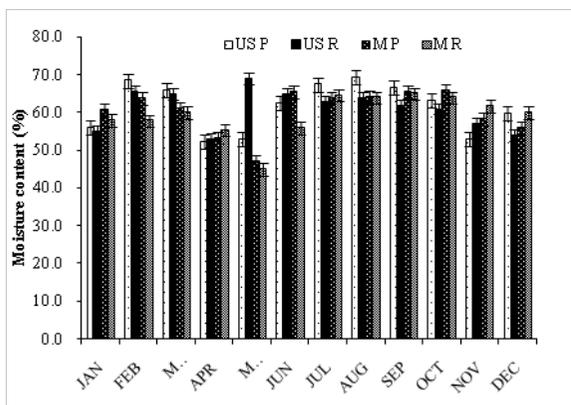


Fig. 2: Moisture content of both the decomposing leaf litter at the two forest stands during the study period.

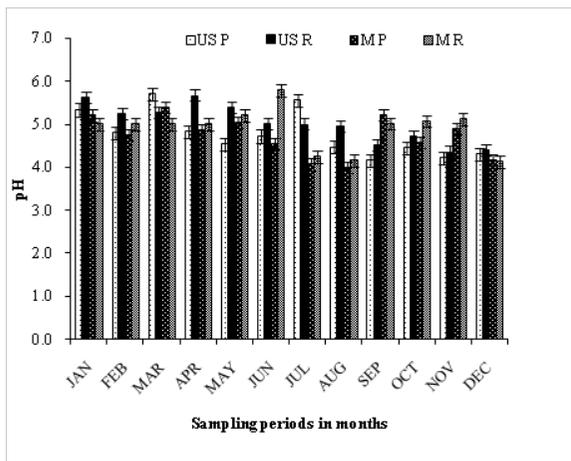


Fig. 3: pH of both the decomposing leaf litter at the two forest stands during the study period.

Quantitative estimation of cellulose, hemicelluloses and lignin contents of decomposing leaf litter

**(a) Cellulose**

Decomposition of cellulose was also higher at the high altitude forest stand than at the low altitude forest stand. It was also higher in *P. longifolia* than that of *R. arboreum*. At the end of the decomposition at the high altitude forest stand, it was 51.00% in *P. longifolia* and 56.00% in case of *R. arboreum*, whereas, at the low altitude forest, it was 58.00% in *P. longifolia* and 59.00% in case of *R. arboreum*.

**(b) Hemicelluloses**

Decomposition of hemicelluloses also followed the same trend

as cellulose. It was higher at the high altitude forest stand than at the low altitude forest stand. It was also higher in *P. longifolia* than that of *R. arboreum*. At the end of decomposition at the high altitude forest stand, it was 54.00% in *P. longifolia* and 56.00% in case of *R. arboreum*, whereas, at the low altitude forest stand, it was 58.0% in *P. longifolia* and 57.0% in case of *R. arboreum*.

**(c) Lignin**

There was not much difference in the decomposition of lignin. However, it was also observed to be higher at the high altitude forest stand than at the low altitude forest stand. It was also higher in *P. longifolia* than that of *R. arboreum*. At the end of decomposition at the high altitude forest stand, the lignin content was 53.00% in *P. longifolia* and 56.00% in case of *R. arboreum*, whereas, at the low altitude forest stand, it was 60.00% in *P. longifolia* and 66.00% in case of *R. arboreum*.

**Table 1: Range of percentage weight remaining, cellulose, hemicelluloses, lignin contents of both the decomposing leaf litter of at the two forest stands during the study period. Mean values are given in parenthesis.**

Leaf properties	Study sites	Range
WTR (%)	US P	52.00-100.00(74.30±0.09)
	US R	69.00-100.00(82.70±0.21)
	M P	75.00-100.00(85.80±0.12)
	M R	80.00-100.00(90.30±0.23)
C (%)	US P	51.00-70.67 (58.22±0.34)
	US R	56.00-70.67 (62.30±0.23)
	M P	58.00-70.67 (63.80±0.19)
	M R	59.00-70.67 (64.30±0.23)
H (%)	US P	54.00-78.67 (65.50±0.17)
	US R	56.00-78.67 (66.50±0.11)
	M P	58.00-78.67 (65.30±0.10)
	M R	57.00-78.67 (67.60±0.13)
L (%)	US P	53.00-78.70 (66.06±0.21)
	US R	56.00-78.70 (67.50±0.08)
	M P	60.00-78.70 (71.50±0.11)
	M R	66.00-78.70 (72.40±0.090)

Note: US P= *P. longifolia* in Upper Shillong; US R= *R. arboreum* in Upper Shillong; M P= *P. longifolia* in Mawkyrdep M R= *R. arboreum* in Mawkyrdep; WTR= Weight remaining; MC= Moisture content; C= Cellulose; H= Hemicelluloses; L= Lignin.

**Table 2: Correlation coefficient (r) values of percentage weight remaining, moisture content, pH, cellulose, hemicelluloses and lignin contents of both the decomposing leaf litter at the two altitude forest stands during the study period.**

Leaf properties	Study sites	MC	pH	C	H	L
WTR	USP	NS	NS	0.97 <sup>c</sup>	0.99 <sup>c</sup>	0.97 <sup>c</sup>
	USR	-0.59 <sup>a</sup>	NS	1.00 <sup>c</sup>	0.99 <sup>c</sup>	0.95 <sup>c</sup>
	MP	NS	NS	0.97 <sup>c</sup>	0.99 <sup>c</sup>	0.88 <sup>b</sup>
	MR	NS	NS	0.98 <sup>c</sup>	0.95 <sup>c</sup>	0.99 <sup>c</sup>

MC	USP		NS	NS	NS	NS
	USR		NS	-0.58 <sup>a</sup>	-0.58 <sup>a</sup>	NS
	MP		NS	NS	NS	NS
	MR		NS	NS	NS	NS
pH	USP			NS	NS	NS
	USR			NS	NS	NS
	MP			NS	NS	NS
	MR			NS	NS	NS
C	USP				0.95 <sup>c</sup>	0.97 <sup>c</sup>
	USR				0.99 <sup>c</sup>	0.96 <sup>c</sup>
	MP				0.98 <sup>c</sup>	0.92 <sup>c</sup>
	MR					0.89 <sup>b</sup>
H	USP					0.97 <sup>c</sup>
	USR					0.95 <sup>c</sup>
	MP					0.96 <sup>c</sup>
	MR					0.96 <sup>a</sup>

Note: WTR= Weight remaining; MC= Moisture content; C= Cellulose; H= Hemicelluloses; L= Lignin.

Values marked with <sup>a</sup>, <sup>b</sup> and <sup>c</sup> indicate significant correlations at  $p \leq 0.05$ ,  $0.01$  and  $0.001$  respectively. Insignificant values are marked with 'NS'

## DISCUSSION

### Rate of leaf litter decomposition

The higher rate of decomposition, moisture content and more acidic of the leaf litter at the high altitude forest stand may be due to the thick ground vegetation of the forest system, and the higher rate of nutrients released during leaf litter decomposition (Mishra, 2011). Moreover, the plants exudates and sloughed-off tissue may enhance the degradation of the complex compounds due to increased bioavailability of the contaminants and the interactions among microbes, nutrients and contaminants (Banks *et al.*, 2003), whereas, at the low altitude forest stand, increased exposure to solar radiation resulted in reduced soil moisture content which in turn resulted in lower microbial activities and ultimately lowering the rate of leaf litter decomposition. The sloppy topography at the low altitude forest stand frequented by soil erosion may also attribute to lower decomposition. Moreover, there is no proper soil aggregation as much of the top soil along with leaf litter is washed away by the rain. The ground vegetation is very less than that of the high altitude forest stand in which dense ground vegetation is observed. These factors ultimately reduced the microbial populations along with other soil macro fauna which may contribute in the decomposition process.

Of the two different leaf litters studied, decomposing leaf litter of *P. longifolia* decomposed faster than that of that of *R. arboreum*. It could be due to its broader leaf nature, palatability of the litter by the different decomposers community. Also it varies considerably in physical structure and chemical composition, which influences its decomposition (Santiago, 2007), and these differences, as well as other plant traits (e.g. quality of below-ground inputs, growth form, and influence on soil structure); often result in different soil communities associated with different plant species (Bardgetta and Walker, 2004). It may also be due to the fact that microorganisms colonizing *R. arboreum* leaf litter are more nutrient limited than *P. longifolia*, the former having an initially lower nitrogen content and lower surface area to volume ratio than *P. longifolia*. The slower decomposition of *R. arboreum* leaves may also be because of a poorer quality of carbon available than *P. longifolia* (Prescott, 2005). Miller (2010) also reported that the chemical composition of litter, referred to as litter quality, is determined by factors such as nutrient concentration, chemical structure, and toxicity.

Fast rate of decomposition is often determined by the availability of limiting elements such as N and P, whereas in late stages carbon loss has been related to elements required to decompose recalcitrant components such as lignin that accumulate in the remaining litter (Berg *et al.*, 2000). Thus, variables controlling the fast decomposition stage and nutrient release could differ from those influencing the proportion of slow decomposing litter and therefore the build up of soil organic matter and carbon sequestration. Occasionally, the same variable could have counteractive effects on the early and late stages of decomposition (Hobbie *et al.*, 2012). Berg (2000) proposed a three-phase decay model with an early decomposition stage, when the rapid decay of soluble and non-lignified carbohydrates is regulated by N, P and S contents, a late decomposition stage, when decay is regulated by the degradation of lignin, and a final or 'humus near' stage. Litter N has often been identified as a rate-enhancer factor for early decomposition (Hobbie *et al.*, 2012).

## CONCLUSION

The rate of decomposition is influenced by the difference in altitude of the two study sites. Understanding decomposition processes and the influence of soil micro flora in changed environmental conditions is important in maintaining long-term productivity in forests of Meghalaya.

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