Potential Donations of Nutritional Contributions in Five Types of Tree Growing Dominantly in Tondano Sub-Das, Minahasa, North Sulawesi

by Anatje Lihiang

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ABSTRACT

One of the benefits of vegetation is the production of litter which plays a role in improving and maintaining soil quality. In addition, the decomposition process in litter also produces chemical compounds in the form of nutrients that have the potential to improve chemical fertility and be reused by plants.The purpose of this study was to evaluate the potential of litter production and the contribution of nutrients from litter of 5 dominant tree species in the Tondano Sub-watershed, Minahasa, North Sulawesi. The study was conducted in October 2017 – May 2018. Litter production was measured using a litter collection net placed under the canopy of 5 tree species, with 15 observation trees each and repeated 3 times. The collection of litter is carried out every day. Furthermore, the litter was analyzed in the laboratory of Sam Ratulangi University Manado to determine the content of macro and micro nutrients.From the observations, it was concluded that the production of litter during the rainy season was mostly produced by Waisan wood (Elmerelliacelebica), which was 16.11 Mg ha-1 year-1. The results of the analysis of the content of the dominant macronutrient contained in the litter is the element Carbon (C). The highest percentage of element C was found in clove tree litter (Eugenia aromaticum) which was 50.24%. The results of the analysis of the content of micro elements showed that the dominant element contained in the litter was iron (Fe) and followed by Manganese (Mn). The highest content of Fe and Mn was found in Waisan Wood (Elmerelliacelebica) litter, which was 416.4 ppm and 132.5 ppm, respectively.
Keywords : litter, macro nutrients, micro nutrients

PRELIMINARY

Lake Tondano is the main component of the Tondano watershed and has an important role in life in 5 districts/cities in North Sulawesi province. The Minahasa Forestry Service noted in 1994 that there has been a decrease in the area and silting of Lake Tondano in the past 30 years, one of which is the impact of forest conversion in the Tondano watershed. According to Prijono et al., 2012 and Rompas et al., 2012 plants that have an Important Value Index (INP) in the Tondano watershed are Waisan wood (Elmerelliacelebica), Cloves (Eugenia aromaticum), Cacao (Theobroma cocao), Mangosteen (Garcinia mangostana). and Aren (Arenga pinnata).

Litter is a part of a plant that has died in the form of leaves, stems, branches, twigs, flowers and fruit that fall on the ground (Wang et al., 2011). The composition and production of litter varies greatly depending on plant vegetation and environmental conditions such as climate, elevation, fertility and soil moisture (Rawat et al., 2009). Litter productivity can be used as an indicator of the condition of a forest, because litter production is a reflection of the interaction between plant biological heredity and the influence of fluctuations in environmental conditions (Rawat et al., 2009). The results of Hairiah et al. (2006) on several types of ecosystems in West Lampung concluded that the production of litter in the forest reached 14 Mg ha-1 year-1, in multistrata coffee plantations it reached 9.8 Mg ha-1 year-1, in coffee plantations under the shade of G.sepium it reached 6 .

Litter plays a role in maintaining and improving soil structure. The functions of litter include (1) reducing the destructive power of rainwater on soil aggregates, (2) preventing erosion, (3) increasing soil infiltration capability, (4) preventing surface runoff, (5) maintaining soil temperature and humidity, (6) increase soil organic matter content, (6) reduce soil bulk, (7) increase soil water holding capacity, (8) increase cation exchange capacity (Treatment)*et al.*, 2009). According to Wang et al. (2011), litter is effective in increasing soil moisture, reducing soil temperature, reducing the rate of evapotranspiration, and acting as mulch in inhibiting the weed germination process. On the forest floor, leaf litter plays a role in the input and output of nutrients N, S and P (Corona et al., 2006).

Almost all plant litter contains essential nutrients such as N, P, S, K, Ca, Mg, Mn and Fe elements, but the concentration of each element varies depending on plant species, climate, soil mineral composition, parent material (Berg and McClaugherty, 2003). 2008), the structure and activity of microbes in the soil, as well as the physical, biological and chemical characteristics of the soil on the surface layer (Rawat et al., 2009; Freschet et al., 2012). The level of litter composition and production in an ecosystem is important to know for the estimation of organic matter exchange in that ecosystem (Rawat et al., 2009; Brovkin et al., 2012). Therefore, this study aims to evaluate litter production and nutrient contribution from litter of 5 dominant tree species in the Tondano Sub-watershed.

RESEARCH METHODS

The research was conducted in the Tondano sub-watershed which is administratively part of the Tondano watershed. The Tondano watershed is located at the northern tip of the North Sulawesi peninsula at an altitude of 0-1556 meters above sea level, 1007' – 1031' North Latitude and 124045' – 125002' East Longitude. The study was conducted during the rainy season, namely in October 2017 – May 2018.

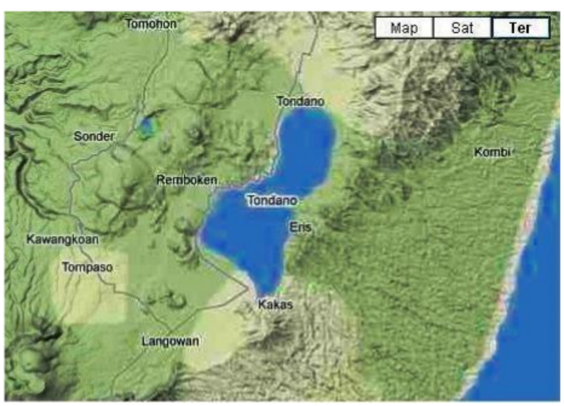

Figure 1. Research location map

Litter production was measured using a litter collection net (J. Huang et al., 2007) measuring 1 mx 1 m and placed under the canopy of the selected trees as research samples. The research sample consisted of 5 tree species that had the highest INP (Rompas et al., 2012; Prijono et al., 2012) namely Waisan wood (Elmerelliacelebica), Clove (Eugenia aromaticum), Cacao (Theobroma cocao), Mangosteen (Garcinia mangostana).), and Aren (Arenga pinnata) with each type consisting of 15 tree samples and each was repeated 3 times.

The collection of litter was carried out every day and was carried out 30 times. The parameter measured was the weight of litter in each litter container in g m-2 day-1.

Each litter from the 5 sample tree species was analyzed for macro and micro nutrient content through laboratory analysis at Sam Ratulangi University, Manado. The macronutrients measured included elements of Carbon (C), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg). Meanwhile, the micro nutrients measured were Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn). The nutrient analysis method measured is presented in Table 1.

Table 1. Methods of Analysis of Nutrient Parameters

No	Parameter	Analysis Method
1	Nitrogen (N)	Distillation (Usman, 2012)
2	Phosphorus (P)	Wet Ashing and Spectrophotometer (Ben Mussa et al., 2009)
3	Potassium (K)	Wet ashing and Flamephotometer (Al-Zubaidi et al., 2008)
4	Calcium (Ca)	Wet ashing and AAS (FAO, 2007)
5	Magnesium (Mg)	Wet ashing and AAS (FAO, 2007)
6	Carbon (C)	Walkey and Black (Corona et al., 2006)
7	Iron (Fe)	Wet ashing and AAS (FAO, 2007)
8	Copper (Cu)	Wet ashing and AAS (FAO, 2007)
9	Zinc (Zn)	Wet ashing and AAS (FAO, 2007)
10	Manganese (Mn)	Wet ashing and AAS (FAO, 2007)

RESULTS AND DISCUSSION

1. Litter production

The litter production of the 5 sample tree species in the Tondano sub-watershed is presented in Table 2. Comparison of the litter production of each sample tree species was varied.

Table 2. Litter Production of 5 Tree Types in Tondano Sub-watershed

No	Tree Type	Tree Scientific Name	Tree Architecture Model*)	Litter production Mg ha-1 year-1
1	wasian wood	*Elmerelliacelebica*	Attims	16.11
2	Clove	*Eugenia aromaticum*	Petit	8.92
3	Chocolate	*Theobroma cocao*	Stone	11.89
4	Mangosteen	*Garcinia mangostana*	Fagerlind	10.00
5	Aren	*Arenga pinnata*	Corner	5.68

*)source :Prijono et al., 2012

The highest litter production was produced by E. celebica with an average weight of around 16.11 Mg ha-1 year-1. Meanwhile, the lowest litter production was produced by A. pinnata. One of the factors that affect the production of litter is the type of plant, where this statement has also been proven by the results of research which concludes that the production of litter under the Albizia plant is 10.58 Mg ha-1 year-1 which is twice as large as the litter production under the Sesbania plant, namely of 5.43 Mg ha-1 year-1 in North Bengkulu (Munawar et al., 2011). Bellingham et al. (2013) stated that one of the factors that influence litter production is plant characteristics, namely plant productivity, chemical compound content in plants, plant structure and canopy. Plant E. celebica produces a fairly large litter mass because this type of wood has a larger leaf size and the nature of its leaves are easier to fall when compared to the other 4 sample tree species. While the leaves on A. pinnata even though they have large leaves, the nature of the leaves does not fall but is attached to the stem and undergoes natural decay. The litter produced by A. pinnata comes from flower and fruit organs, because A. pinnata has a "corner" canopy type where plants with this canopy type have straight stems without branches. Meanwhile, the production of E. celebica litter comes from leaves, flowers, and stems because E. celebica has a canopy type "Attims" which one of the characteristics of the plant is to have branching stems. The results of this study are in accordance with the opinion of Celentano et al. (2011) which states that there is a strong relationship between litter production and canopy type and the increase in aboveground biomass. Plant species with different types of canopy produce different litter production. It has also been concluded in the research results that the highest litter production is found in forest ecosystems in West Lampung, which is 14 Mg ha-1 year-1, which consists of leaf litter of 8.5 Mg ha-1 year-1 and mixed litter of stems, flowers and fruit of 5.6 Mg ha-1 year-1 (Hairiah et al., 2006).

Litter production varies which is influenced by climate, soil fertility, topography, vegetation type, vegetation age and time (Arianoutsou and Radea, 2000). This statement is supported by Bellingham et al. (2013) which states that the quantity and quality of litter in forest ecosystems is influenced by abiotic factors (climate and soil fertility) and plant characteristics, as well as disturbances to the ecosystem. In addition, the quantity and quality of litter is also influenced by the characteristics of microbial decomposers, which include size, composition, function and microbial physiology (Berg and McClaugherty, 2008).

Fluctuations in litter production are influenced by time (Triadiati et al., 2011), where pThe highest litter production usually occurs in dry months (Rawat et al., 2009). According to Lorenzen et al. (2007), litter production experienced a sharp increase at the beginning of the dry month and decreased during the transition period between the wet and dry months. Litter production may reach its peak during the rainy season, especially when there is rain accompanied by strong wind storms.

2. Content of macro and micro nutrients

Element parametersMacro nutrients tested were: C, N, P, K, Ca and Mg. while the micronutrient content tested were: Fe, Cu, Zn and Mn. The results of the analysis of macro nutrients above are presented in Table 3. While the results of the analysis of micro nutrients are presented in Table 4.

Table 3. Content of Macro Nutrients in Litter of 5 Tree Types in Tondano Sub-watershed

No	Tree Type	Content of Macro Nutrients (%)					
		C	N	P	K	Ca	Mg
1	*Elmerelliacelebica*	49.05	1.21	0.09	0.30	2.60	0.46
2	*Eugenia aromaticum*	50.24	1.65	0.08	0.28	1.49	0.48
3	*Theobroma cocao*	49.67	1.40	0.07	0.15	3.20	0.58
4	*Garcinia mangostana*	48.79	1.27	0.09	0.28	2.00	0.89
5	*Arenga pinnata*	47.83	1.47	0.10	0.24	2.22	0.46

Table 4. Potential Content of Macro Nutrients on Litter Production in Tondano Sub-watershed

No	Tree Type	Content of Macro Nutrients (Mg ha-1 year-1)					
		C	N	P	K	Ca	Mg
1	*Elmerelliacelebica*	790.20	19.49	1.45	4.83	41.89	7.41
2	*Eugenia aromaticum*	448.14	14.72	0.71	2.50	13.29	4.28
3	*Theobroma cocao*	590.58	16.65	0.83	1.78	38.05	6.90
4	*Garcinia mangostana*	487.90	12.70	0.90	2.80	20.00	8.90
5	*Arenga pinnata*	271.67	8.35	0.57	1.36	12.61	2.61

The results of laboratory analysis (Table 3 and Table 4) show that the element Carbon (C) is the dominant macronutrient contained in the litter of 5 sample tree species with an average content of more than 40%. Based on Table 5, it is known that the highest potential C nutrient content is found in E. celebica litter, which is 790.20 Mg ha-1 year-1, while A. pinnata litter has the lowest potential C nutrient content, which is 271.67 Mg ha-1 year-1. . This is in accordance with previous research which concluded that the highest amount of nutrient return by litter to the soil was carbon (C), which was followed by N and Ca (Wang et al., 2008). E. aromaticum vegetation produced litter with the highest C content (50.24%) compared to the other 4 sample plant species. While A. pinnata produced the lowest C content (47.83%) compared to the other 4 sample plants. The percentage of chemical compounds contained in litter varies depending on the type of litterplants (Berg and McClaugherty, 2008). This is also consistent with the results of the study which concluded that the carbon content of B. nana and E. nigrum litter was higher than that of C. bigelowii and D. flexuaosa (Olofsson and Oksanen, 2002); Carbon content in the litter of B. tomentellus and P. fragilis was higher than that of A. tauri species (Saberi et al., 2012). Carbon content in litter can affect the rate of decomposition of litter, where the ratio of C/N or lignin, and N is the best indicator to determine the rate of decomposition (Prescott, 2005). The release of carbon (C) elements through the litter decomposition process can contribute > 20% of the CO_2 efflux on the soil surface required by the soil respiration process (Karberg et al., 2008).

Table 5. Content of Micro Nutrients in Litter of 5 Tree Types in Tondano Sub-watershed

No	Tree Type	Content of Micro Nutrients (ppm)			
		Fe	Cu	Zn	M N
1	*Elmerelliacelebica*	416.4	1.9	17.0	132.5
2	*Eugenia aromaticum*	93.1	2.8	32.5	103.9
3	*Theobroma cocao*	345.4	2.5	20.6	110.8

4	*Garcinia mangostana*	92.4	1.8	15.2	91.6
5	*Arenga pinnata*	120.3	2.3	76.1	94.6

Table 6. Potential Content of Micro Nutrients on Litter Production in Tondano Sub-watershed

No	Tree Type	Micronutrient content (Mg ha-1 year-1)			
		Fe	Cu	Zn	M N
1	*Elmerelliacelebica*	6708.20	30.61	273.87	2134.58
2	*Eugenia aromaticum*	830.45	24.98	289.90	926.79
3	*Theobroma cocao*	4106.81	29.73	244.93	1317.41
4	*Garcinia mangostana*	924.00	18.00	152.00	916.00
5	*Arenga pinnata*	683.30	13.06	432.25	537.33

The results of laboratory analysis (Table 4) show that the micro-nutrients contained in the litter vary. The dominant micronutrients in the sample plant litter were Iron (Fe) and Manganese (Mn) with varying ranges. The highest Fe nutrient content was contained by E. celebica plant litter, namely 416.4 ppm, while G. mangostana litter had the lowest Fe content (92.4 ppm). The highest Mn content was contained in E. celebica litter (132.5 ppm), while G. mangostana litter had the lowest Mn content (91.6 ppm).

The chemicals contained in litter are strongly influenced by habitat factors, namely the composition of the vegetation (Li-Xin et al., 2003; Prescott, 2005), and the addition of nutrients to the soil through the fertilization process. A study conducted to determine the decomposition process and nutrient dynamics in leaf litter of three wet tropical forest communities in Queensland Australia showed that Alphitoniapetriei litter had the highest total N content, followed by litter from mixed rainforest vegetation, and then litter. Eucalyptus grandis tree (Parsons and Congdon, 2008). Another study showed that the concentration of N and P in Cherry plant litter was higher than Pine litter, where the same thing happened to Beech plants compared to Oak plants in German forest ecosystems (Lorenz et al., 2004). The content of C and N varies depending on the species, with the highest N content in Betula nana litter and the highest C content in Betula nana litter and Empetrum nigrum in Norway (Olofsson and Oksanen, 2002). The content of Ca, Mg, N, P and S was higher in Q. canariensis leaf litter compared to Q. suber leaf litter, but Q. suber contained the highest C and Mn in Spain (Aponte et al., 2012). A study conducted by Mubarak et al., (2008) to determine the process of decomposition and release of nutrients from litter in Sudan concluded that there was an accumulation of Fe, Zn, Mn and Cu elements during the decomposition process of Jambu, Mango, Eucalyptus, Ficus, and Lucaena,

The quality of litter is also influenced by factorsFe (Li-Xin et al., 2003). According to Kasurinen et al. (2007) the content of carbon dioxide (CO_2) and ozone (O_3) in the air has the potential to affect the quality of litter, especially in deciduous trees. The CO_2 content in the air had an impact on decreasing the N concentration in the leaves and increasing the C/N ratio in the leaf litter. Liu et al. (2007) stated that the CO_2 content in the air did not affect the P content in the litter, but it could increase the K and S content, decrease the B content, while its effect on Mn depended on the level of CO_2 content. According to Kasurinen et al. (2006), the CO_2 content in the air was able to reduce the S content in the litter, but did not significantly affect the Ca, Mg, Mn, Fe, Zn, Cu and B content in the litter. Kasurinen et al.

Xuluc-Tolosaa et al. (2003) suggested that the content of chemical compounds in litter is influenced by time. Nutrients contained in young forest litter were higher and had a positive reciprocal relationship for plant growth and production. High nutrient content in litter and rapid decomposition process occur in early succession (Xuluc-Tolosa et al., 2003). A study conducted by Celentano et al. (2011) to determine the nutrient content of several types of restoration forest in Costa Rica showed that the highest concentrations of Ca, Mg, K, Zn and Mn were contained in leaf litter originating from secondary forests, namely forests aged 7-9 years with a species composition varied trees but no tree that can fix N.

CONCLUSION

The litter production of the five sample tree species was quite diverse and in general the litter production in low rainfall (dry season) was higher than during high rainfall (rainy season). The highest production of litter was produced by E. celebica, while the lowest production of litter was produced by A. pinnata. The production of litter has a correlation with plant characteristics, especially the type of canopy and the type and nature of the leaves.

The results of the analysis of macro and micro nutrients from the five sample tree species were quite diverse. The elements contained in the 5 types of sample trees were dominated by elements of Carbon (C), Iron (Fe) and Manganese (Mn) with varying ranges. In general, E. celebica is a tree species that has the highest contribution to the nutrient cycle compared to other sample tree species because the average content of macro and micro nutrients contained in E. celebica litter is higher. The dynamics of nutrient content in litter has a correlation with the type of plant. This description of the potential of litter can be used as a basis for managing litter in the land, to support the improvement of physical and chemical fertility of the soil.

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