

Decomposition rate of *Rhizophora stylosa* litter in Tanjung Rejo Village, Deli Serdang Regency, North Sumatera Province

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Abstract. Research on the decomposition rate of *Rhizophora stylosa* litter in Tanjung Rejo village, Deli Serdang Regency, North Sumatera Province was conducted from September 2016 to May 2017. The objectives of this research were (1) to measure the decomposition rate of *Rhizophora stylosa* litter and (2) to determine the type of functional fungi in decomposition of litter. *R. stylosa* litter decomposition is characterized by a reduction in litter weight per observation period. Decomposition rate tended to increase every week, which was from 0.238 in the seventh day and reached 0.302 on the fiftysixth day. The decomposition rate of *R. stylosa* litter of leaf was high with the value of k per day > 0,01 caused by macrobentos and fungi, and also the decomposition of *R. stylosa* litter conducted in the pond area which is classified far from the coast. Therefore, to enable the high population of fungi which affect the decomposition rate of the litter. The types of fungi decomposers were: *Aspergillus* sp.-1, *Aspergillus* sp.-2, *Aspergillus* sp.-3, *Rhizophus* sp.-1., *Rhizophus* sp.-2, *Penicillium* sp., *Syncephalastrum* sp. and *Fusarium* sp.

1. Introduction

Litter production includes the vegetative and reproductive litterfall of *R. stylosa*/mangrove trees caused by aging, death, and damage of the whole plant by climate (rain and wind) [1]. The mangrove litter produced in the form of leaf plays the most important litter role compared to other organs as it is a source of nutrition for the organism. The higher litter production also causes the higher productivity of mangrove forest. The difference of the total litter of each organ for each mangrove varies due to be the environmental conditions and biological characteristics. Biological characteristics include the small size of leaves and round fruit. Other litter components, due to the shape and size of the leaves are wide and thin so it is easily lost by wind and rain [2].

Decomposition is the process of destruction or decay of organic matter by biological agents and physical changes into mineral materials and organic colloidal humus. Therefore, the decomposition of organic matter is also often called the process of mineralization. This process is a microbial process (decomposer) in obtaining energy for the regeneration process. The factors that affect the decomposition of organic materials from the side of decomposer are temperature, humidity, salinity, and pH. This process has a very essential role in the energy and food chain cycles in the mangrove ecosystem [3]. This



decomposition process is very important because it converts non-digestible mangrove leaf fibers into more easily digestible fibers. Rotting mangrove litter will be degraded into smaller pieces and digested by crabs and other invertebrates. These pieces are known as POM (particulate Organic Matter). Once digested, organic particles are formed smaller and then used by food filtering organism (filter feeder) [4].

The objectives of this study were (1) to measure the decomposition rate of leaf litter of *R. stylosa* and (2) to know the type of fungi that play a role in litter decomposition.

2. Materials and Methods

2.1. Time and Place

The research was conducted from September 2016 to May 2017. The sampling of *R. stylosa* leaf litter was conducted in Tanjung Rejo village, Percut Sei Tuan subdistrict, Deli Serdang district, North Sumatera. While the isolation of litter decomposer fungi was done in Soil Biology Laboratory, Faculty of Agriculture, Universitas Sumatera Utara.

2.2. Experiment of Litter Decomposition Rate

The litter was weighed as much as 50 g and then put into a litter bag and tied up. The bags were then placed on the surface of the mangrove substrate randomly and tied to the root or base of the mangrove plant stems so as not to drift away at high tide. Each week for two months experiment, one sample was taken randomly. Then each bag was purged from mud using distilled water or clean water and dried with 75°C drying oven for 1 × 24 hours then weighed using an analytic scale. The same activity was done for next week's litter sampling.

2.3. Data analysis of litter decomposition

The estimation of litter decomposition rate was performed according to the following Olson equation:

$$X_t / X_0 = e^{-kt}$$

Where:

- X_t = Weight of litter after the observation period
- X₀ = Initial weight of litter
- e = Natural logarithm number (2.72)
- t = Observation period
- k = Decomposition rate

2.4. Isolation of litter decomposer fungi

The tools used were firstly sterilized using an oven with a temperature of ± 80 °C for 3 hours. Media used for culture of fungi is Potato Dextrose Agar (PDA) medium and added with Chloramphenicol. The medium was heated and sterilized using an autoclave.

Leaf litter taken was first cleaned then cut aseptically with a knife into pieces measuring approximately 1cm × 1cm and placed directly on the surface of PDA in a petri dish. Then incubated in the incubator. After incubated for 2 -7 days at the appropriate temperature (28 °C), fungi colonies that grow apart or grow singly were observed and are immediately transferred aseptically to another petri dish with a PDA medium [5].

2.5. Identification of litter decomposer fungi

a. Macroscopic identification

Each type of fungi obtained, cultured singly on PDA media and identified microscopically by observing the color of spores, top surface, bottom surface and colony diameter..

b. Macroscopic identification

The identification was performed by observation of hyphae, conidia, spore shape and spore color performed under the light microscope. From macroscopic and microscopic observation. The results were identified and matched using fungi identification books [5].

2.6. Calculation of fungi population

A total of 10 g of litter sample of *R.stylosa* has gounded with mortar and pestle aseptically. Then the smoothed litter was suspended with 90 ml distilled water and diluted into 10^{-1} to 10^{-7} . One milliliter of each dilution was inserted into a petri dish containing PDA medium with the spread plate method then incubated for 5-8 days. The number of growing fungi was counted by the formula as follows: *Total number of fungi = Number of colonies appeared x dilution factor* [6].

3. Results and discussion

Decomposition of *R. stylosa* litter was characterized by a reduction in litter weight per observation period. The weight of residual litter at each observation time is shown in Table 1.

Table 1. Decomposition rate of *Rhizophora stylosa* litter

Day observation	Initial weight (g)	Residual litter (g)	Decomposition litter (g/day)
7	50	10.564	0.029
14	50	10.021	0.061
21	50	9.671	0.094
28	50	8.887	0.132
35	50	8.098	0.174
42	50	8.20	0.208
49	50	7.545	0.253
56	50	6.962	0.302

Table 1 showed that the decomposition of *R. stylosa* is relatively fast. It refers to Graca *et al.* [7] stating that the decomposition rate is slow if the value of k is <0.005 per day (<1.8 per year), the rate is moderate if $k = 0.005 - 0.01$ per day ($1.8 - 3.6$ per year) and the rapid rate if $k > 0.01$ per day (> 3.6 per year). It is thought to be influenced by a low salinity level of 0-10 ppt. In high salinity little microorganisms and livestock decomposers macrobentos can survive. Kurniawan [8] stated that the number of fungi types at the salinity level of 0-10 ppt and 10-20 ppt geater than the salinity level of 20-30 ppt and > 30 ppt further explained Damanik [9] that one of the responses of microorganisms to salinity is not Can tolerate and will die under high salinity conditions. From Table 2 it is found that the residual litter tends to decrease, whereas the residual litter on the 7th day is 10.564 g and the residual litter at 56th day is 6.962 g, while the decomposition rate tends to increase from 0.029 g / day on 7th day and reached 0.302 g/day on day 56. The above shows that the litter decomposition rate can be said to be inversely proportional to the remaining litter at each observation time, can be seen in (figure 1). The more residual litter left behind, meaning slow decomposition of litter. Conversely, the less residual litter left behind, the decomposed litter can be said to be short-lived. The figure below shows the weight and decomposition rate of *R. stylosa* leaf litter at each observation time (figure 1.)

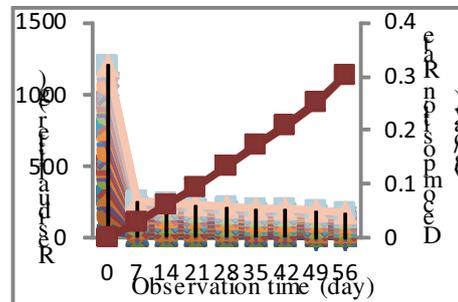


Fig. 1. Reduction and Decomposition *Rhizophora stylosa* litter

From figure 1 it can be seen that the biggest weight reduction occurred at first observation on the 7th day from 50 g to 10.564 g. The remainder of the second observation litter on the 14th day was 10.021 g. The difference in cistern litter was on the first observation on the seventh day and the second observation on the 14th day and then very different. The decrease in residual litter at the beginning of the observation is much greater than subsequent observations. According to Leo [10] decomposition of leaf litter in each week is different, where the weight loss of the litter will initially be high. This is possible because in the new litter there is still a lot of supply of elements that are food for organism decomposers, so litter quickly destroyed. Arief (2003) in Kurniawan [8] said that the nutrients contained by mangrove leaves are carbon, nitrogen, phosphorus, potassium, calcium and magnesium.

The element is reduced until only the element that is not required by the decomposer. One such decomposer, decomposer is a worm. On the 14th day and the 28th day found worms in the litter bag (Appendix 1). The worms affect the increase in decomposition rate. Kurniawan [8] stated that macrobentos is one of the earliest decomposers that chopped the remains of leaves which were then released back as dirt after which was continued by bacteria and fungi to decompose organic matter. Yahya (2014) says that the most number of bacteria are found in environments with salinity levels of 10-20 ppt. Bacteria will be more easily isolated from the soil with a certain depth. Nurrochman [11] stated that the most populations of bacteria found in mangrove forest land with a depth of 20 cm, while the fungi can be isolated from leaf litter. Therefore, in this research the isolated decomposer microorganisms are fungi.

3.1. Fungi as Decomposer

Types of fungal decomposer. The results of fungal decomposer isolation from *Rhizophora stylosa* leaf litter obtained 8 types of fungal isolates. Macroscopic observation could be seen through the growth of litter fungi decomposers colonies, while microscopic observation could be done by using a microscope. These types of fungi are as follows:

Isolate 1. Macroscopically, small round shape colonies like the original white columns, then turn yellowish green, then within 4 days turn brown to black on days 5-7. Microscopically, conidia are round with tapered bulges. This is consistent with Gandjar's [5] statement which stated that *Aspergillus* sp. is characterized by a black conidial head, round in shape, and tends to break into columns in old colonies. Conidia are round to semi-round in shape, brown, has ornamentation in the form of bulge and uneven spines. Based on the explanation, isolate 1 is classified as *Aspergillus* sp-1. The figures below are macroscopic and microscopic shapes of *Aspergillus* sp.

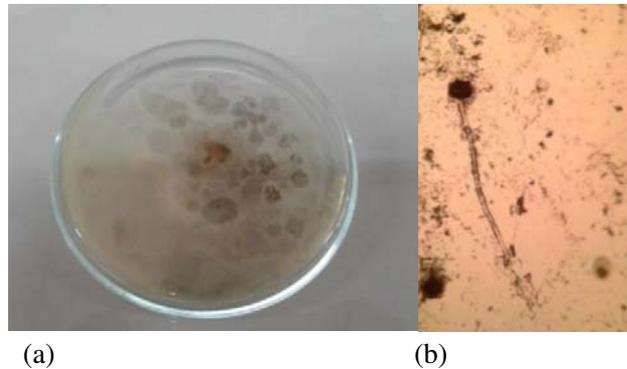


Figure 2. Macroscopic (a) and microscopic (b) shapes of *Aspergillus* sp.-1 isolated from *Rhizophora stylosa* leaf litter.

Isolate 2. If it is observed macroscopically, the first colonies are yellowish green with the white base become black within 7-10 days. The colony fills the cup, the diameter of the colony can reach 5 cm in 7 days. Microscopically, it is characterized by a smooth conidiophore. This is in line with Gandjar's [5] statement that *Aspergillus* sp. colony is characterized by a colony that reaches 4-5 cm in diameter in 7 days and consists of a compact basal layer of white to yellow and conidiophore layer that is dark brown to black. Conidiophore walled smooth, hyaline color, but can also brown. Based on the explanation, it is concluded that isolate 2 is *Aspergillus* sp.-2. It is in details can be seen in Figure below which is the macroscopic and microscopic shapes of *Aspergillus* sp.-2.

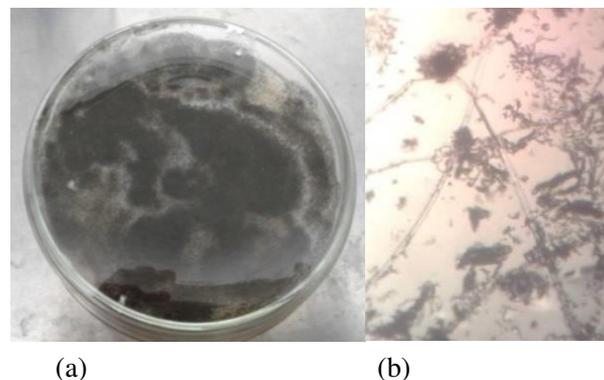


Figure 3. Macroscopic (a) and microscopic (b) shapes of *Aspergillus* sp.-2 isolated from *Rhizophora stylosa* leaf litter.

Isolate 3. Macroscopically, isolate 3 is characterized by brown and dispersed colonies. Microscopically, conidia tend to be elliptical. Referring to Gandjar [5] stated that *Aspergillus* sp. colonies consist of a solid layer formed by darker brownish conidiophores that darken with increasing age of colonies. Based on the explanation, this isolate is a fungi type *Aspergillus* sp.-3. It can be seen in the figures below which are macroscopic and microscopic shapes of *Aspergillus* sp.-3.

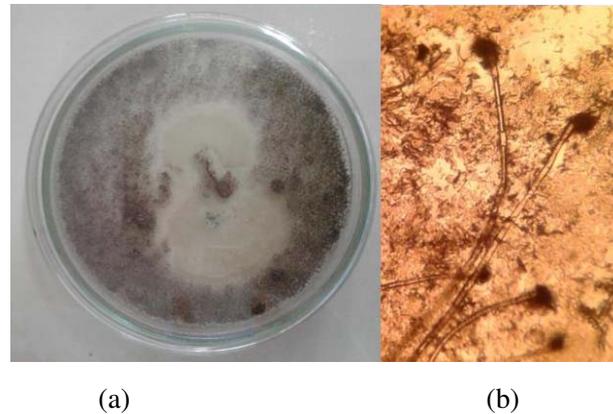


Figure 4. Macroscopic (a) and microscopic (b) shapes of *Aspergillus* sp.3 isolated from *Rhizophora stylosa* leaf litter.

Isolate 4. Macroscopically, this isolate was looked like white cotton and brownish gray to black in the middle with a quite slow growth. The diameter is 1-2 cm within 3-5 days. Microscopically, the isolates have sporangiophore and at the bottom are shaped like roots, referring to Dwidjoseputro [12] which stated that the mycelium of *Rhizopus* sp. looks like a group of cotton, over the time the colony became blackish due to a large number of sporangium and spores. The mycelium of *Rhizopus* is divided into stolons which produce tools like roots (Rhizoid) and sporangiophore. Based on these explanations, then this isolate is *Rhizopus* sp.-1. The figure below is macroscopic and microscopic shapes of *Rhizopus* sp.-1.

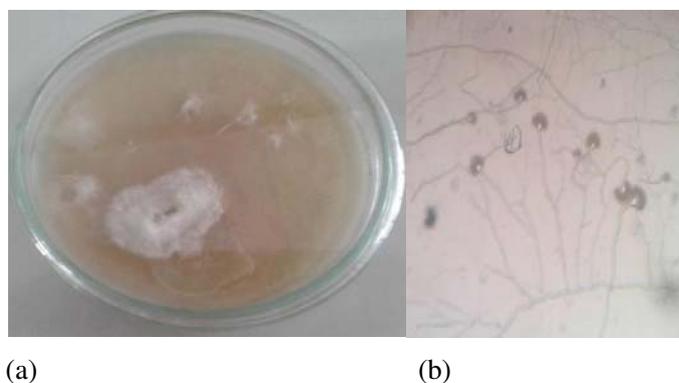


Figure 5. Macroscopic (a) and microscopic (b) shapes of *Rhizopus* sp.-1 isolated from *Rhizophora stylosa* leaf litter.

Isolate 5. The macroscopic observation shows that the isolated colony is white and diffuse with slower growth. While microscopically, this isolate has sporangia with branched sporangiophore which divided into rhizoids. This is consistent with the Gandjar's statement [5] that rhizoid of *Rhizopus* sp. has a brownish color, bifurcated in opposite direction with its sporangiophore which is single or grouped up to 5 and sometimes forming structures such as fork branching. Thus, it can be concluded that isolate 5 is *Rhizopus* sp.-2. The figures below are macroscopic and microscopic shapes of *Rhizopus* sp.-1.

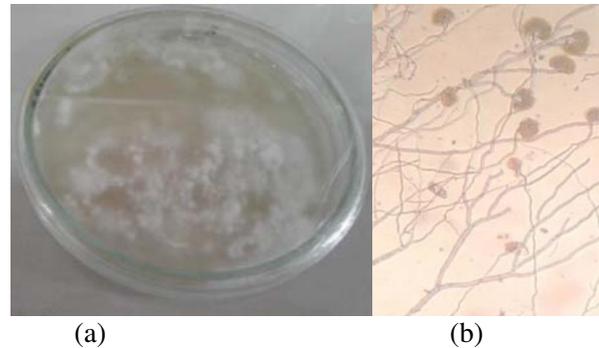


Figure 6. Macroscopic (a) and microscopic (b) shapes of *Rhizopus* sp.-2 isolated from *Rhizophora stylosa* leaf litter.

Isolate 6. Macroscopically, this colony is brownish green and velvety. While microscopically, the conidia are shaped like an elongated radiate chain. Referring to the book of Gandjar [5] which says that *Penicillium* sp. colony has a surface like velvet and sometimes like cotton and yellow to brownish green. Meanwhile, according to Kurnia (2011) who conidiophore of *Penicillium* sp. has a length of 5-50 μ m. Conidia radiate with 80 μ m chain length. So according to the literature, it can be concluded that isolate 6 is a fungi type of *Penicillium* sp. In more details, it can be seen in figures below which are macroscopic and microscopic shapes of *Penicillium* sp.

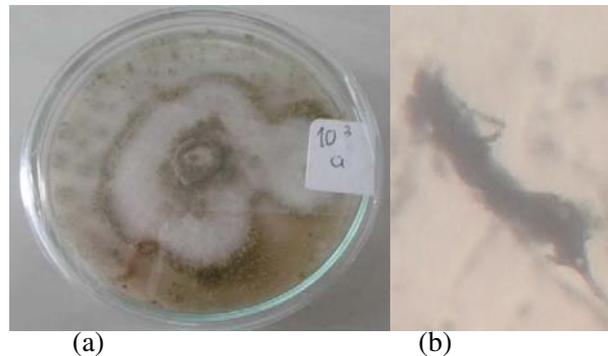


Figure 7. Macroscopic (a) and microscopic (b) shapes of *Rhizopus* sp. isolated from *Rhizophora stylosa* leaf litter.

Isolate 7. Macroscopically, the colony initially was a white colony then turn to grey and furtherly to brown. Microscopically, the sporangia head is in the form of a round with such a rhizoid place to grow and branch. This is in line with the statement of Gilman (1957) which stated that the colony of *Syncephalastrum* sp is white at the first, then turn to grey. Moreover, its Konidiopor is strong, initially not branched, then form a laterally curved branch and connected to the short rhizoid that becomes the place to grow. Based on the explanation, the isolate 7 is *Syncephalastrum* sp. The figures below show the macroscopic and microscopic shapes of *Penicillium* sp.

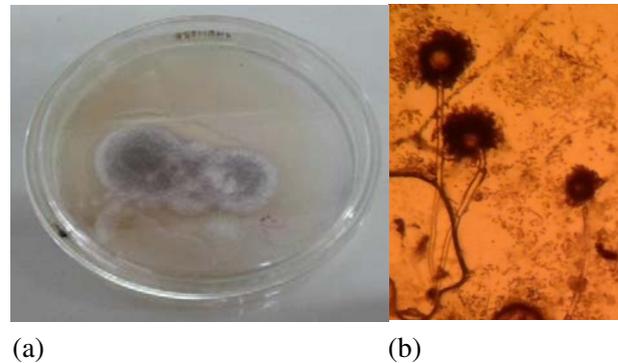


Figure 8. Macroscopic (a) and microscopic (b) shapes of *Syncephalastrum* sp. isolated from *Rhizophora stylosa* leaf litter.

Isolate 8. Macroscopically, colonies are white like cotton and spread. Microscopically, conidia are macro-lengthwise. Referring to the Gandjar's literature [5] which stated that *Fusarium* sp. has mycelia like cotton, then becomes velvety. Macroconidia shaped almost like a sickle, slightly straight, to slightly bent. Based on these explanations, isolate 8 can be classified as *Fusarium* sp. The figures below are macroscopic and microscopic shapes of *Fusarium* sp.

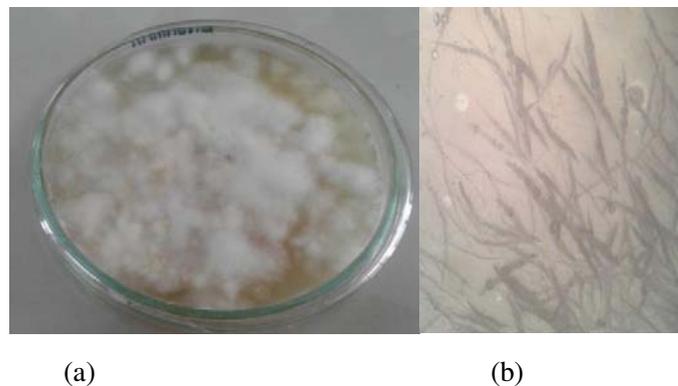


Figure 9. Macroscopic (a) and microscopic (b) shapes of *Fusarium* sp. isolated from *Rhizophora stylosa* leaf litter.

Based on the observation on the isolates, there were 8 types of decomposer fungi. The types of fungi were from the genus of *Aspergillus*, *Rhizopus*, *Penicillium*, *Syncephalastrum*, and *Fusarium*. Compared with the study [14] by Ratna's [14] on the fungal diversity on the decomposition processes of *Ceriopstagal* litter at various salinity levels in Kampung Nipah Sei Nagalawan North Sumaterathe they found 5 genus of decomposer fungi from *Ceriopstagal* leaves including *Aspergillus* sp.1, *Aspergillus* sp.2, *Aspergillus* sp.3, *Aspergillus* sp.4, *Aspergillus* sp.5, *Aspergillus* sp.6, *Aspergillus* sp.7, *Aspergillus* sp.8, *Aspergillus* sp.9, *Syncephalastrum* sp.1, *Syncephalastrum* sp.2, *Syncephalastrum* sp.3, *Syncephalastrum* sp.4, *Tricoderma* sp. and *Penicillium* sp.

In *R. stylosa* litter, the decomposer of the genus *Aspergillus* is the largest of the three types. The result of the observations showed that *Aspergillus* is the easiest type of fungi to grow on the petri dish. This is in

line with Gandjar's [5] statement that *Aspergillus* cosmopolites in the tropics and subtropics, and easily isolated from soil, air, water, and leaf litter. Ratna [14] also reported that nine types of *Aspergillus* sp. played important role in litter decomposition process of Cerioplastagal mangoves (family *Rhizoporaceae*).

The second largest type of fungus is *Rhizopus* sp. Soeroyo [13] stated that the types of *Rhizopus* from *Sonneratia* let a slightly salt enter their root system through the roots of which the very small entering salts are excreted and the excess salt may be associated with leaf storage.

The type of *Penicillium* obtained was one type. Gandjar [5] stated that the species is cosmopolitan, and common in the tropics area. This species is easily isolated from air, cereals, spices, litter, vegetables, pulp, and paper. The next type of fungus is *Syncephalastrum* sp. Ratna [14] reported that at the salinity level of 21-30 ppt, the highest colony is *Syncephalastrum* sp. that is 66.6%. This shows that this type of fungus is able to compete with other cosmopolite fungi types in litter decomposition. The last type is *Fusarium* sp. Gandjar [5] stated that *Fusarium* sp is generally found only in parts of plants that have died.

The types of fungi above are microorganisms that help the fertility of the growing place and growth of *R. stylosa* as well as provide natural nutrients for biota in the ecosystem.

4. Conclusions

Decomposition rate of *R. stylosa* litter on salinity level 0-10 ppt is classified as fast decomposition with decomposition value >0,01 g/day. Eight types of fungi were successfully identified to play important role in the decomposition process in leaf litter *R. stylosa* at salinity level 0-10 ppt. The fungi were *Aspergillus* sp.-1, *Aspergillus* sp.-2, *Aspergillus* sp.-3, *Rhizopus* sp.-1, *Rhizopus* sp.-2, *Penicillium* sp., *Syncephalastrum* sp. and *Fusarium* sp.

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