Diversity of fungi in decomposition process the *Avicennia marina* leaf litter at various level of salinity

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Abstract. Factors affecting the rate of the decomposition are animals and microorganisms such as worms, snails, bacteria, fungi etc. as well as environmental conditions, such as type of soil, pH and salinity of water, etc. This research was conducted at the Deli Belawan River and Forest Cultivation Laboratory, Medan, North Sumatra Sumatera. A study was undertaken to find out the effect of the salinity on the number of species, the population, the species diversity and the frequency of colonization of the different species of fungi during the process of the composition of the *A. marina* leaf litter decomposition. The leaf litter of *A. marina* to be put in a litter bag that is 50 g and it’s 33 litter bags for each level of salinity totally. The level of salinity to be used such as < 10, 10 – 20, 20 – 30 and > 30 ppt. The time series to collect data were 0 (control) , 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, and 165 days. The leaf litter of *A. marina* in a litter bag was taken from each salinity level that was three bags for each time. It was used for isolation and identification of the fungi. There were 21 fungal species isolated from the *A. marina* leaf litter before being decomposed and from those decomposed at < 10, 10 – 20, 20 – 30 and > 30 ppt. The highest population was found in the leaf litter before being decomposed with an average of 1.6 x 10^3 cfu/ml. The Species Diversity Indices of the fungi isolated from the leaf litter at < 10, 10 – 20, 20 – 30, and > 30 ppt were 1.96, 1.86, 1.75 and 1.50. The frequency of the fungal colonization ranged from 9.1 to 100 %.

1. Introduction
Litter decomposition process can be influenced by salinity in addition to animal and microorganism factors such as worms, snails, bacteria, fungi and environmental factors such as soil type and water pH [1]. There are several other factors that also affect the rate of litter decomposition, namely the release of energy, tidal frequency, soil temperature and humidity [2], and the presence of animals and microbes that decompose waste in the mangrove forest [3]. Microbes are the main component of biodiversity, both bacteria and fungi which constitute 91% of the total biomass of the mangrove ecosystem [4]. Fungi with various types of enzymes they produce can accelerate the litter decomposition process. To be able to live and play a role in the litter decomposition process, microorganisms need several requirements, including the availability of nutrients, the availability of extractive materials, optimum temperature, pH, O₂, CO₂ and sufficient water. Bacteria and fungi obtain energy for their metabolism from the breakdown of carbohydrates [5]. Yunasfi et.al (2006) found that differences in salinity levels also caused differences in the number of fungi involved in the decomposition process of *A. marina* leaf litter [6]. Microbes are a major component of this biodiversity, with bacteria and fungi constituting 91% of the total biomass of mangrove ecosystems [7] is generally an important soil component because both decomposers and plant symbionts, play a
major role in ecological and biogeochemical processes [8]. They contribute significantly to the degradation of organic matter derived from mangrove materials [9], being a major mineral in mangrove sediments and representing an important food source for benthic fauna [10].

Microorganisms play an important ecological role in the decomposition of organic matter and produce protein-rich detritus that serves as fish food, especially those made from marine ecosystem detritus such as mangroves [11]. Two types of parasitic fungi, namely Pestalotiopsis agallochae and Cladosporium marinum were found on the leaves of A. marina and Excoecaria agallocha [12]. The process of decomposition of mangrove leaves can be divided into three phases [13]. Large losses of carbon and nitrogen occur within a few days during the initial phase of decomposition, mainly by microbial decomposition of organic matter biomass. In the end the material is quite large, namely organic and inorganic materials [14]. In the second and third phases of leaf litter decomposition, unstable organic matter and structural components will decompose, followed by a physical decomposition process and biological decomposition of the litter. Zafar et al (2014) argued that leaf litter of A. marina decomposed more slowly than that of R. mucronata (p<0.001) [1]. The time required to lose 50% of the initial dry mass (t1/2) was 49.55 days for A. marina and 44.43 days for R. mucronata. The study results of Zafar et. al (2014) showed that the decomposition rate of A. marina (k = 0.83) was higher than that of R. apiculata (k = 0.41) [1]. Organic content in leaves is initially high but will decrease gradually during decomposition [1,15]. Nutrients released during decomposition are available for primary productivity and are also available to the plant itself and are not lost from the system.

2. Materials and methods

2.1. Place and time of research

The research was conducted in the Sungi Deli area, Forest Cultivation Laboratory, Faculty of Forestry, North Sematera University. The research activities were carried out from November 2018 to April 2019. The variables observed in this study were: the number of species of fungi, the population of fungi, the diversity of fungi species and the frequency of colonization of various types of fungi in the leaf litter of A. marina.

2.2. Leaf litter collection A. marina

Leaf litter was collected using 5 to 10 gauze/nylon measuring 3 x 4 m, which was placed by tying it between two trees at a height above the highest tide line. A. marina leaf litter collected as much as 6600 g (50 g litter x 11 treatments x 3 replications x 4 levels of salinity).

2.3. Placement of A. marina leaf litter in the field

50 g of A. marina leaf litter into a 40 x 30 cm bag made of nylon with a 1 x 1 mm mesh. The total number of bags was 132 (11 times taken x 3 replications x 4 levels of salinity). Litter bags that already contained A. marina leaf litter were placed in the field which had various levels of salinity, according to the treatment. Salinity was measured with a hand refractometer. At locations with predetermined salinity levels, four plots were made, each measuring 430 cm x 50 cm. A total of 33 litter bags containing 50 g of A. marina leaf litter were randomly assigned to each plot. In order not to be washed away by the tide, the four ends of the litter bag are tied to wooden stakes made of bamboo with a length of 50 cm each and a diameter of 1.5 cm. The four woods that have been tied with litter bags are then plugged into the ground to a depth of 40 cm. Another method that can be used is to tie the four corners of the litter bag to the roots or the base of the nearest tree trunk. A total of 3 bags containing litter were taken from each salinity level once every fifteen days and bags filled with litter were collected until the 165th day (11 times of collection) after the litter was placed in the field.

2.4. Isolation of fungi from leaf litter of A. marina

Determination of the fungal population was carried out using the dilution method by making a dilution series suspension. Determination of the fungal population from leaf litter of A. marina that has received various treatments is also carried out using the dilution method by making a series of dilutions of leaf litter of A. marina like the method of dilution of leaf litter that has not undergone decomposition.
2.5. Identification of fungi

Pure cultures of fungi were rejuvenated on PDA media, and incubated for 5-7 days at room temperature. The fungal isolates that had grown on the media were observed for macroscopic characteristics, namely colony characteristics such as the growth characteristics of hyphae, color and diameter of the colony and the color of the mass of spores or conidia. Fungal isolates were also grown on slide culture, by placing 4 x 4 x 2 mm agar pieces that had been overgrown with fungi on a slide, which was then covered with a cover slip. The isolate on this slide was placed in a plastic box measuring 30 x 20 x 6 cm, which had been moistened with wet cotton. The fungal isolates on this slide were left for several days at room conditions until the fungal isolates grew sufficiently. When the fungal isolates have developed, carefully remove the cover glass that has been overgrown with fungi to remove the pieces of agar. Furthermore, on the former cut agar, 1 drop of Lactophenol solution was dropped to make a permanent culture. The cover glass which has also been overgrown with fungi is then placed on top of the Lactophenol solution on the slide. This glass culture was observed using a light microscope to determine the microscopic characteristics of the fungus, namely the characteristics of the hyphae, the presence or absence of a bulkhead on the hyphae, the type of branching of the hyphae, conidiophores, conidiogenesis, as well as the characteristics of conidia or spores (shape and series) and the size of the spores. The characteristics obtained were tabulated, then matched with the fungi identification key. Furthermore, the identification elaboration process was also carried out at the LIPI Serpong Laboratory. After the identified fungi were recorded, the number of species, population, species diversity and frequency of fungal colonization found in the leaf litter of A. marina. This activity was carried out at each time the litter was taken from the field during the decomposition process, starting from day 0 (control) to day 165.

2.6. Data collection

Data on the identity, number of species, population, species diversity and frequency of colonization of each type of fungi were collected to determine the effect of seawater salinity level, as well as the duration of decomposition on these parameters. The leaf litter of A. marina is placed in locations with the following salinity levels:
A. Salinity level < 10 ppt
B. Salinity level 10 – 20 ppt
C. Salinity level 20 – 30 ppt
D. Salinity level > 30 ppt

Data collection was carried out after the litter was placed in the field with various levels of salinity, during the following time:
A. No litter placement (control) G. Day 90
B. Day – 15 H. Day – 105
C. 30th day I. 120th day
D. Day 45 J. Day 135
E. Day – 60 K. Day – 150
F. Day – 75 L. Day – 165

Each time the observations were carried out in 3 replications for 165 days, for each of which a bag containing 50 g of litter was taken.

2.7. Determination of the fungi diversity index

The Fungal Diversity Index was calculated using the Shannon's Index [16]. The formula:

\[ H = - \sum_{i=1}^{s} (Pi \ln Pi) \]

\[ Pi = \frac{ni}{N} \]
3. Results

3.1. Types of Fungi Found in A. marina leaf litter that have not undergone the decomposition process.

In the control, namely litter that has not undergone a decomposition process in the field, 5 types of fungi are found. The average number of colonies and the types of fungi found in the leaf litter of A. marina that have not decomposed in the field can be seen in Table 1. From Table 1 it can be explained that the types of fungi found in the leaf litter of A. marina are have not decomposed in the field are as follows: Aspergillus sp. 1, Aspergillus sp. 2, Aspergillus sp. 3 which is fully presented in Table 1.

Table 1. Average number of colonies x 10^2 (cfu/ml) of each type of fungi in leaf litter of A. marina that has not undergone the decomposition process (control).

| No. | Types of fungi       | Average number of colonies x 10^2 (cfu/ml) |
|-----|----------------------|------------------------------------------|
| 1.  | Aspergillus sp. 1    | 1                                        |
| 2.  | Aspergillus sp. 2    | 5.33                                     |
| 3.  | Aspergillus sp. 3    | 1.33                                     |
| 4.  | Fusarium sp. 1       | 0.67                                     |
| 5.  | Curvularia lunata    | 8.67                                     |

The total number of colonies on average is 17.33

3.2. Types of fungi found in leaf litter of A. marina that experience decomposition at a salinity level < 10 ppt.

Leaf litter of A. marina which decomposed at salinity < 10 ppt found 17 species of fungi. The type of fungi that colonize the leaf litter of A. marina which undergoes a decomposition process from 15 days to 165 days. The amount of each type of fungus varies from week to week during the decomposition period. The 17 types of fungi are not always present during the decomposition period. The types of fungi that are always found during the decomposition period, namely Aspergillus sp. 2 except for litter which decomposed for 15 days. The most abundant fungal colonies were Aspergillus sp. 2, which is 6.79 x 10^2 cfu/ml. This type of fungus colonizes litter that has undergone a decomposition process from 15 days to 165 days or with a colonization frequency of 100%. Aspergillus sp. 4 was the second most abundant fungal colony, colonizing litter from 15 days to 165 days. The number of colonies of this fungus was on average 2.91 x 10^2 cfu/ml with a frequency of 27.3%. Litter colonization by this type of fungus occurs after the litter undergoes a decomposition process for 30, 75 and 90 days. The largest number of colonies, which was 2.90 x 10^3 cfu/ml, was found in litter that had undergone a 30-day decomposition process. The third largest fungal colony found in leaf litter was Aspergillus sp. 1 with an average amount of 2.64 x 10^2 cfu/ml. This type of fungus colonizes litter that has been decomposed for 15, 60, 105, 120, 135, 150 and 165 days. The frequency of colonization of this type of fungus is greater than the frequency of colonization of Aspergillus sp. 4, which is 63.6%. Trichoderma sp. 1 colonized litter that had undergone decomposition for 105 days with a colonization frequency of only 9.1%. The number of colonies that were isolated was an average of 2.03 x 10^2 cfu/ml. This type of fungus was successfully isolated in litter that had undergone a decomposition process for 45 and 75 days with a colonization frequency of 18.2%. The type of fungi that also colonizes leaf litter of A.
marina which decomposes in an environment with salinity < 10 ppt is Fusarium sp. 2. This type of fungus emerged and was successfully isolated in leaf litter of A. marina which had been decomposed for 75, 135 and 165 days. The number of colonies of this type of fungus was an average of 0.76 x 10^2 cfu/ml with a colonization frequency of 27.3%. Penicillium sp. 1 was isolated by an average of 0.46 x 10^2 cfu/ml in litter that underwent a 60-day decomposition process. The frequency of colonization of this fungus was 9.1% from eleven observations. Trichoderma sp. 2 and Aspergillus sp. 3 were isolated from leaf litter of A. marina with the same colonization frequency of 18.2% with an average colony number of 0.27 x 10^2 cfu/ml. Trichoderma sp. 2 was found in leaf litter that had undergone a 45 and 120 days decomposition process, similar some study in [17,18]. As for Aspergillus sp. 3 was found in litter that had undergone a decomposition process for 150 and 165 days. Other types of fungi that were found once in eleven times each observed in the decomposed leaf litter of A. marina were as follows: Penicillium sp. 2. Aspergillus sp. 5, Fusarium sp. 3, Penicillium sp. 3, Penicillium sp. 4, Curvularia lunata, Trichoderma sp.3, Aspergillus sp., Penicillium sp. 5.

3.3. Types of fungi found in leaf litter of A. marina that experience decomposition at salinity levels 10 – 20 ppt.
There were 12 species of fungi isolated from the leaf litter of A. marina which decomposed at a salinity level of 10 – 20 ppt. The most common types of fungi found in the decomposed leaf litter of A. marina were Aspergillus sp. 2 with an average colony count of 2.0 x 10^2 cfu/ml. Aspergillus sp. 2 was found in leaf litter that had decomposed for 15, 45, 60, 105, 120, 135, 150 and 165 days and was not found on days 30, 75 and 90. The frequency of finding this fungus was 72.7%. The highest number of colonies isolated from leaf litter of A. marina was in litter that had undergone a 15-day decomposition process with an average colony count of 8 x 10^2 cfu/ml. Aspergillus sp. 4 was found in litter that had been decomposed for 30, 75, 90, 135, 150 and 165 days with an average colony count of 1.76 x 10^2 cfu/ml. The number of these colonies occupies the second largest number after Aspergillus sp. 2 with a colonization frequency of 54.6%. Aspergillus sp. 3 and Aspergillus sp. 1 occupies the third position with an average colony number of 0.46 x 10^2 cfu/ml for each species. Aspergillus sp. 3 and Aspergillus sp. 1 occupies the third position with an average colony number of 0.46 x 10^2 cfu/ml for each species. Aspergillus sp. 3 was successfully isolated in litter that had undergone a decomposition process for 15, 150 and 165 days.

Furthermore, the types of fungi that were isolated from the leaf litter of A. marina which decomposed at a salinity level of 10 – 20 ppt, were Penicillium sp. 1 with a colonization frequency of 9.1% which was successfully isolated from leaf litter that had undergone a 60-day decomposition process with a colony count of 0.46 x 10^2 cfu/ml. From the leaf litter of A. marina, Aspergillus sp. has also been isolated. 5 with an average colony count for 165 days of decomposition of 0.27 x 10^2 cfu/ml. The frequency of colonization of this type of fungus was 18.2% which was successfully isolated from leaf litter which underwent a decomposition process for 45 and 105 days. Other types of fungi that were isolated from the leaf litter of A. marina at a salinity level of 10 – 20 ppt, each of which had a colonization frequency of 9.1%, were as follows: i) Trichoderma sp. 1 mean colony count 0.18 x 10^2 cfu/ml, ii) Trichoderma sp. 4 The number of colonies of this fungus in leaf litter was on average 0.12 x 10^2 cfu/ml, iii) Fusarium sp. 2 with an average colony of 0.09 x 10^2 cfu/ml which was isolated from leaf litter that had been decomposed for 75 days, iv) Penicillium sp. 3 and v) Penicillium sp. 2.

3.4. Types of fungi found in leaf litter of A. marina undergoing a decomposition process at a salinity level of 20 – 30 ppt.
The number and types of fungi from the leaf litter of A. marina which had undergone a decomposition process at a salinity level of 20-30 ppt were isolated as many as 11 species of fungi. The number of colonies of this type of fungus according to the length of the decomposition period ranged from 0.03 x 10^2 cfu/ml to 1.52 x 10^2 cfu/ml. The highest number was colony of Aspergillus sp. 2, which is an average of 1.52 x 10^2 cfu/ml. This type of fungus was successfully isolated from leaf litter that had undergone a decomposition process for 15, 30, 45, 60, 105, 120, and 135 days with a colonization frequency of 9.1%.
frequency of 54.6%. *Aspergillus* sp. 4 was found in the leaf litter of *A. marina* which had undergone a decomposition process for 30, 75, 105, 150 and 165 days with an average colony number of $1.15 \times 10^2$ cfu/ml. The frequency of colonization of this fungus on leaf litter of *A. marina* was 45.5% with the highest number of colonies obtained after the litter experienced 165 days of decomposition. *Trichoderma* sp. 4 ranks third with an average colony count of $0.73 \times 10^2$ cfu/ml. The frequency of this type of fungus colonizing litter was 36.4% from eleven times of observation. This type of fungus was successfully isolated from leaf litter which had undergone a decomposition process for 30, 45, 105 and 165 days.

Furthermore, in the leaf litter of *A. marina* which underwent a decomposition process for 15 to 165 days at a salinity level of 20-30 ppt, *Aspergillus* sp. 3 with an average colony of $0.64 \times 10^2$ cfu/ml. The frequency of colonization of this fungus during the decomposition process of *A. marina* leaf litter was 81.8%. This type of fungus was found in litter that had undergone a decomposition process for 15, 30, 45, 75, 90, 105, 150, 165 days. It is also known that *Aspergillus* sp. 3, colonize almost during the observed decomposition time, except after 60 and 120 days of the decomposition period. As in the leaf litter of *A. marina* which was at salinity levels $< 10$ and 10 – 20 ppt, then at salinity levels of 20 – 30 ppt, *Aspergillus* sp. 1. The number of colonies of this type of fungus is $0.46 \times 10^2$ cfu/ml. This type of fungus was found 15 days after the decomposition period with a colonization frequency of 9.1%. *Penicillium* sp. 1 successful isolated from litter after 60 and 90 days of decomposition with an average colony number of $0.36 \times 10^2$ cfu/ml. The frequency of colonization of this type of fungus in the leaf litter of *A. marina* which underwent decomposition was 18.2% of all observations. Six types of fungi, namely *Aspergillus* sp. 5, *Penicillium* sp. 3, *Trichoderma* sp. 1, *Aspergillus* sp. 7, *Aspergillus* sp. 6 had the same colonization frequency (9.1%) in *A. marina* leaf litter which underwent a decomposition process at a salinity level of 20-30 ppt. *Aspergillus* sp. 5 can be isolated from litter that has been decomposed for 150 days with an average colony number of $0.27 \times 10^2$ cfu/ml. Colonies of *Penicillium* sp. 3 were isolated $0.06 \times 10^2$ cfu/ml, while *Trichoderma* sp. 1 with an average colony of $0.06 \times 10^2$ / ml, found in litter that has undergone a decomposition process for 150 days. As for *Fusarium* sp. 3 with an average colony count of $0.03 \times 10^2$ / ml can be isolated after the litter undergoes a decomposition process for 165 days. *Aspergillus* sp. 7 with an average colony number of $0.03 \times 10^2$ / ml can be isolated from litter that has undergone 75 days of decomposition. *Aspergillus* sp. 6 was successfully isolated from litter after 60 days of decomposition. The frequency of colonization of this fungus is 9.1%.

### 3.5. Types of fungi found in leaf litter of *A. marina* that experience decomposition at salinity levels > 30 ppt

There were 14 types of fungi in *A. marina* leaf litter that had undergone a decomposition process at salinity levels > 30 ppt. The type of fungus with the highest average number of colonies $1.21 \times 10^2$ cfu/ml was found in leaf litter that had undergone a decomposition process at a salinity level > 30 ppt, *Penicillium* sp.6. These types of fungi were isolated in litter that had undergone a decomposition process for 30, 45, 120 and 165 days. The frequency of colonization of this fungus in *A. marina* leaf litter was 36.4% from eleven observations made. The type of fungus that occupies the second highest position with an average colony of $1.03 \times 10^2$ cfu/ml in leaf litter that undergoes a decomposition process at a salinity level > 30 ppt, is *Fusarium* sp. 2. This type of fungus was successfully isolated from litter that had undergone a decomposition process for 15 days, with a colonization frequency of 9.1%. *Aspergillus* sp. 2 has the highest frequency of colonization, which is 72.7% in the leaf litter of *A. marina* which undergoes a decomposition process at a salinity level of >30 ppt. This type of fungus was found at 30, 60, 90, 105, 120, 135, 150 and 165 days after the litter underwent the decomposition process. The average number of colonies for this type of fungus was $0.94 \times 10^2$ cfu/ml. *Trichoderma* sp. 4 was isolated from leaf litter that had undergone a decomposition process for 30, 45, 105, 120, 135, 150 and 165 days. The frequency of colonization of this fungus is 63.6%. The average number of colonies that can be isolated is $0.88 \times 10^2$ cfu/ml. Types of fungi that were not identified 3 were isolated 30 days after the litter was decomposed, with an average colony of $0.06 \times 10^2$ cfu/ml.
3.6. Comparison of fungi populations at various levels of salinity

In Figure 1 it can be seen that the largest fungi population was $18.33 \times 10^2$ cfu/ml on average, which was found in the leaf litter of *A. marina* which had not yet undergone a decomposition process in the field. The population of fungi in *A. marina* leaf litter at a salinity level of < 10 ppt, which is $16.67 \times 10^2$ cfu/ml, is greater than that in *A. marina* leaf litter which decomposes at a salinity level of 10 – 20 ppt, 20 – 30 ppt, and > 30 ppt with an average of $6.04 \times 10^2$ cfu/ml, $5.34 \times 10^2$ cfu/ml and $4.99 \times 10^2$ cfu/ml.

![Fungi Population Graph](image)

**Figure 1.** The population of fungi found in the leaf litter of *A. marina* that has not and that has undergone a decomposition process in environments with various levels of salinity.

3.7. Fungi diversity index

The average value of the Shannon Index for Diversity of Fungal Species found in the leaf litter of *A. marina* which had undergone a decomposition process at various levels of salinity, ranged from low to moderate. Diversity Index of Fungal species in leaf litter of *A. marina* which underwent a decomposition process in an environment with salinity < 10 ppt, 10 – 20 ppt, 20 – 30 ppt and > 30 ppt were 1.96, 1.86, 1.75 and 1.50, respectively. The Species Diversity Index was greater than the Fungal Diversity Index found in the leaf litter of *A. marina* which had not yet undergone the decomposition process, which was 1.26.

3.8. Fungi colonization frequency

In the leaf litter of *A. marina* which has decomposed at various levels of salinity, there are differences in the frequency of appearance of colonies of various types. The frequency of fungal colonization on leaf litter of *A. marina* which had undergone a decomposition process at a salinity level of < 10 ppt ranged from 9.1 to 100% from eleven observations made. The highest frequency of colonization was occupied by *Aspergillus* sp. 2, which is 100%. This type of fungus colonizes the leaf litter of *A. marina* after 30 to 165 days of undergoing the decomposition process, while 15 days after undergoing the decomposition process this type of fungus has not been found to colonize the litter. The frequency of colonization of *Aspergillus* sp.1 in leaf litter of *A. marina* was 63.6% which was the second position of the types of fungi found at salinity levels < 10 ppt. This type of fungus was found in the leaf litter of *A. marina* which underwent a decomposition process for 15, 60, 105, 120, 135, 150 and 165 days. In the leaf litter of *A. marina* which underwent a decomposition process at a salinity level of 10 – 20 ppt, the highest colonization frequency was also occupied by *Aspergillus* sp. 2 with a frequency value of 72.7%, which means that there were eight appearances of this fungal colony out of eleven observations made. The frequency of fungal colonization at salinity levels of 10 – 20 ppt ranged from 9.1% to 72.7%. The types of fungi that have the second and third largest frequency values are
Aspergillus sp. 4 and Aspergillus sp. 1 with a value of 54.6% and 36.4%, respectively. The frequency of colonization of fungal species in the leaf litter of A. marina which underwent a decomposition process at a salinity level of 20-30 ppt ranged from 9.1 to 81.8%. The type of fungus that has the highest frequency value is Aspergillus sp. 3 which was followed by Aspergillus sp. 2, Aspergillus sp. 4 and Trichoderma sp. 4 with the respective frequency values are 81.1%, 54.6%, 45.5% and 36.4%. In the leaf litter of A. marina which underwent a decomposition process at a salinity level > 30 ppt, the highest frequency of fungal colonization was occupied by Aspergillus sp. 2 with a frequency value of 72.7%. This type of fungus was found in the leaf litter of A. marina which had undergone a decomposition process for 30, 60, 90, 105, 120, 135, 150 and 165 days. The second largest frequency of fungal colonization with a value of 63.6% was occupied by Trichoderma sp. 4.

4. Discussion
The largest number of fungal species was found in the leaf litter of A. marina which underwent a decomposition process at a salinity level of < 10 ppt. This happens because this condition is almost the same as the fresh (brackish) conditions which are quite good for the growth and development of various types of fungi compared to conditions at higher salinity levels. The number of these species decreases with increasing salinity, which is 12 at 10 – 20 ppt and 20 – 30 ppt salinities respectively. The largest population of fungi species was found in the leaf litter of A. marina which had not undergone a decomposition process in the field. This can be explained that in the litter that has not been placed in the field, it is estimated that the fungi’s breeding materials come from the surrounding environment that comes from the soil, carried by the wind, birds, insects and others. It is estimated that leaf litter that has not undergone a decomposition process in the field is a suitable place for various types of fungi to grow and develop. Although the number of types of fungi found in leaf litter is small, these types of fungi are able to reproduce well, resulting in a large population. At various salinity levels studied, the largest population of fungi species was found in the leaf litter of A. marina which had undergone a decomposition process at a salinity level of < 10 ppt. This pattern is almost the same as the pattern of the number of fungal species which is also the largest in litter that has undergone a decomposition process at a salinity level of < 10 ppt. This higher the environmental salinity level, the lower the fungal population. This occurs because the factors needed for the growth and development of various types of fungi are more abundant in the leaf litter of A. marina which undergoes a decomposition process at a salinity level that is almost close to fresh, ie < 10 ppt. Various types of fungi can grow and develop better at salinity < 10 ppt compared to salinity levels of 10 – 20 ppt and 20-30 ppt. The fungal population was smaller in the leaf litter of A. marina which was at a salinity level > 30 ppt.

The diversity of fungi species in the leaf litter of A. marina which decomposed at all salinity levels studied showed a large difference. Here it is clearly seen that although the number of species of fungi and the population of fungi is greatest at the level of salinity < 10 ppt, but for the diversity of species this does not apply. It was even seen that the diversity of fungi species in the leaf litter of A. marina which underwent a decomposition process at salinity levels > 30 ppt was greater than those at lower salinities. According to Fisher and Binkley (2000), the factors that affect population density and species diversity of soil organisms are oxygen supply, humidity, soil temperature, nutrient content and the amount of soil organic matter [19]. The relationship between the level of salinity and the number of fungal colonies obtained in leaf litter that has not and has undergone decomposition at various levels of salinity, shows the types of fungi that have the largest colonies, namely Aspergillus sp. 2 (largest in control, < 10, 10 – 20 and 20 – 30) and Fusarium sp 2 (largest at > 30 ppt).

5. Conclusion
Salinity level < 10 ppt is an environmental condition that is more suitable for the survival, growth and development of various types of fungi in A. marina leaf litter compared to higher salinity levels. The effect of salinity level can be seen based on the number of types of fungi found in the leaf litter of A. marina which underwent a decomposition process at a salinity level of < 10 ppt with the number of
species 17 compared to the number of types of fungi found in the leaf litter of A. marina which underwent a decomposition process at a level salinity 10 – 20 ppt, 20 – 30 ppt and > 30 ppt which were 11, 11 and 10 respectively. The fungal population was $16.75 \times 10^2$ cfu/ml contained in the leaf litter of A. marina which underwent a decomposition process at the salinity level. < 10 ppt is also the largest, compared to the large population of fungi in the leaf litter of A. marina which undergoes a decomposition process at salinity levels of 10 – 20 ppt, 20 – 30 ppt, > 30 ppt and controls, each of which is an average of $5.79 \times 10^2$ cfu/ml, $5.31 \times 10^2$ cfu/ml, $4.99 \times 10^2$ cfu/ml. Diversity Index of Fungal species in leaf litter of A. marina which underwent decomposition at various levels of salinity showed no large difference, except when compared to litter that had not undergone decomposition, there was a large difference. The species diversity index for fungi found in litter of A. marina which underwent a decomposition process at salinity levels < 10 ppt, 10 – 20 ppt, 20 – 30 ppt, > 30 ppt and in litter that had not undergone a decomposition process, respectively were 1.96, 1.86, 1.75, and 1.25. The frequency of fungal colonization at < 10 ppt salinity was 100% of the eleven observations made on various types of fungi present during the decomposition process of A. marina leaf litter. The frequency of fungal colonization, namely 72.7%, 81.1% and 72.7%, was found in the leaf litter of A. marina which underwent a decomposition process at salinity levels of 10 – 20 ppt, 20 – 30 ppt and > 30 ppt.

Recommendation
From this research, it can be recommended to get the largest population of fungi should use sea water with low salinity or close to brackish.

Acknowledgment
To DRPM Kemristekdikti for Fiscal Year 2019 between the Chancellor and the Chair of the University of North Sumatra Research Institute According to Number: 5211/UN5.1.R/PPM/2019.

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