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Zoning Patterns of Mangrove Forests in Lampung Timur Regency

Imron[1], Duryat[*2], Sandy Erggi Irawan[2], Tri Maryono[3], Rodiani[4]

[1] *Department of Occupational Safety and Health, Faculty of Engineering, Indo Global Mandiri University, Palembang, South Sumatra, 30129, Indonesia*

[2] *Forestry Department, Faculty of Agriculture University of Lampung, Bandar Lampung, Lampung, 35145, Indonesia*

[3] *Plant Protection Department, Faculty of Agriculture University of Lampung, Bandar Lampung, Lampung, 35145, Indonesia*

[4] *Department of Obstetrics and Gynecology, Faculty of Medicine, University of Lampung, Bandar Lampung, Lampung, 35145, Indonesia*

[*]Corresponding Author: duryatunila2@gmail.com

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ABSTRACT

Mangrove forests form due to vegetative distribution along coastlines with varying growing conditions concerning substrate, freshwater intake, and oceanic currents. These disparities facilitate zoning and subsequent distinct growth patterns. The research objective was to identify the zoning structure of mangrove ecosystems in Lampung Timur Regency, Lampung Province, Indonesia. The degradation of mangrove forests in Lampung Timur Regency was thought to be caused by anthropogenic activities and inappropriate zoning patterns. Concerning data collection, the cluster sampling method was employed, which was selected based on the preliminary study's findings that the mangrove status in the study area exhibits a variety of substrates, freshwater supply, and strong ocean currents. There are five clusters on the study site, with each cluster containing sample plots measuring 10m x 10m. The sampling method employed a striped path starting from the outermost part of the mangrove ecosystem, with the number of plots in each cluster dependent on the thickness of the mangrove vegetation. A regional map and GIS applications were used for mangrove zonation mapping, and the factors influencing the zonation of mangrove ecosystems were analyzed descriptively. The research findings demonstrated that the mangrove ecosystem located in Lampung Timur comprises three distinct zones: the outer zone, the middle zone, and the terrestrial zone.

Keyword: Lampung Timur, Mangrove Forest, Salinity, Water pH, Zoning

1. Introduction

Mangrove ecosystems are characterized by their evergreen nature and capacity to withstand high levels of salt [21]. It is located at the interface of salt and fresh water. These brackish ecosystems serve as valuable habitats for marine biota, carbon sinks, agents of climate change mitigation, and protectors against abrasion and coastal erosion [7,11]. Mangrove vegetation comprises various types, exhibiting different levels of adaptability [26]. The diverse types of mangrove ecosystems are influenced by the prevailing growth conditions, as reported by [13]. This study found that mangrove species exhibit distinct responses to physical environmental variations, creating distinct vegetation zones.

Mangrove forests form due to the distribution of vegetation ranging from the sea to the land with varying growing conditions. This results in the development of zonation. Tides, salinity, and substrate, as reported by [20], play a significant role in the formation of mangrove zonation. In addition, [14] suggests that substrate, salinity, and tides have a strong influence on the zonation of mangrove forests. When confronted with environmental variations like these, mangroves will naturally establish zonation [5]. Mangrove zonation is an

ecological phenomenon affected by coastal tides [18]. This influence promotes the emergence of a distinctive community in the coastal region [16].

The importance of establishing zoning patterns lies in their role as a form of nature conservation, which helps to maintain natural ecosystems and safeguard endangered biodiversity. Furthermore, it provides environmental protection against degradation caused by human activities and aids in reducing the risk of natural disasters through appropriate zoning and planting patterns [27]. The determination of zoning patterns is carried out to facilitate the arrangement of the area and the management of forest resources in a sustainable manner. Setting zoning patterns aims to preserve mangrove forests and achieve sustainable management, as described by [25]. According to [13], mangrove forest vegetation in almost every region has deteriorated in quality and quantity due to excessive community exploitation and may be further damaged.

The Lampung Timur Regency boasts a significant mangrove forest along the coast from Margasari Village to Pruworejo Village, covering an area of 2,592.20 ha, as reported by [6]. Currently, the condition of mangrove forests in Lampung Timur Regency is deteriorating due to human activity, global climate change, and inappropriate zoning patterns, such as the conversion of land into ponds or residential areas. These factors have impacted the growth of mangrove forests [1]. This study aims to establish the zoning pattern of mangrove ecosystems in Lampung Timur Regency, Lampung Province.

2. Method

2.1 Research Location

The study was carried out from November 2022 to January 2023 in three areas located in Lampung Timur Regency, Lampung, Indonesia. They are Margasari, Sriminosari, and Pasir Sakti. The study was conducted from November 2022 to January 2023 (Figure 1).

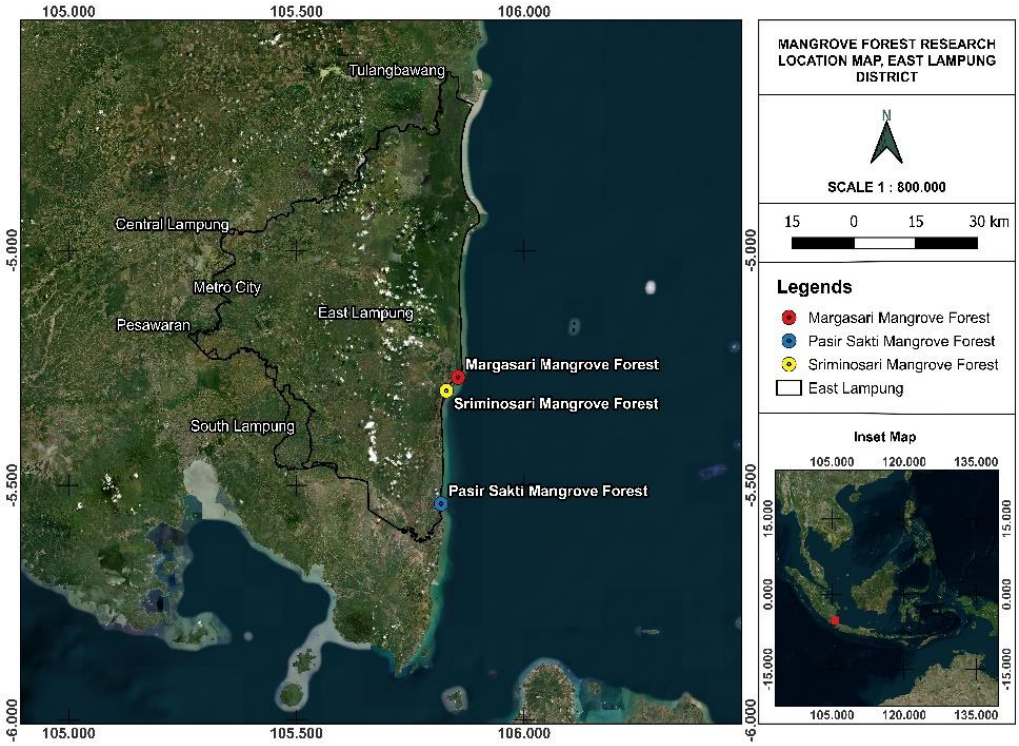

Figure 1. Site of study in the village of Margasari, Sriminosari, and Pasir Sakti, Lampung Timur Regency

2.2 Sampling and Observation Plots

The data were collected using the cluster sampling method. This approach was selected because the previous inquiry reveals that mangrove status in the research region manifests substrate diversity, freshwater supply, and robust ocean currents. These are the three crucial factors closely linked to the existence of mangrove vegetation. Sampling locations at each site were selected based on substrate diversity, freshwater intake, and ocean currents. Sample plots of 10m x 10m were positioned within each cluster using the mapped path method,

starting from the outermost section of the mangrove ecosystem (Figure 2). The number of plots within each cluster varied, depending on the thickness of the mangrove vegetation, as they were taken from the sea towards the land.

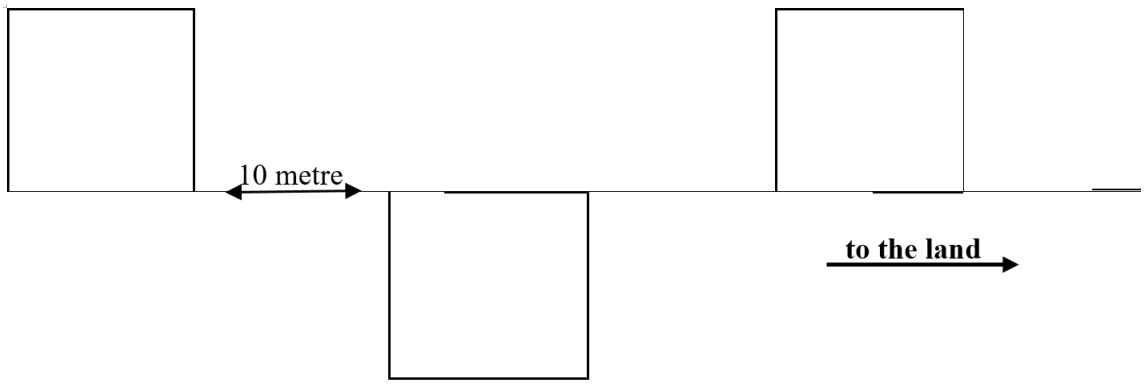

Figure 2. Observation sampling plots

Following the placement of the litter with varying salt levels in the field, data collecting was done. The observations were made in three replications for 90 days, each with a bag containing 50 g of litter collected over the subsequent 90 days such as (a) no littering (control), (b) day 15th, (c) day 30th, (d) day 45th, (e) day 60th, (f) day 75th, and (g) day 90th.

2.3 Parameteres Measurement

Vegetation analysis was conducted directly in the field to obtain plant data. The identification of mangrove species through direct observation using the Indonesian mangrove determination key [15]. Measurements of salinity and water pH were carried out in each observation plot using a refractometer and pH meter. Five points of the measurement are at the four corners of the plot 10m x 10m. One point is in the middle of the plot. Complete measurement points of water salinity and pH values are presented in Figure 3.

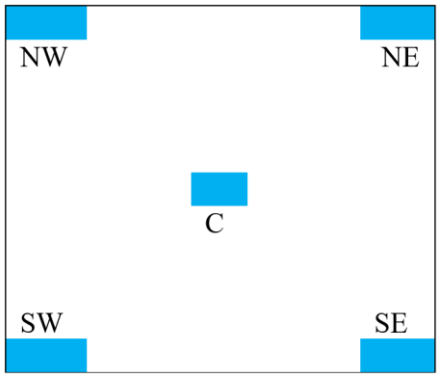

Figure 3. Measuring points for water salinity and pH in the sample plot (Note : NW is Northwest, SW is Southwest, C is Central, NE is Northeast, and SE is Southeast)

2.4 Data Analysis

Vegetation analysis was conducted directly in the field to obtain plant data. The mangrove species were identified through direct observation using the Indonesian mangrove determination guideline book [15]. Mangrove zonation mapping was conducted using regional maps and Geographic Information System (GIS) applications. GIS is a computer-based information system that combines elements of the map and information about the map. This system is designed to process, manipulate, analyze, and display spatial data [12]. Then describe the arrangement of mangrove formations from the outermost to the land in each region. The final process carried out was the depiction of each cluster with the dominance of mangrove species to determine the zoning pattern. The factors that affect the mangrove ecosystem zonation were analyzed descriptively. These factors include freshwater intake, water salinity, sea currents, and substrate.

3. Result and Discussion

3.1 Mangrove Zoning Pattern

Mangrove ecosystems have a unique character compared to other types of ecosystems due to the formation of zoning [24]. Mangrove zoning is divided into four zones: open zone, middle zone, brackish zone, and terrestrial zone [9]. The complete zoning of mangrove ecosystems in Lampung Timur Regency is presented in Table 1.

Table 1. Mangrove zonation in Lampung Timur

Area (Village)	Mangrove Zonation
Margasasi	Outer Zone
	Middle Zone
	Terrestrial Zone
Sriminosari	Outer Zone
	Middle Zone
	Terrestrial Zone
Pasir Sakti	Outer Zone
	Middle Zone
	Terrestrial Zone

Mangrove ecosystems in three areas in Lampung Timur (Margasari, Sriminosari, and Pasir Sakti) have three mangrove zones consisting of the outer zone, middle zone, and terrestrial zone. This finding is by Bengen's [3] statement that mangrove zonation formed from sea to land is the outer zone with *Avicennia* vegetation associated with *Sonneratia*, *Rhizophora*, and *Bruguiera* vegetation in the middle of mangrove zonation, and the nearshore zone with minor mangrove vegetation associated with coastal vegetation. The complete mangrove zoning map in the Margasari, Sriminosari, and Pasir Sakti areas is presented in Figure 4, 5, and 6.

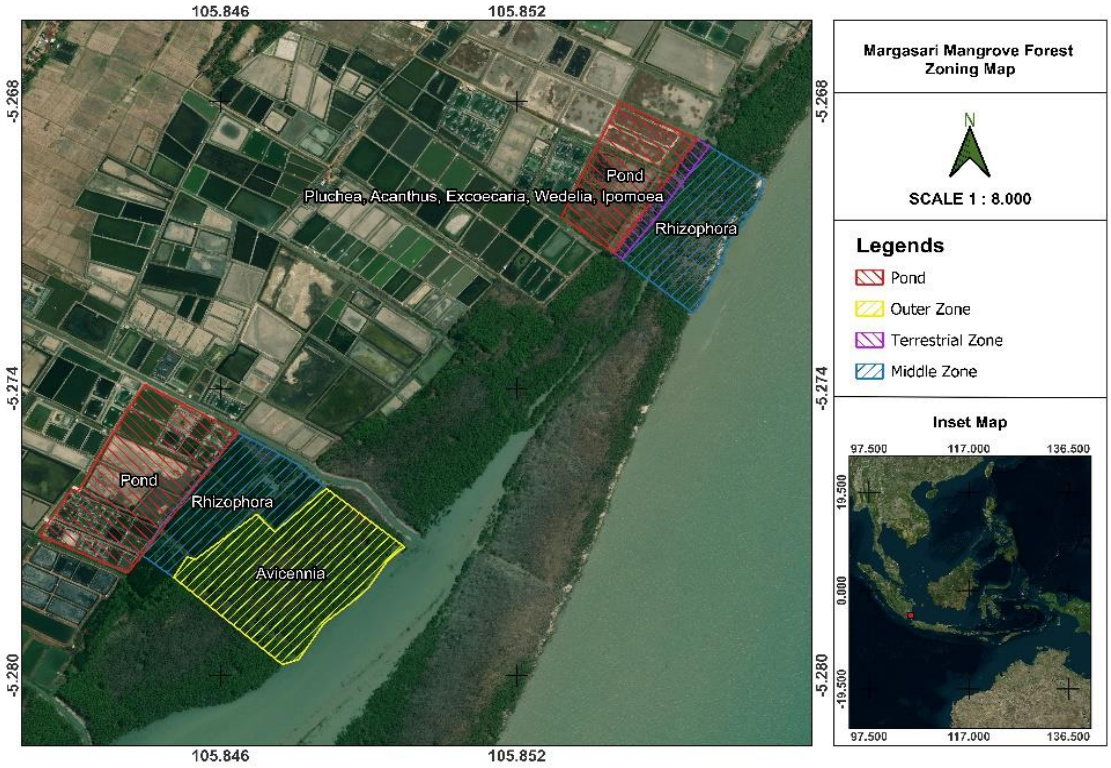

Figure 4. Zonation Map of Mangrove of Margasari

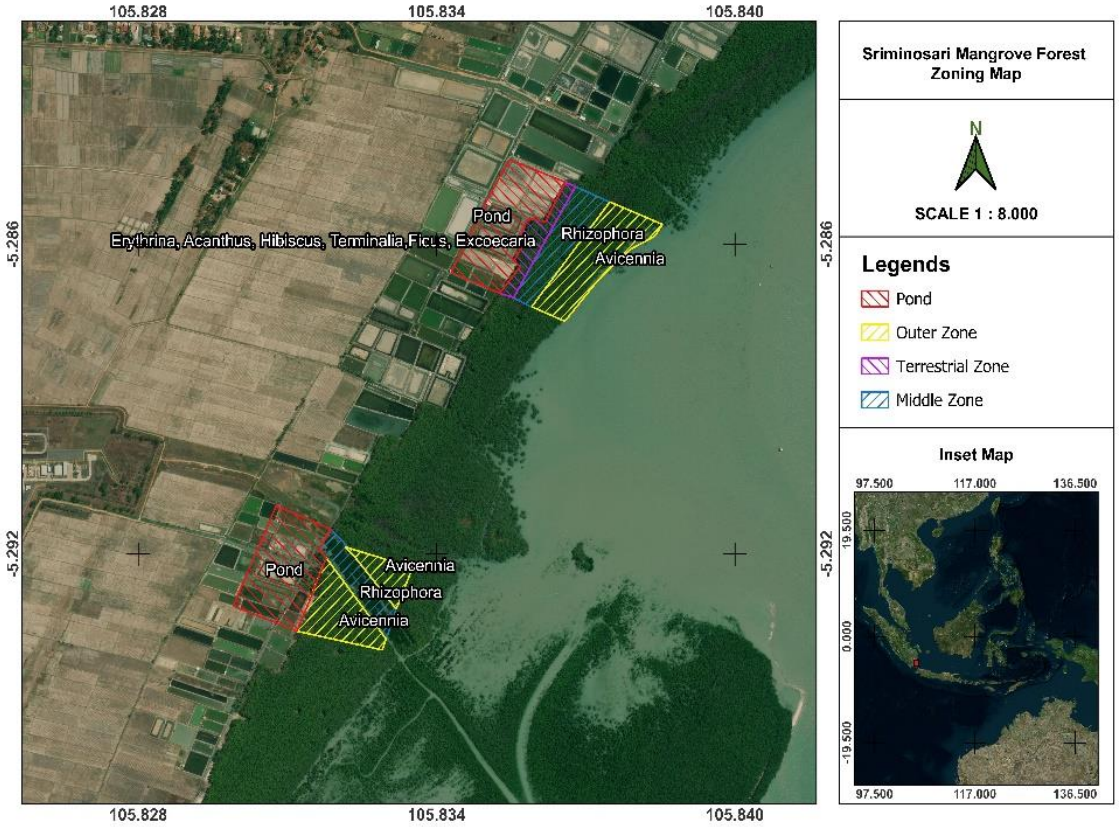

Figure 5. Zonation Map of Mangrove of Sriminosari

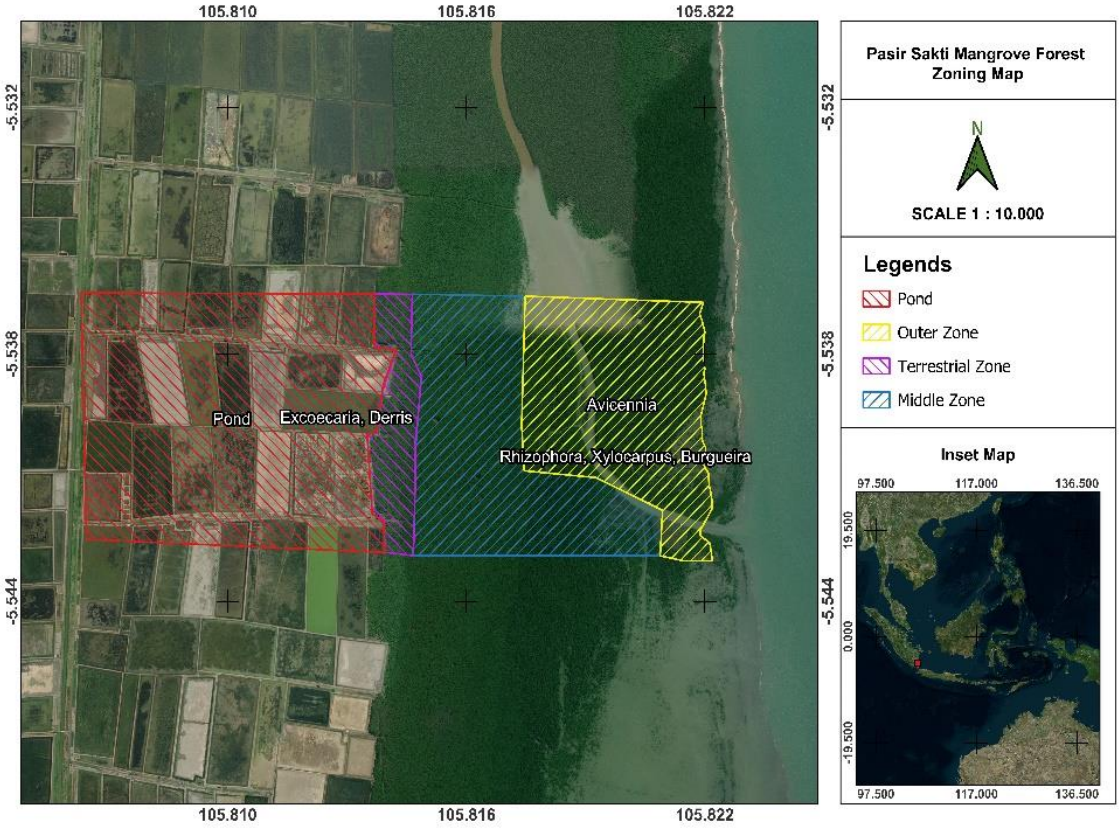

Figure 6. Zonation Map of Mangrove of Pasir Sakti

3.2 Plant Zoning

Mangrove forest zoning is determined by soil status, salinity, tides, and deposition rates [4]. The division of mangrove forest zoning is the result of competition among mangrove species because mangroves have different adaptability depending on where they grow, so the plants that make up the mangrove zone are different. The complete mangrove zone constituent plants are presented in Table 2.

Table 2. Plant species that compose each zone

Area (Village)	Outer Zone		Midle Zone		Terrestrial Zone	
	Species	Thickness (m)	Species	Thickness	Species	Thickness (m)
Margasari	*A. marina*	171 m	*R. apiculata* *R. mucronata*	128 m	*Acanthus* *E. agallocha* *I. pescaprae* *P. indica* *W. biflora*	57 m
Sriminosari	*A. marina*	164 m	*R. apiculata* *R. stylosa* *R. mucronata*	214 m	*Acanthus* *E. agallocha* *Erythrina variegata* *H. tiliaceus* *T. catappa* *F. sacalavarum*	65 m
Pasir Sakti	*A. marina*	653 m	*R. apiculata* *R. stylosa* *X. rumphii* *B. gymnoriza*	392 m	*E. agallocha* *D. trifolia*	146 m

The vegetation that makes up the outer zone is only found in the species *A. marina*. The results of the study are different from those conducted by Kurnia [10], who found that there are *A. alba*, *A. marina*, and *A. germinans* species in the Pasaran Island Mangrove Area, City of Bandar Lampung. This happened allegedly because the three research areas facing the Java Sea have a larger ocean current than the ocean currents in the area facing the Sunda Strait, especially on Pasaran Island. It is what was reported by the Centre of Oceanography Research (*Pusat Penelitian Oseanografi-LIPI)* [17]: the waters of Lampung Bay are a semi-enclosed water environment facing the Sunda Strait, with its location far inland and quite protected.

Rhizophora stylosa was not found in the Margasari area (Table 2). This is because there is no suitable site factor for *R. stylosa*, namely sandy substrate. Sukardjo [22] reported that *R. stylosa* tends to like sandy substrates. It is known that in the Pasir Sakti, no *R. mucronata was* found. This is because the region does not have a muddy substrate favored by *R. mucronata*. It is what was stated by Hilmi [8]: *that R. mucronata* is found in deep mood substrates.

It is known that there is an engrossing zone with relatively diverse plant constituents, even though the three locations have ponds. This is because the pond land in the region is not intensively cultivated. Thus, the terrestrial zone is still founded. Susanto [23] reported that in most mangrove forests that have been influenced by human activities (anthropogenic), such as aquaculture and settlements in general will be difficult to determine the terrestrial zones.

3.3 Environmental Factors Affecting Mangrove Zoning

Each area of the mangrove ecosystem in Lampung Timur has a different site factor. The environment is very influential on zoning patterns, as are the plants that make up the zone. Noor et al. [14] reported that mangrove forest zonation is strongly influenced by several environmental factors, such as substrate, salinity, and tides. The complete environmental factors that affect mangrove zonation are presented in Table 3.

It is known that each zone has different pH and salinity values. Therefore, there are different types of mangroves in each zone. It is by Tihurua et al. [24] suggest that the zoning formed has a different species composition and structure because there is an adaptation for each species to its habitat. Furthermore, Arief [2] reported that the frequency of inundation, receiving sufficient freshwater supply from land through river flow, and being protected from large waves and strong tidal currents determine the composition of mangrove forest vegetation.

Table 3. Environmental Factors Affecting Mangrove Zones

Area (Village)	Outer Zone		Midle Zone		Terrestrial Zone	
	Water pH	Salinity (ppm)	Water pH	Salinity (ppm)	Water pH	Salinity (ppm)
Sriminosari	7.5	1,017.0	7.5	1,016.5	7.5	1,018.0
Margasari	7.5	1,019.2	7.0	1,019.5	7.5	1,018.0
Pasir Sakti	7.2	1,016.5	7.1	1,015.0	7.2	1,016.0

The salinity in the outer zone tends to be higher than the terrestrial zone. This is because the outer zone gets more abundant seawater than the terrestrial zone. Rahmadhani et al. [19] state that the salinity levels will decrease gradually from the sea to the terrestrial. However, in the Sriminosari area, the outer zone has a lower salinity value than the salinity value in the terrestrial zone. It is presumably because seawater is trapped in the terrestrial zone during the tides.

4. Conclusion

The zoning pattern of mangrove ecosystems in Lampung Timur Regency Lampung Province consists of 3 zones. They are the outer zone, the middle zone, and the terrestrial zone. The outer zone vegetation composition is composed of *Avicennia marina* species; the middle zone constituent plants are *Rhizopora stylosa, Rhizopora apiculata, Rhizopora mucronata, Xylocarpus rumpii, Brugueira gymnoriza;* and in the terrestrial zone are *Acanthus, Excoecaria agallocha, Ipomoea pescaprae, Pluchea indica, Wedelia biflora, Erythrina variegata, Hibiscus tiliaceus, Terminalia catappa, Ficus sacalavarum,* and *Deris trifolia.*

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