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The Effect of Soil Environmental Parameters on Mangrove Tree Growth in Lingga District

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Abstract: This study was conducted in Lingga District, Lingga Regency with the aim of determining the effect of environmental parameters such as physical and chemical properties of soil on mangrove forest communities in Lingga Regency. The results showed that soil quality affected mangrove growth in two research locations, where the low soil pH was around 6.1-6.8 but still supported the growth of mangrove trees. The two research locations had soil from the dusty clay texture class, found in all sampling locations, and this land was still suitable for mangrove growth, so it did not interfere with mangrove life in the research location.

Keywords: Chemical properties; Dusty clay texture; Environmental conditions; Mangroves; Physical properties; Soil pH

Introduction

Mangrove ecosystems are the tidal and supra tidal zones of muddy beaches and bays, gulfs and estuaries which are dominated by halophytes, namely plants which live in salt water, are tree-like and highly adaptable and are associated with tributaries, swamps and floods, together with populations of plants and animals (Smith et al., 2009; Sternberg et al., 2007; Lee, 1999). While other researchers (Basyuni et al., 2018; Robertson & Alongi, 1992) states that mangrove forests are a general term used to describe a variety of tropical coastal plant communities dominated by several species of distinctive trees or shrubs that have the ability to grow in salt water. Mangrove plants grow on mudflats inundated with seawater or brackish water during high tide or inundated with water all day long (Iftekhar, 2008; Macintosh et al., 2002; Mehlig et al., 2010). Ecologically, mangrove forests can ensure the maintenance of the physical environment, such as waves, wind and sea water intrusion barriers, and are a breeding ground for various types of marine life such as fish, shrimp, crabs, shellfish, snails and other types of animals (Gunawan & Anwar, 2017; Mechsan, 2012; Pigawati, 2005). Apart from that, mangrove forests are also a habitat for wild animals such as monkeys, snakes, otters, monitor lizards and birds (Pigawati, 2005; Kalitouw et al., 2015; Fathurrohmah, 2013). The importance of mangrove forests from a socio-economic aspect can be proven by community activities to search for wood and also natural tourism sites. In addition, it is also a life and source of income for fishermen and farmers on the coast who are very dependent on natural resources from existing mangrove forests (Ontorael et al., 2012).

Mangrove forest management is often faced with a problem, how to create a balance between the 3 functions of mangrove forests, namely ecological, economic and physical functions (Basyuni et al., 2018; Robertson & Alongi, 1992; Iftekhar, 2008). Furthermore, Macintosh et al. (2002), Geldenhuys et al. (2016), and Thompson et al. (2017) stated that mangrove forest conservation is a very complex effort to implement because this activity really requires an accommodating nature towards all parties, both those around the area and outside the area (Phang et al., 2015; Rasool et al., 2002). The most important function of mangroves for

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coastal areas is to act as a link between land and sea, as well as a dampener for natural phenomena caused by waters, such as abrasion, waves, storms and also as a buffer for the life of other biota which are a source of livelihood for the surrounding community (Lucas et al., 2017; Woodrofe et al., 2015).

The development of mangrove forests cannot be separated from the environmental aspects where the mangroves grow and develop. The environmental aspects in question are environmental parameter aspects such as physical properties of the soil (texture and soil structure) and chemical properties of the soil (pH, N content) (Farrier & Tucker, 2001; Wood et al., 2004; Breacker, 2016). While other researchers Wardle et al. (2004), Bourque et al. (2015), and Purvaja et al. (2000) stated that the key to the fertility of the waters around the mangrove forest area lies in the input of organic matter originating from fallen litter. This is what is studied in this study in relation to the growth and community of mangrove forests. Specifically, the purpose of this study is to determine the effect of physical and chemical soil properties on the mangrove forest community.

Method

Location and Time of Research

This research was conducted in two villages/sub-districts in Lingga Regency, namely Bukit Langkap Village and Kerandin Village, East Lingga District, Lingga Regency. This research was conducted from January to March 2024.

Research Design

This study uses a case study approach, and the research design used to answer the problems in this study is a survey method, which is descriptive analysis. Furthermore, quantitative analysis is carried out to reveal the relationship between one variable and another.

Data Collection Techniques

Before data collection, field observations were conducted covering the entire mangrove forest area with the aim of knowing the general condition of the mangrove forest. Furthermore, the observation area was divided into three, namely sample stations to determine the phytosociology (structure and classification), and the composition of mangrove species. Stations were selected based on the condition of the mangrove vegetation itself, such as thick vegetation, moderate vegetation, and stations representing areas with only a little mangrove vegetation. Each of these stations was made a line transect perpendicular to the coastline towards the land. The length of the transect line varies according to the thickness of the green line on the coast (Fachrul, 2007).

Sampling was carried out at a distance of 0-10 m, 20-30 m and 40-50 m from the coastline and so on. From each transect, vegetation data was taken using the line quadrat method, measuring 10x10 m^2 for trees with a diameter of > 10 cm located on the left and/or right of the transect. In each quadrant plot, a smaller plot was made with a size of 5x5 m^2. In the quadrant plot, data was collected on saplings with a diameter of 2-10 cm (Fachrul, 2007). The soil was taken and then put in a plastic bag and taken to the laboratory for analysis. Therefore, the mangrove forest at this research location is very large, so it is not possible to conduct a census study, and therefore the study was carried out by sampling the mangrove plants or mangrove vegetation that were the objects of the study. The data collection method that will be carried out in the implementation of this research or vegetation monitoring will use the transect method, namely a narrow path across the land to be studied. The purpose of this method is to determine the relationship between vegetation changes and environmental changes or to quickly determine the types of vegetation in a land area. To complete the analysis of vegetation in this mangrove forest community, environmental parameter data that affect mangrove life are collected, such as soil physical properties (soil texture and structure) and soil chemical properties (pH, N content).

Data Analysis

The soil samples were analyzed in the Aquatic Biology Laboratory, Faculty of Fisheries and Marine, University of Riau. The parameters analyzed were the physical and chemical properties of the soil. The physical properties analyzed were soil texture; while the chemical properties of the soil analyzed were acidity and N content.

Result and Discussion

The results of soil analysis in the Aquatic Biology Laboratory at the Faculty of Fisheries and Marine Sciences, University of Riau on soil quality at the research locations, namely in Bukit Langkap Village and Kerandin Village (Figure 1, Table 1 and 2).

Table 1 shows that the quality of mangrove forest soil at the research location, especially in Bukit Langkap Village, has almost the same soil quality at sparse, medium and dense mangrove tree densities. Soil pH ranges from 6.4–6.8. This pH value is still very suitable for the growth of almost all types of mangroves, especially *Rhizhopora* sp. However, the N content (%) is still relatively small because it only ranges from 0.12–0.18%. Based on the soil texture, it shows that all research

locations with sparse, medium and dense densities are generally dominated by dust texture with a texture between 59–61%.

Different from the research results by Antara (2016) who conducted research in the Mangrove Forest of Baluran National Park, East Java, showed that soil acidity at all research locations tended to be neutral-alkaline. The results of the study by Suryani (2016), Wood et al. (2004), and Ujud (2006) also showed no problem soil pH, with a range between 5.51–7.09. The soil acidity category in this rehabilitation area is slightly acidic to neutral. However, when compared between the green lane, pond embankment and nursery location, it appears to vary, but the difference is small and almost the same, namely between 5.51-5.59 (slightly acidic) on the pond embankment 6.24-7.09 (slightly acidic to neutral) on the green lane and 6.80-9.90 (neutral) at the nursery location. This soil pH condition also seems to be a factor in the smooth decomposition of organic matter.

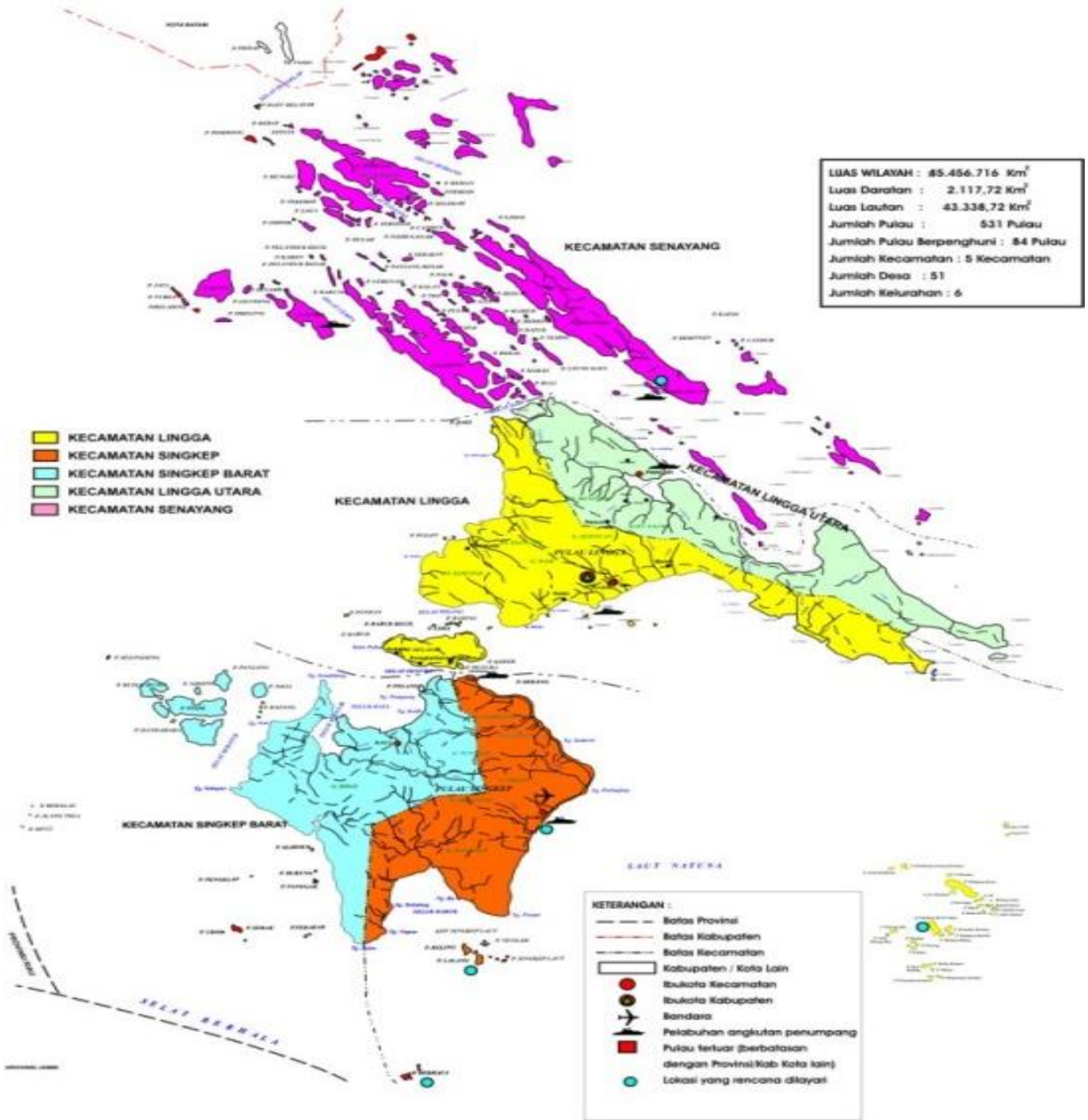

Figure 1. Map of Lingga District

Table 1. Mangrove Forest Soil Quality Based on Tree Density Level in Bukit Langkap Village, 2022

Tree Density	pH	N (%)	Texture (%)			Texture class
			Sand	Clay	Dust	
Dense	6.6	0.16	20	21	59	Dusty Clay
Medium	6.8	0.18	20	20	60	Dusty Clay
Less dense	6.4	0.12	18	21	61	Dusty Clay

Source: Results of Analysis of Aquatic Biology Laboratory, Faculty of Fisheries and Marine Sciences, University of Riau

Table 2 shows that the quality of mangrove forest soil at the research location, especially in Kerandin, shows that the pH value does not show a significant difference either in locations with sparse mangrove trees, or in locations with moderate or dense mangrove trees, which ranges from 6.1-6.8. This pH value is still considered good for the growth and development of various types of mangrove forests including the Rhizophora type. This is also different from the research results by Suyanto (2008) and Hadadi et al. (2016) who conducted research in the Mangrove Forest of Baluran National Park, East Java, showed that soil acidity in all research locations tended to be neutral-alkaline. Likewise, the N (%) value is still relatively low with a range of 17-19%. However, the N (%) value at the Pangasa Environment location is still high compared to the soil N in Bukit Langkap Village.

Table 2. Mangrove Forest Soil Quality Based on Tree Density Level in Kerandin Village, 2022

Tree Density	pH	N (%)	Texture (%)			Texture class
			Sand	Clay	Dust	
Dense	6.1	0.15	17	22	61	Dusty Clay
Medium	6.4	0.18	19	22	59	Dusty Clay
Less dense	6.8	0.19	19	21	60	Dusty Clay

Source: Results of Chemistry and Soil Laboratory Analysis, Pangkep State Agricultural Polytechnic

All the soil in the research location, both in Bukit Langkap Village and Kerandi Village, has a dusty clay texture class, so it is very possible that the soil will be inundated at high tide and will dry out at the lowest ebb. Research results by Breacker (2016), Wood et al. (2004), and McLachlan (1985) shows a fine texture (in the pond area, and green belt area) to rather fine (in the nursery area) with a fairly high clay and dust (clay) content, with a percentage range of 39.26–51.82%. This texture condition is not beneficial for the development of soil structure, the soil is easily muddy when wet and compacted or hardened when dry. Muddying and compaction of the surface layer (assisted by rain, wetting, alternating drying) will have a bad mechanical effect on the roots and inhibit/ stop the exchange of gas and air between the soil and the atmosphere, besides also disrupting the circulation of soil moisture so that it thwarts seed germination.

Male mangroves/large mangroves (Rhizophora) can grow well in deep mud and are resistant to waves and wind. This type is suitable for planting on the front of the coastline, especially on beaches with quite large waves (Breacker, 2016; Brooks, 2010). Furthermore, Mathew & Panchanatham (2016) and Breacker (2016) states that mangrove plants (Rhizophora) are mangrove plants, in the form of forest vegetation that grows between the tidal lines. This plant belongs to the Rhizophoraceae family with 2-16 compound flowers, flower stalks longer than leaf stalks, and leaves with pointed tips. Good coastal conditions for growing mangroves are beaches that have characteristics such as calm water/not big waves, brackish water, containing mud deposits, and sediment slopes of no more than 0.25-0.5%. Bacteria found in almost all ecosystems are responsible for degrading and recycling essential elements such as carbon, nitrogen, and phosphorus. The energy contained in the body of the organism is alive, so that bacteria can regulate the food chain system in water and land (Sapp, 2003; Deye et al., 2016). Furthermore, Ola et al. (2011) and Nilsen et al. (2011) states that the presence of bacteria in mangrove forests has a very important meaning in decomposing the decay of mangrove leaves into organic elements which are very important in providing food for organisms that inhabit mangrove forests.

The results of research conducted by Giarrizzo et al. (2011), Wahyuni et al. (2014), and Bird et al. (2004) also shows a significant relationship between the area of mangrove areas and aquaculture production. The increasing area of mangrove areas, the fisheries production also increases by forming the equation Y = 0.06 + 0.15 X; Y is the catch production in tons/ha, while X is the area of mangroves in hectares. Mangroves as forest vegetation that grows between the tidal lines, but also grows on coral beaches that are overgrown with a thin layer of sand or mud or muddy beaches with characteristics that are not influenced by climate, influenced by tides, land inundated by sea water, forests

do not have a canopy, trees can reach a height of 40 m, tree species from sea to land form a zone consisting of Rhizopora sp, Avicennia sp, Sonneratia sp, Xylocarpus sp, Lamnitzera sp, Bruguira sp and nipa. plants that are under the population of Acosticum aureum, Acanthus Illicifalus, usually plants on the coast form tree paths and show typical roots (Barkati & Tirmizi, 1987; Gopal & Chauhan, 2006; Vaz, 2014; Polidoro et al., 2010).

Conclusion

The soil environmental parameters that affect mangrove growth in the two research locations show that low soil pH (around 6.1-6.8) is still supportive for mangrove forest growth. The soil in both research locations has a dusty clay texture class, and this soil is still supportive for mangrove growth, so that mangrove life in Bukit Langkap Village and Kerandin Village is not disturbed.

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Author Contributions
K.E.: Conceptualization, methodology, investigation, data curation, writing—original draft preparation. A.H.: validation, formal analysis, resources, writing—review and editing, visualization, supervision. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
All author declares that there is no conflict of interest.

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