BIO-EDU: JURNAL PENDIDIKAN BIOLOGI
Available in https://jurnal.unimor.ac.id/JBE/index
2026, Vol. 11, Issue. 2, pp 166 - 172, e-ISSN: 2527-6999
https://doi.org/10.32938/jbe.v11i2.11189

Analysis of Mangrove Vegetation Abundance and Species Richness in the Mangrove Forest Area of Mojo Village, Ulujami District, Pemalang Regency, Central Java

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Article Information
Received: 2026-01-25
Revised: 2026-08-12
Accepted: 2026-08-14
Published: 2026-08-30

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Abstract

Ulujami district is one of the districts in Pemalang district and has a mangrove forest area of 445 Ha but continues to suffer abrasion. The purpose of this practice is to know the common and richness of mangrove vegetation in the mangrove forest area of Mojo Village, Ulujami district, Pemalang district. The research was conducted in August 2023 – September 2023. The method used is purposive sampling by dividing 4 stations and each station has 3 plots with different sizes namely 10 x 10 m, 5 x 5 m and 2 x 2 m. Based on the research that has been done on the mangrove species found as many as 4 (four) species of mangrove namely *Avicennia alba* Blume, *Avicenna marina* (Forssk.) Vierh., *Rhizopora mucronata* Poir., and *Sonneratia caseolaris* (L.) Engl. The sørensen Safety Index has the highest 0-100% range of values in the tree, shrub, and straw categories obtained by plot 1 and 2 with 100% values belonging to very similar categories. The results of water quality measurements at each station in the mangrove forest area of Mojo Village include temperature 28.8-30°C, salinity 25-29 ppt, water pH 5.9 6.21, and DO 5.5-14.9 mg/l.

Keywords: *Mangrove vegetation analysis; Ulujami mangrove Forests; Mangrove forest water quality*

Abstrak

Kecamatan Ulujami merupakan salah satu kecamatan di Kabupaten Pemalang yang memiliki kawasan hutan mangrove seluas 445 ha, tetapi terus mengalami abrasi. Penelitian ini bertujuan untuk mengetahui kelimpahan dan kekayaan vegetasi mangrove di kawasan hutan mangrove Desa Mojo, Kecamatan Ulujami, Kabupaten Pemalang. Penelitian dilaksanakan pada Agustus–September 2023. Metode yang digunakan adalah purposive sampling dengan membagi lokasi penelitian menjadi empat stasiun. Setiap stasiun terdiri atas tiga plot dengan ukuran berbeda, yaitu 10 × 10 m, 5 × 5 m, dan 2 × 2 m. Berdasarkan hasil penelitian, ditemukan empat spesies mangrove, yaitu *Avicennia alba* Blume, *Avicennia marina* (Forssk.) Vierh., *Rhizophora mucronata* Poir., dan *Sonneratia caseolaris* (L.) Engl. Indeks kesamaan Sørensen menunjukkan kisaran nilai 0–100% pada kategori pohon, pancang, dan semai. Nilai tertinggi diperoleh pada plot 1 dan 2 sebesar 100%, yang termasuk dalam kategori sangat mirip. Hasil pengukuran kualitas air pada setiap stasiun di kawasan hutan mangrove Desa Mojo menunjukkan suhu berkisar antara 28,8–30 °C, salinitas 25–29 ppt, pH air 5,9–6,21, dan DO 5,5–14,9 mg/L.

Kata Kunci: *Analisis vegetasi mangrove; Hutan mangrove ulujami; Kualitas air hutan mangrove*

1. INTRODUCTION

Mangrove forests are a type of forest that grows in intertidal areas, particularly along sheltered coasts, lagoons, and river estuaries that are inundated at high tide and exposed at low tide, and they have a high tolerance to salinity (Kusmana *et al.*, 2003). In general, mangrove forests are defined as forests growing on brackish-water swamps located along coastlines and influenced by tidal seawater, particularly in coastal areas and around river estuaries (Ndede *et al.*, 2017). Mangrove ecosystems can develop well in intertidal zones along tropical coastlines, including lagoons, swamps, deltas, and river estuaries. Mangrove ecosystems are complex and dynamic but unstable (Kusmana, 1995). Factors affecting zonation are related to species responses to soil conditions, wave exposure, tides, and salinity, as well as combinations of local chemical and physical conditions. Soil conditions (Gilman *et al.*, 2008), for example, influence the zonation and distribution of plants and animals, as indicated by differences in crab species under different soil conditions (Irwanto, 2006).

Pemalang Regency is one of the regencies in Central Java Province with approximately 35 km of coastline and around 2,839.44 ha of mangrove area. Ulujami District has approximately 327 ha of mangrove forest, representing 40.18% of the total mangrove forest area in Pemalang Regency, which is 813.8 ha (Pemerintah Kabupaten Pemalang, 2006). In 2014, the mangrove forest of Mojo Village covered 72 ha, while 327 ha of land had been converted into pond areas used for milkfish, whiteleg shrimp, and soft-shell crab culture. Between the mid-1970s and 1990, the mangrove forest of Mojo Village was converted into aquaculture ponds. The remaining mangrove forest occurs only in certain areas and is capable of directly reducing coastal abrasion from the sea (Purnamawati *et al.*, 2015).

Pemalang Regency is one of the areas affected by coastal abrasion in Central Java Province, with an affected area reaching 445 ha. In 1999, abrasion eroded 200 ha of the coastal area of Mojo Village, and the village continues to experience abrasion at an average rate of 2–2.5 ha/year, resulting in damage to mangrove forests, aquaculture ponds, and residential areas. This figure may continue to increase if coastal environmental management does not consider the sustainability of natural resources. The increasing conversion of mangrove forests into aquaculture ponds has also contributed to abrasion. Data from the Pemalang Regency Marine and Fisheries Office (2016) indicate that the total pond area in Pemalang Regency reaches 2,179 ha, with Mojo Village ranking second after Pesantren Village, with an area of 425.3 ha (Muali, 2020).

This study aimed to analyze the similarity and species richness of mangrove vegetation in the mangrove forest area of Mojo Village, Ulujami District, Pemalang Regency. The results are expected to provide information on mangrove ecosystem diversity, particularly from an ecological perspective. The study may also provide input for stakeholders involved in mangrove ecosystem management and preservation, including conservation and rehabilitation efforts in Mojo Village. A previous study on mangrove community structure in Mojo Village was conducted by Renta *et al.*, 2016 which provided data on the vegetation diversity index (H′) in Mojo Village. However, that study did not discuss mangrove similarity or species richness; therefore, the present study is expected to provide updated information on mangrove vegetation in Mojo Village, Ulujami.

2. METHOD

2.1. Time and Location

The research and data analysis were conducted from 5 August 2023 to February 2024 in the mangrove forest area of Mojo Village, Ulujami District, Pemalang Regency. The four sampling stations were determined by first identifying the research problem, followed by sample collection or field-data collection (Figure 1).

2.2. Tools and Materials

The equipment used in this study included a refractometer to measure seawater salinity, a Neutron Water Quality Checker to measure seawater quality, a Garmin GPS Map to determine station coordinates, transect plots to define sampling locations, data sheets to record observations, and documentation equipment to document the research activities.

The water-sampling procedure was conducted in several stages. Approximately 250 mL of seawater was collected in a container at a depth close to the bottom surface of the mangrove waters while avoiding air bubbles. The seawater samples were then assessed for several water-quality parameters, including pH, dissolved oxygen (DO), temperature, and salinity. Salinity was measured using a refractometer, while pH, DO, and temperature were measured using a water-quality checker.

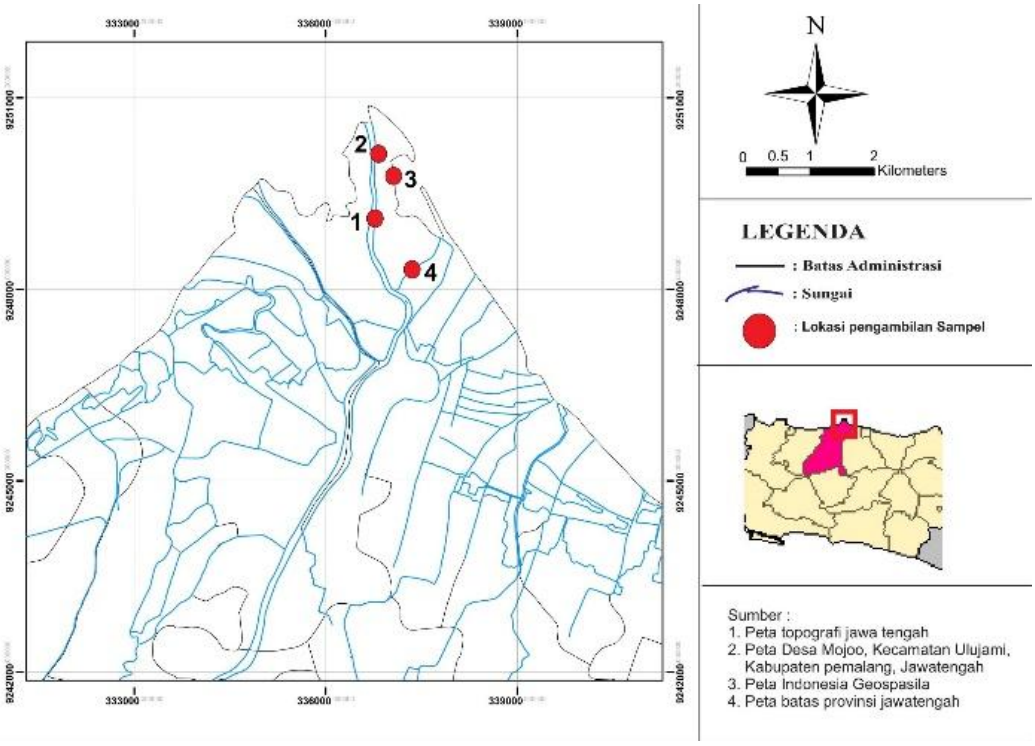

Figure 1. Map of the study location and sampling stations. Original map legend: administrative boundary, river, and sampling location.

2.3. Sampling Procedure

Vegetation data were collected using the quadrat-transect method. The transects consisted of three different plot sizes, and each plot size was established at four sampling plots in different areas, with approximately 50–100 m between plots (Figure 2). The three different plot sizes were used because each size represented a different mangrove growth category. A 10 × 10 m plot was used to collect data on tree-stage mangroves with stem diameters ≥ 4 cm. A 5 × 5 m plot was used to collect data on sampling-stage mangroves with stem diameters of 1–4 cm (1 cm ≤ stem diameter < 4 cm) and heights > 1 m. A 2 × 2 m plot was used to collect data on seedling-stage mangroves with heights < 1 m (Küchler, 1976).

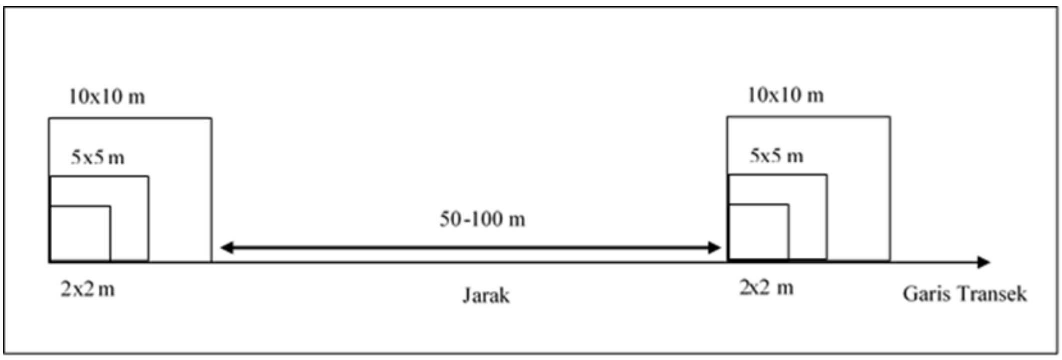

Figure 2. Scheme of mangrove vegetation data collection and analysis.

2.4. Data Analysis

The Sørensen similarity index was used to compare similarity among stations based on biological parameters or species composition. Similarity Index (IS) values range from 0 to 100% and are grouped into four categories: very dissimilar (IS ≤ 25%), dissimilar (IS 25–50%), similar (IS 50–75%), and very similar (IS ≥ 75%) (Hadi et al, 2016).

According to Hadi et al, (2016) the community similarity index between habitats can be calculated using the Sørensen formula:

$$\text{Is} = \frac{2C}{A+B} \text{ x } 100\%$$

Note:
IS = Sørensen species similarity index
A = number of species at location A
B = number of species at location B
C = number of species shared by the two locations

The species-richness index was calculated to determine the richness of species within each observed community. Species richness was analyzed using the Margalef species-richness formula (Margalef, 1958):

$$\text{DMg} = \frac{(S-1)}{Ln\ (N)}$$

Note:
DMg = species-richness index
S = number of observed species
N = total number of observed individuals
ln = natural logarithm

3. RESULT AND DISCUSSION

Mangrove similarity was analyzed to determine the similarity of species composition between two different areas using the Sørensen Species Similarity Index. Four station plots were used in this study.

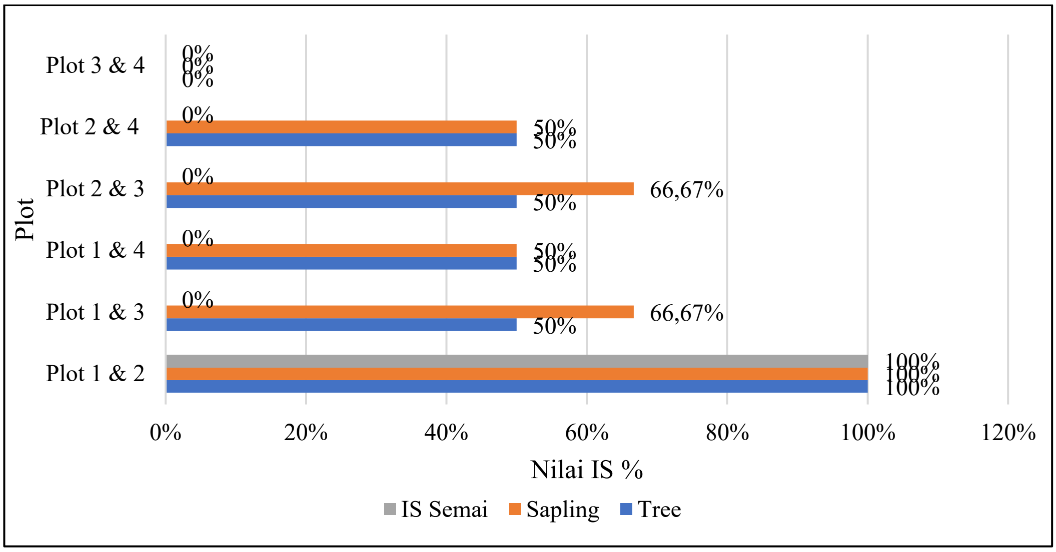

Figure 3. Sørensen Similarity Index of mangrove vegetation

Based on observations using 10 × 10 m plots, several differences in tree-stage mangrove species were found among the station plots. Plot 1 contained two mangrove species, namely *Soneratia caseolaris* (L.) *Engler* and *Avicennia alba* Blume; Plot 2 contained *Soneratia caseolaris* and *A. alba* Blume; Plot 3 contained *A. alba* and *Avicennia marina* (Forssk.) Vierh; and Plot 4 contained *Soneratia caseolaris* and *Rhizopora mucronate* Poir.

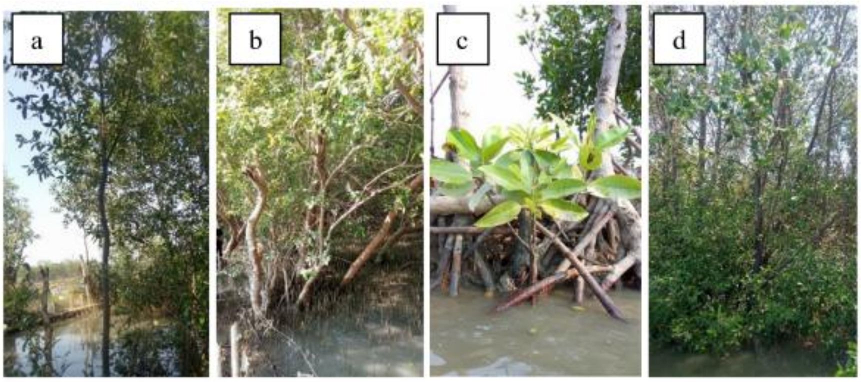

Figure 4. (a) *Avicennia alba*, (b) *Avicennia marina*, (c) *Rhizopora mucronata*, and (d) *Sonneratia caseolaris*. Source: personal documentation.

The IS values for the sapling category ranged from 0 to 100%. The highest value was recorded between Plots 1 and 2 at 100%, which was classified as very similar. Two plot pairs, Plots 1 and 3 and Plots 2 and 3, had the same IS value of 66.67%, which was classified as similar. Two other plot pairs, Plots 1 and 4 and Plots 2 and 4, also had the same IS value of 50%, which was classified as similar. The lowest IS value, 0%, occurred between Plots 3 and 4 and was classified as very dissimilar.

Based on observations using 2 × 2 m plots, only limited variation in seedling-stage mangrove species was found. Plots 1 and 2 each contained only one mangrove species, *Avicennia alba* Blume, whereas no seedling-stage mangroves were found in Plots 3 and 4. Species similarity was found only between Plots 1 and 2, with a similarity value of 100%, classified as very similar, because the same species, *A. alba*, occurred at both plots. No shared species were found between Plots 1 and 3, 1 and 4, 2 and 3, 2 and 4, or 3 and 4; consequently, their similarity-index values were 0% and classified as very dissimilar.

The occurrence of the same mangrove seedling species at the two stations may be related to the relatively similar characteristics of Plots 1 and 2. Plot 1 was located near a milkfish pond with abundant wild grasses. Plot 2 was also located near the milkfish-pond area but had a relatively greater water depth than Station 1, approximately ±1.5 m. Few wild grasses were found at this location, and a pipe inlet was present to supply water to the milkfish pond.

The Sørensen Similarity Index (IS) is an index used to calculate similarity between two areas or sampling plots based on species composition. A study by Gaol *et al.*, (2023) on the composition, diversity, and distribution of mangrove species in East Nusa Tenggara reported a maximum similarity value of 40%, a minimum value of 18%, and an average index value of 27%. These values were very low and differed considerably from the mangrove similarity values recorded in Mojo Village. The difference may be related to differences in ecosystem characteristics between the coast of East Nusa Tenggara and the coast of Mojo Village. In addition, the low IS values in that study may indicate major differences between the two research locations in the proportions of species within their communities, both for mangrove vegetation and associated mollusks. These large differences may also result from lower proportions of particular species at one location compared with the same species at another location, as well as differences in the total number of species recorded between the two locations.

The vegetation analysis showed that four mangrove species were found at the tree stage: *Soneratia caseolaris* (L.) Engler, *Avicennia alba* Blume, *Avicennia marina* (Forssk.) Vierh, and *Rhizopora mucronate* Poir. The species-richness value (DMg) at the tree stage was 0.74. Three species were found at the sapling stage, namely *Soneratia caseolaris*, *Avicennia alba*, and *Rhizopora mucronate*, with a richness-index value of 0.69. At the seedling stage, only one mangrove species, *Avicennia alba*, was found, with a species-richness value of 0 (Figure 5).

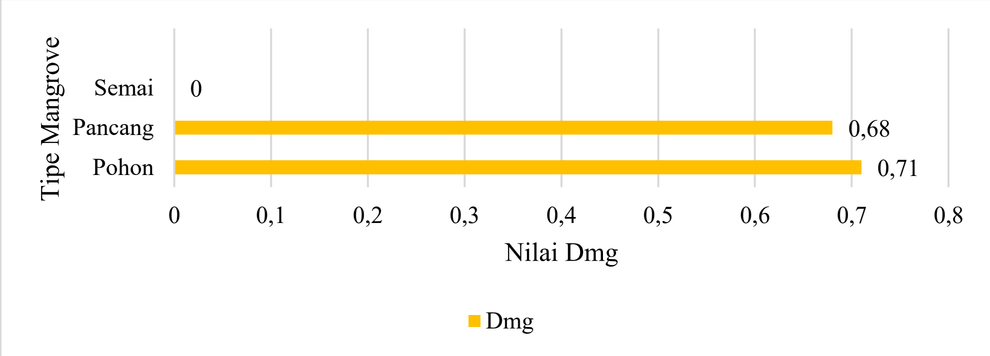

Figure 5. Mangrove Species-Richness Index

The species-richness value at the tree stage was higher than that at the sapling stage, indicating that the number of mangrove individuals at the tree stage was greater than at the sapling and seedling stages. Based on these results, the mangrove forest in Mojo Village can be categorized as a climax forest. This is consistent with Anhar *et al.*, (2025) who stated that a climax forest is a plant community dominated by trees and is in a stable stage of natural succession. A climax forest develops when the trees growing in an area are able to maintain species composition. In summary, a climax forest is a relatively stable and undisturbed plant community that has adapted to its environmental conditions in the absence of human disturbance. This climax condition can also prevent many mangrove offspring from growing well and may even cause mortality. This occurs because the greater abundance of tree-stage vegetation reduces the amount of sunlight reaching the forest floor because it is blocked by the tree canopy (Sanadi et al., 2023). This condition is consistent with the mangrove forest in Mojo Village, where the seedling stage had a very low abundance, with only nine individuals of Avicennia alba. In addition to limited sunlight, low seedling survival may be caused by coastal abrasion. Mojo Village is an area with a relatively high abrasion rate; in 1999, abrasion eroded 200 ha of the coastal area of Mojo Village, and abrasion continues to occur at an average rate of 2–2.5 ha/year (Muali, 2020).

The pattern of richness values from trees to seedlings shows a decline in abundance. Without preventive measures, this condition may lead to limited or even absent regeneration because mangrove seedlings may die during the juvenile or seedling stage as they compete with mature plants for space and sunlight (Setyawan *et al.*, 2005). A similar condition occurs in the mangrove forest of Telaga Tujuh Island, West Langsa District, where tree-stage mangroves are more frequently found than saplings and seedlings. The species-richness results for the Mojo Village mangrove forest therefore fall into a similar category. Species richness is determined by the number of species (S) within a community; the greater the number of species identified, the higher the species richness. Across all stations, the distribution of Margalef Index values showed that only N (total individuals) increased, whereas S (number of species) remained constant. This condition indicates a tendency for the richness value (R) to decrease and remain low.

Table 1. Water Quality of the Mangrove Ecosystem

No.	Environmental Parameter	Plot 1	Plot 2	Plot 3	Plot 4	Average
1.	Temperature (°C)	28,8	30,5	29,8	29,5	29,68
2.	Salinitas (ppt)	30	25	29	29	28,25
3.	pH	6,21	5,90	5,98	6,06	6,04
4.	DO (mg/l)	9,8	7,6	5,5	14,9	9,45

Physical water-quality measurements showed differences in temperature among the four stations, although the differences were not substantial. The highest temperature was recorded in Plot 2 at 30.5°C, followed by Plot 3 at 29.8°C and Plot 4 at 29.5°C, while the lowest temperature was recorded in Plot 1 at 28.8°C. The mean temperature across the four stations was 29.68°C. According to Gilman *et al.*, (2008) the optimal temperature range for mangrove photosynthesis is

28–32°C, whereas temperatures above 38°C can cause photosynthesis in leaves to cease. Thus, the water temperature in Mojo Village is suitable for mangrove habitat.

Salinity is the concentration of dissolved salts in water. The measured mean salinity was 28.25 ppt. Stations III and IV had the same salinity value of 29 ppt. The highest salinity was recorded at Station I at 30 ppt, whereas the lowest salinity occurred at Station II at 25 ppt. Kusmana *et al.*, (2003) stated that *A. marina, Rhizophora sp., Sonneratia sp., E. agallocha, L. racemosa*, and *C. Tagal* can grow well at salinities of 10–30 ppt. Therefore, salinity at all four stations in the Mojo mangrove forest area was within the suitable range for mangrove growth.

Chemical water-quality measurements of pH at the four mangrove-forest stations showed that all stations were acidic, with pH values < 7. The highest pH was recorded at Station I at 6.21, followed by Station IV at 6.06 and Station III at 5.98, while the lowest pH was recorded at Station II at 5.90. The overall mean pH was 6.04. Wahyuningsih et al., (2024) stated that a water pH range of 6–8.5 is highly suitable for mangrove growth. Low aquatic productivity can reduce the abundance of aquatic resources and may also reduce photosynthetic rates (Pelupessy et al., 2017). In addition, (1987) stated that low pH strongly affects the decomposition of organic matter by slowing the process.

Dissolved oxygen is the amount of oxygen dissolved in water originating from photosynthesis and absorption from the atmosphere. Water-quality measurements showed that the highest dissolved oxygen (DO) value occurred at Station IV at 14.9 mg/L, whereas the lowest occurred at Station III at 5.5 mg/L. DO values at Stations I and II were 9.8 mg/L and 7.6 mg/L, respectively, with an overall mean of 9.45 mg/L. Water quality in mangrove ecosystems strongly influences mangrove health, although mangroves are known for their high adaptability to changes in salinity. Mangrove plants can also be vulnerable to changes in water-quality parameters such as temperature, pH, and DO. Instability in water-quality parameters such as DO may reduce habitat quality and may even cause mangrove mortality (Schaduw, 2018).

4. CONCLUSION

The study in the mangrove forest of Mojo Village, Ulujami, Pemalang recorded four mangrove species: *Avicennia alba, Avicennia marina, Rhizophora mucronata, and Sonneratia caseolaris*. The Sørensen similarity index showed the highest similarity (100%) for the tree, sapling, and seedling categories between Plots 1 and 2. Species-richness values for trees, saplings, and seedlings were 0.71, 0.68, and 0, respectively. Water-quality parameters, including temperature (28.8–30°C), salinity (25–29 ppt), pH (5.9–6.21), and DO (5.5–14.9 mg/L), remained within ranges that support mangrove growth.

5. ACKNOWLEDGMENT

The authors thank Universitas Jenderal Soedirman and LPPM for funding this research through the Research Competency Development (RPK) scheme under contract number 26.667/UN23.35.5/PT.01/II/2024. The authors also thank Aisyah Fajar, Abdillah Shohwatul Islam and Akmal Triputra Wardhana for their assistance with data collection.

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