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# Analysis of Plankton Abundance Based on The Year of Mangrove Planting in Kaliwlingi Village, Brebes Regency

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***ABSTRACT***

This study aims to analyze the abundance, diversity, uniformity, and dominance of plankton based on the differences in mangrove planting years in Kaliwlingi Village, Brebes Regency. Sampling was conducted at four stations representing the mangrove planting years of 2010, 2015, 2017, and 2018. A total of 30 L of surface water was filtered using a 25 µm plankton net and preserved with 1% Lugol's iodine solution. Plankton identification was carried out to the genus level. Data analysis included abundance (cells/mL), Shannon–Wiener diversity index (H'), Pielou uniformity index (E), and Simpson dominance index (C). The results identified 13 phytoplankton genera belonging to the classes Chlorophyceae, Bacillariophyceae, Haptophyceae, and Cyanophyceae, while no zooplankton were found. The highest plankton abundance was recorded in the 2010 planting area (1,955,000 cells/mL), while the lowest abundance was observed in the 2015 planting area (1,502,500 cells/mL). The Shannon–Wiener diversity index (H') ranged from 0.730 to 0.887, indicating low diversity, the evenness index (E) ranged from 0.408 to 0.551, and the dominance index (C) ranged from 0.460 to 0.608, indicating moderate dominance in all planting years. Chlorella was the most abundant genus in all planting areas. These findings suggest that differences in mangrove planting years are associated with variations in plankton abundance and community structure in the Kaliwlingi mangrove ecosystem.

## INTRODUCTION

The mangrove ecosystem in Kaliwlingi Village, particularly the Pandansari "Dewi Mangrove Sari" area, is a coastal region of high productivity that plays a crucial role as a shoreline protector, sediment trap, habitat for various organisms, and supplier of organic matter to surrounding waters. Mangrove rehabilitation in this area has been conducted over several distinct planting periods, resulting in mangrove stands of varying ages and canopy density. This variation is thought to influence the aquatic environmental conditions and the structure of aquatic organism communities, including plankton (Nainggolan *et al.*, 2022).

Phytoplankton, as the primary component of plankton, serve as primary producers that support the food web in aquatic ecosystems and determine the level of water productivity (Andriyanto & Purnomo, 2019). Furthermore, phytoplankton can be used as bioindicators to assess water quality and fertility through parameters of abundance, diversity, evenness, and dominance. Previous research in the Dewi Mangrove Sari ecotourism area documented relatively high phytoplankton abundance alongside moderate to high diversity values, indicating fairly fertile, stable waters not dominated by any single genus. (Aminah & Nuraini, 2020).

The mangrove rehabilitation program in the Pandansari area has established high-density mangrove stands from several planting years, including 2010, 2015, 2017, and 2018, dominated by *Rhizophora mucronata* with considerable sediment carbon storage capacity

(Nainggolan *et al.*, 2022). Differences in stand age are thought to influence aquatic environmental characteristics through variations in litter accumulation, organic matter content, and nutrient availability, which in turn potentially affect water productivity including plankton abundance. This indicates that the rehabilitation process not only contributes to the recovery of vegetation structure, but also potentially influences the broader ecological functions of the mangrove ecosystem.

## METHOD

This research was conducted in the mangrove ecosystem of Kaliwlingi Village, Brebes Regency, Central Java. Sampling was carried out using purposive sampling technique based on differences in mangrove planting year, comprising four observation stations: 2010 mangrove planting located in the ecotourism area (Station I), 2015 mangrove planting located in the marine area (Station II), 2017 mangrove planting located in the center of the mangrove area (Station III), and 2018 mangrove planting located near the estuary (Station IV). At each station, three sampling points were established for plankton sample collection and water quality measurement. Plankton samples were obtained by filtering 30 L of surface water using a 25 µm mesh plankton net (Ambar *et al.*, 2015), the filtrate was placed into 300 mL sample bottles and preserved with 1% Lugol iodine solution for subsequent laboratory identification (Endang, 2020).

Plankton abundance was calculated in units of cells/mL, while water quality parameters measured included temperature, pH, dissolved oxygen (DO), salinity, nitrate, nitrite, ammonia, and phosphate. The data obtained were analyzed descriptively quantitatively. Phytoplankton abundance was calculated using the formula (Arinardi *et al*., 1997). Diversity Index (H‟) according to Shannon-Weiner (Meiriyani *et al*., 2011) The range of the Diversity Index is as follows: 0-1 = low category; 2-3 = medium category; >3 = high category Evenness is the distribution of individuals between different species or genera and is obtained from the relationship between diversity (H‟) and its maximum diversity (Odum, 1993). The evenness index can be calculated using the formula from Basmi (1997). According to Odum (1993), the magnitude of the evenness index ranges from 0-1 as follows: e>0.6 = High species evenness; 0.6=e=0.4= Moderate species uniformity; e<0.4= Low species uniformity The Dominance Index is used to determine the extent to which a species or genus dominates other groups. The calculation method used is the Simpson dominance index formula (Odum, 1993). The dominance index criteria according to Odum (1993) are as follows: 0<C=0.5 = No genus dominates; 0.5<C<1 = There is a dominant genus.

## RESULT AND DISCUSSION

### Plankton Species Composition

Identification of all samples from the four research stations revealed that the plankton community in the mangrove ecosystem of Kaliwlingi Village consisted entirely of phytoplankton. No zooplankton were found at any observation point. A total of 13 phytoplankton genera were identified, grouped into four major taxonomic classes: Chlorophyceae, Bacillariophyceae, Haptophyceae, and Cyanophyceae. The complete list of genera is presented in Table 1.

Table 1. Composition of plankton genera found in the mangrove ecosystem of Kaliwlingi Village

| No. | Genus | Class |
|---|---|---|
| 1 | *Chlorella* | Chlorophyceae |
| 2 | *Oocystis* | Chlorophyceae |
| 3 | *Dictyosphaerium* | Chlorophyceae |
| 4 | *Isochrysis* | Haptophyceae |
| 5 | *Amphora* | Bacillariophyceae |
| 6 | *Amphiphora* | Bacillariophyceae |
| 7 | *Cyclotella* | Bacillariophyceae |

| No. | Genus | Class |
|---|---|---|
| 8 | *Cymbella* | Bacillariophyceae |
| 9 | *Skeletonema* | Bacillariophyceae |
| 10 | *Streptotheca* | Bacillariophyceae |
| 11 | *Nitzschia* | Bacillariophyceae |
| 12 | *Oscillatoria* | Cyanophyceae |
| 13 | *Anabaena* | Cyanophyceae |

Bacillariophyceae was the most diverse group with seven identified genera. The dominance of Bacillariophyceae (diatoms) in coastal and estuarine waters is a common phenomenon, as this group possesses remarkable adaptive capacity to dynamic environmental conditions. Their silica cell walls (frustules) provide structural protection while enabling efficient nutrient utilization, allowing diatoms to thrive even under considerable salinity and temperature fluctuations characteristic of mangrove waters (Widianingsih *et al.*, 2022).

The absence of zooplankton at all stations needs to be considered carefully. The lack of zooplankton does not necessarily indicate their complete absence from the waters. Several methodological factors that may have influenced this result include: the 25 µm mesh plankton net size, which is more suitable for capturing small phytoplankton than zooplankton, which are generally larger; daytime sampling, while most zooplankton perform diel vertical migration to deeper layers during the day; and the patchy distribution of zooplankton, which reduces the probability of capture (Ambar *et al*., 2015)

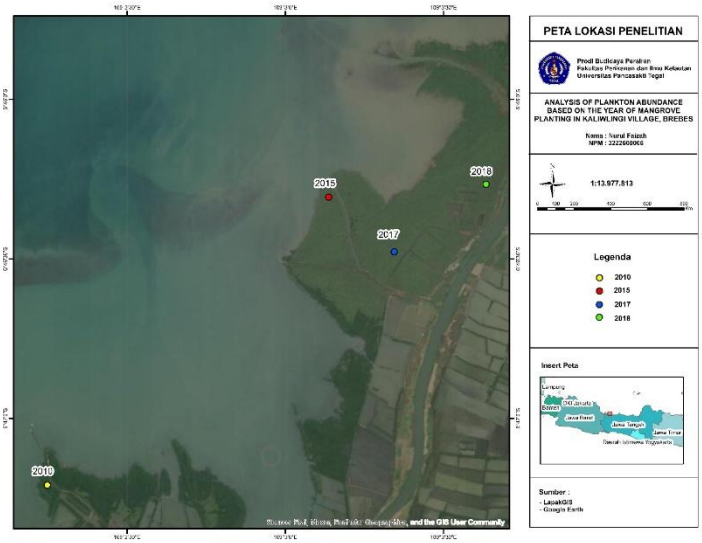



Figure 1. Map of mangrove planting in Kaliwlingi Village,Brebes Regency

**Plankton Abundance**

The average plankton abundance in each area based on mangrove planting year is presented in Table 2. Analysis revealed a gradient of abundance correlated with mangrove stand age, although the relationship was not entirely linear.

Table 2. Average plankton abundance by mangrove planting year

| Planting Year | Average Abundance (cells/mL) |
|---|---|
| 2010 | 1.955.000 |
| 2017 | 1.642.500 |
| 2018 | 1.580.000 |
| 2015 | 1.505.000 |

The 2010 mangrove planting area recorded the highest plankton abundance of 1,955,000 cells/mL, followed by the 2017 planting area with 1,642,500 cells/mL, the 2018

planting area with 1,580,000 cells/mL, and the 2015 planting area with the lowest abundance of 1,424,000 cells/mL. Higher plankton abundance in the 2010 planting area is associated with the greater accumulation of mangrove litter, which increases the availability of organic matter and nutrients in the surrounding waters. The decomposition of mangrove litter releases nutrients that support phytoplankton growth and increase plankton abundance in mangrove ecosystems (Adam & Quraisyn, 2024).

The lower plankton abundance in the 2015 planting area reflects differences in environmental conditions among sampling stations. Plankton abundance in mangrove ecosystems is influenced not only by mangrove age but also by hydrodynamic conditions, nutrient availability, and water quality. These environmental factors determine the distribution and abundance of phytoplankton in mangrove waters (Norman *et al.*, 2022).

**Diversity, Evenness, and Dominance Indices**

The Shannon-Wiener diversity index (H'), Simpson dominance value (C), and evenness index (E) values are presented in Figure 2.

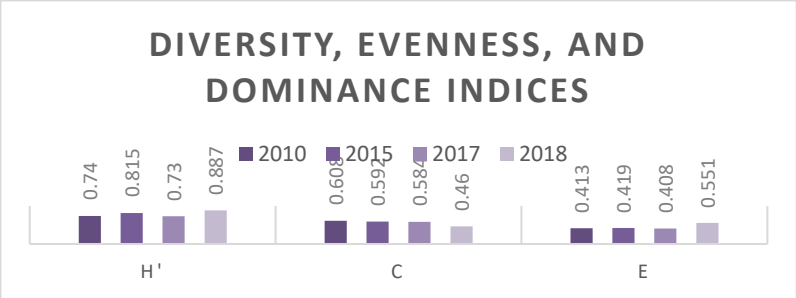



Figure 2. Diagram of Diversity, Uniformity, and Dominance Index.

The H' values ranged from 0.730 to 0.887, indicating low diversity across all mangrove planting years. The highest H' value was recorded in the 2018 mangrove planting area (0.887), followed by the 2015 planting area (0.815), the 2010 planting area (0.740), and the 2017 planting area (0.730). This finding suggests that the 2018 mangrove planting area supported a relatively more diverse plankton community than other planting years. Conversely, the lower diversity values observed in the 2010 and 2017 planting areas indicate that the plankton community was represented by fewer genera, resulting in a less balanced community composition. This finding is important because it suggests that areas with higher plankton abundance do not necessarily indicate higher species diversity. Differences in environmental conditions and community composition across mangrove planting years may contribute to variations in plankton diversity. Plankton abundance data is presented in Table 3.

Table 3. Plankton abundance data

| Types of Plankton | Planting year | | | |
|---|---|---|---|---|
| | 2010 | 2015 | 2017 | 2018 |
| Chlorella | 1.480.000 | 1.130.000 | 1.190.000 | 850.000 |
| Dictyosphaerium | 0 | 10.000 | 0 | 0 |
| Oocystis | 60.000 | 100.000 | 10.000 | 0 |
| Anabaena | 20.000 | 0 | 0 | 0 |
| Oscillatoria | 0 | 0 | 20.000 | 10.000 |
| Isochrysis | 30.000 | 30.000 | 0 | 0 |
| Amphiphora | 0 | 0 | 10.000 | 60.000 |
| Amphora | 360.000 | 230.000 | 400.000 | 650.000 |
| Cyclotella | 0 | 2500 | 0 | 0 |
| Cymbella | 0 | 0 | 0 | 10.000 |
| Nitzschia | 5000 | 0 | 0 | 0 |

| Types of Plankton | Planting year | | | |
|---|---|---|---|---|
| | 2010 | 2015 | 2017 | 2018 |
| Skeletonema | 0 | 2500 | 0 | 0 |
| Streptotheca | 0 | 0 | 12.500 | 0 |

Dominance index (C) values ranged from 0.460 to 0.608, indicating moderate dominance across all mangrove planting years. The highest dominance value was recorded in the 2010 planting area (C = 0.608), while the lowest value was found in the 2018 planting area (C = 0.460). The relatively higher dominance in the 2010 planting area was associated with a higher abundance of Chlorella (1,480,000 cells/mL), which was the most abundant genus compared to other plankton genera. However, because the dominance index remained below 1, no single genus completely dominated the plankton community. Similar findings were reported by Siti Aminah et al., (2020) and Adam and Quraisyn (2024), who found that although certain phytoplankton genera were more abundant than others, the dominance index remained at a level indicating that no single genus completely controlled the community structure.

Evenness index (E) values ranged from 0.408 to 0.551, indicating moderate evenness of plankton distribution across mangrove planting years. The highest evenness value was recorded in the 2018 planting area (E = 0.551), indicating a more balanced distribution of individuals among plankton genera. Conversely, the lowest evenness value was observed in the 2017 planting area (E = 0.408), reflecting a less balanced distribution of individuals among plankton genera. The relatively similar evenness values recorded in the 2010, 2015, and 2017 planting areas indicate that the plankton communities in these areas had comparable distribution patterns, although some genera were more abundant than others. These results are consistent with Adam and Quraisyn (2024), who stated that lower evenness values are associated with communities in which some genera are more abundant than others, while higher evenness reflects a more balanced distribution of individuals among plankton genera.

**Water Quality Parameters**

The physicochemical conditions of the water at the four research areas are presented in Table 4. Water quality parameters measured include temperature, salinity, pH, nitrate, and phosphate as the most relevant variables for explaining variation in plankton communities among stations.

Table 4. Water quality parameters at each research area

| Parameters | 2010 | 2015 | 2017 | 2018 |
|---|---|---|---|---|
| Temperature (°C) | 31,10 | 29,13 | 29,20 | 28,43 |
| Salinity (ppt) | 26,30 | 26,00 | 24,57 | 0,10 |
| pH of water | 6,77 | 6,89 | 5,07 | 6,80 |
| Soil pH | 7,55 | 6,66 | 7,72 | 7,60 |
| Amonia (mg/L) | 0 | 0 | 0 | 0 |
| Fosfat (mg/L) | 0 | 0 | 0 | 0,03 |
| Nitrat (mg/L) | 10 | 0 | 0 | 10 |
| Nitrit (mg/L) | 0 | 0 | 0 | 0 |

Water temperature across all stations ranged from 28–31.8°C, still within the optimal range for phytoplankton growth in tropical waters. However, values at the upper end of the range (30.5–31.8°C at the 2010 area) warrant attention. High temperatures accelerate phytoplankton metabolic and reproductive rates, but also increase the rate of organic matter decomposition and respiration, which may suppress dissolved oxygen concentrations. Zainuri *et al.* (2023)affirmed that temperature is a controlling factor for the spatial and temporal

distribution of phytoplankton in tropical estuarine waters, and significant fluctuations can trigger shifts in dominant species composition.

Measured pH values ranged from 6.2 to 8.86, showing considerable variation. The lowest pH (6.2) was found in the 2015 planting area facing open sea but showing slightly acidic conditions, possibly related to organic matter inputs undergoing decomposition in the vicinity. Conversely, the highest pH (8.86) was found in the 2017 planting area, indicating high photosynthetic activity or influence of more alkaline ocean currents. The pH range of 6.5–8.5 is generally tolerable by most phytoplankton genera found, so pH variation in this study was not considered a primary limiting factor (Putri *et al.*, 2024).

Salinity showed the most striking variation among stations. The 2018 planting area had very low salinity (0.1 ppt), reflecting strong freshwater inputs from river flow in the estuarine area. Very low salinity can significantly affect phytoplankton community composition, as not all genera can adapt to drastic osmotic pressure changes. This finding may contribute to the moderate abundance values in that area (526,667 cells/mL), as only genera with broad salinity tolerance such as *Chlorella* and some euryhaline diatoms could survive (Widianingsih *et al.*, 2022).

Nitrate availability is the most directly relevant factor for phytoplankton abundance. Nitrate was detected only in the 2010 and 2018 planting areas, each with concentrations of 10 mg/L, while the 2015 and 2017 areas showed undetectable nitrate levels (0 mg/L). The presence of nitrate in the 2010 area is highly consistent with the hypothesis regarding the role of mangrove litter in supplying nutrients to the water: the oldest stand produces the most intensive litter decomposition, releasing nitrate as the end product of organic nitrogen mineralization. Dzakwan *et al.*, (2023) stated that nitrate at concentrations of 5–15 mg/L can drive significant increases in phytoplankton productivity, so the detection of 10 mg/L nitrate in the 2010 area is very compatible with the high plankton abundance found there.

Interestingly, the 2015 and 2017 planting areas showed no detectable nitrate, yet their abundances were not far different from the 2018 area, which had nitrate. This suggests that alternative nutrient sources, such as ammonia and dissolved organic nitrogen from incomplete organic matter decomposition, may also support phytoplankton growth in those areas. Phosphate was only detected in the 2018 planting area (0.03 mg/L), likely originating from terrestrial flow inputs through the river. Despite the very low concentration, phosphate presence remains relevant as it acts as a co-limiting nutrient alongside nitrate for phytoplankton growth (Wijaya *et al.*, 2022).

**Relationship Between Mangrove Age and Plankton Community**

The study results indicate that mangrove planting year was associated with differences in plankton community structure. Variations in diversity, dominance, and evenness among planting years suggest that differences in mangrove development were accompanied by changes in plankton community composition.

These findings are consistent with Siti Aminah *et al.* (2020), who reported that phytoplankton composition and abundance in the Kaliwlingi mangrove ecosystem varied according to environmental conditions. Similarly, Adam and Quraisyn (2024) found that differences in mangrove habitats were associated with variations in plankton community structure, indicating that mangrove ecosystem characteristics influence plankton distribution and composition.

This study shows that different years of mangrove planting are associated with different plankton community characteristics, suggesting that mangrove rehabilitation contributes to shaping plankton community structure. This pattern may reflect differences in ecological conditions between planting years, including habitat development and nutrient availability, which influence phytoplankton communities in mangrove ecosystems. Similar findings were reported by Siti Aminah *et al.* (2020), who found that environmental conditions in the Kaliwlingi mangrove ecosystem were associated with variations in phytoplankton composition and abundance.

## CONCLUSION

This study yielded several important findings regarding the plankton community in the mangrove ecosystem of Kaliwlingi Village based on different planting years. First, all 13 identified plankton genera included the phytoplankton classes Bacillariophyceae, Chlorophyceae, Haptophyceae, and Cyanophyceae, while no zooplankton were identified at any of the observation stations. Second, the 2010 mangrove planting area recorded the highest plankton abundance (1,955,000 cells/mL), indicating differences in plankton abundance among mangrove planting years. Third, low diversity values (H' = 0.730–0.887), moderate dominance values (C = 0.460–0.608), and moderate evenness values (E = 0.408–0.551) indicated differences in plankton community structure among mangrove planting years, with Chlorella as the most abundant genus in all planting areas. Fourth, differences in mangrove planting years were associated with variations in plankton community structure, suggesting that mangrove ecosystem development influences plankton community composition and distribution. Further research with longer temporal scopes and additional environmental parameters is recommended to improve understanding of plankton community dynamics in mangrove rehabilitation areas.

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