Abundance and Distribution of Macroalgae in the Nusa Tenggara and Their Effect on Algae Blooms

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Abstract. Macroalgae is a primary component of coastal biodiversity that is beneficial in protecting the balance of marine ecosystems. Macroalgae is a biological resource that is quite abundant in our country Indonesia, one of which is in the waters of Nusa Tenggara. Exploration of macroalgae diversity has been conducted in Nusa Tenggara waters. Referring to this, this article aims to assess the types of macroalgae distributed and whether there are algae blooming events around the waters of Nusa Tenggara. The method used in this article is a literature review by reviewing a number of articles used as references. The steps in analyzing a number of information obtained from 30 or more related articles are: 1) Search for several articles from national and international journals that are relevant to the title of the article topic. 2) Analyzing the content of each article that has been found. 3) The results of the analysis are used as a reference in the preparation of this article. The result that the author of the article got was to find out a number of dominant algae in Nusa Tenggara waters that caused algae blooming which became a destroyer of aquatic ecosystems.

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1 INTRODUCTION

Macroalgae is one type of plant that has a large size and body structure such as talus. Macroalgae include organisms from the Protista kingdom that are similar to plants that have different color and pigment characteristics [1]. One of the ecosystems on the coast that plays an important role in maintaining ecological balance is macroalgae. Macroalgae (algae plants) are tuberous plants that live in water, both fresh water and sea water. Macroalgae live by attaching to something in the water, such as rocks, sand, or wood called benthos. Macroalgae is also a component of the coral reef ecosystem, because macroalgae itself contributes a lot to the life of aquatic animals, especially marine herbivores. In addition to these functions, macroalgae also have an ecological function as a provider of carbonate and strengthening of the bottom substrate which is useful for supporting the needs of human life as industrial food. The distribution of macroalgae in marine waters generally follows the distribution of coral reefs as their habitat. However, the distribution of macroalgae is also influenced by environmental factors and characteristics of macroalgae species. One of the indicators to assess water quality is by assessing the population of macroalgae ecosystems, namely by looking at the distribution, abundance and utilization of macroalgae found around these waters [2].

Eutrophication is a condition where waters experience increased levels of organic matter, this condition is characterized by an increase in phytoplankton and increased growth of aquatic plants (blooming algae). Eutrophication is also feared to reduce dissolved oxygen levels in waters, and high ammonia content which is toxic to aquatic biota. Eutrophication that lasts too long will disrupt water conditions, especially the occurrence of algae blooming conditions. High levels of nitrate and phosphates will cause an increase in the number and abundance of certain types of phytoplankton (generally of the diatom algae type) and the growth of aquatic plants is too high [3]. The quality status of a water body is the level of water quality conditions that indicate polluted conditions or good conditions within a certain time by comparing with predetermined quality standards. Pollutants that enter coastal and marine areas can come from various sources. Ammonia, nitrate and phosphate are nutrients that support water fertility. Enrichment of nutrients in the aquatic environment has a positive impact, but at certain levels it can also have a negative impact.

Based on Government Regulation of the Republic of Indonesia Number 19 of 1999, marine pollution is the entry or inclusion of living things, substances, energy, and/or other components into the marine environment by human activities, so that the quality drops to a certain level that causes the marine environment to no longer comply with quality standards and/or functions. Pollutants that enter coastal and marine areas can come from various sources. The physical state of pollutants from one source can be different from other sources with different compositions, thus the impact on the environment also varies. The quality status of a water body is the level of water quality conditions that indicate

a polluted or good condition at a certain time by comparing with the quality standards set in Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation and Protection and Management of the Environment. Every pollutant that enters water bodies in coastal waters has the potential to cause a decrease in water quality which will reduce the biological and ecological functions of the ecosystem, even though coastal areas are areas rich in various natural resources that can be utilized by humans for the benefit of their lives [4].

Therefore, the concentration of ammonia, nitrate and phosphate has been regulated in the Decree of the Minister of Environment No. 51 Year 2004. If their concentration in the waters has exceeded the predetermined quality standards, it will certainly result in a decrease in water quality and will have a negative impact on marine biota in these waters. There is a decrease in oxygen content in the waters, a decrease in biodiversity and sometimes increases the potential for the emergence and development of harmful phytoplankton species, more commonly known as Harmful Algae Blooms [5].

There are 500 species of seaweed in Indonesian waters, some of which are used as basic ingredients for industrial products. One of them is a type of red algae, namely from *Eucheuma cottonii, Gracilaria, Gelidium, Hypnea and Sargassum*. Of the five types of red algae that have been utilized, two of them can grow in Indonesia, namely *Eucheuma cottonii* along the coast and sea water, while *Gracilaria* can be cultivated in ponds [6]. The richness of marine flora in Indonesia is also abundant, both from microalgae and microalgae groups of various types. Nusa Tenggara is the eastern part of Indonesia which is close to sea waters. This geographical location close to the sea is widely used by the people of Nusa Tenggara to work as fishermen. The high diversity of microalgae and macroalgae in the ocean waters around Nusa Tenggara has not been widely utilized [7]. Seaweeds have abundant varieties available in commercially utilized waters. Macroalgae/seaweeds are categorized into green algae (*Chlorophyta*), brown algae (*Phaeophyta*), and red algae (*Rhodophyta*), according to their pigmentation, nutrition, and chemical composition [8].

The potential of seaweed needs to be explored, given the high diversity of seaweed in Indonesian waters. One of the most important, but often overlooked, components of the ocean is seaweed. The world's seaweed ecosystems are facing environmental crisis and climate change. East Nusa Tenggara is one of the provinces in Indonesia that has abundant natural marine resources and is the second largest seaweed producer in Indonesia. However, East Nusa Tenggara has limited availability of fuel and electricity to carry out activities [9]. West Nusa Tenggara (NTB) is an area that has a variety of coastal and marine biological resources (SDHPL), including seaweed species *Eucheuma cottoni* and *Kappaphycus alvarezii* which are 5 types of seaweed that are utilized and cultivated in Indonesia [10].

Pollution can change the structure of aquatic ecosystems. Increased biodiversity in a community will greatly support the realization of water stability. Basically, an organism can be a bioindicator of water quality. Planktonic

organisms can be indicators of water quality both phytoplankton and zooplankton, because plankton have a very fast response to changes in aquatic environmental conditions [11]. The difference in diversity values in a water body is influenced by environmental factors, namely the availability of nutrients (nitrate and phosphate) and the ability of each type of phytoplankton when adapting to the surrounding environment. Based on the description above, it is necessary to study the diversity of phytoplankton microorganisms and their relationship to the quality and physical and chemical factors of waters. The assessment of biological quality is very important because its accumulative function can anticipate environmental changes that occur in a particular area [12].

Coastal and marine areas are important from various planning and management perspectives. From the location point of view, the coast is a transitional part between land and sea that has formed various ecosystems that are very productive and provide tremendous economic value to humans. The entry of organic and inorganic pollutants into coastal water bodies can cause a decrease in water quality, where the potential of aquatic and marine resources utilized by the community will be disrupted [5]. Plankton, nektonic, and benthic are included in marine biota based on the nature and way of life is divided into three. Many types of marine life and divided into several groups (taxa). Sponge, coral, *chrustacean, Mollusca, Echinodermata*, and fish are included in the animal group. Algae, mangroves, and seagrasses from the plant group. These biota can be found in coastal and marine areas [13].

If the amount of organic matter waste exceeds its capacity and environmental factors are less favorable, such as temperature, oxygen, pH and organic matter that is difficult to decompose by bacteria completely, it can have a negative impact on water conditions. Phytoplankton consisting of the *Bacillariophyta, Chlorophyta, Euglenophyta, Cyanophyta, Crysophyta, Dinoflagellata* and zooplankton *Rotifera, Arthopoda and Sarcodina*. Water quality parameters can also fluctuate, as they are affected by weather, plankton abundance and incoming water [14]. Factors affecting seaweed growth include internal factors such as type, seedling age and seedling quality. While external factors are the environment, seed weight, seed selection, and planting distance [15].

The author wrote this article to determine and identify the distribution of algae and the effect of the abundance of several algae species that cause algae blooming events in Nusa Tenggara waters. The problem was taken because of the correlation of algae blooming events that resulted in damage to aquatic ecosystems in the area around Nusa Tenggara. From these problems, the purpose of making this article is to review several articles related to the diversity of algae species and their distribution and their influence on algae blooming events that occur that disturb marine biota around the waters they pollute.

2 RESEARCH METHOD

The type of research used in several articles as literature to develop the content of this article uses descriptive research methods by looking at the overall

content of the 30 and more existing articles. The procedures carried out in the preparation of articles for this literature review are:

a. Search for several articles from national and international journals that are relevant to the title of the article topic.

b. Analyzing the contents of each article that has been found.

c. The results of the analysis are used as a reference in the preparation of this article.

d. Finally, the results of the article analysis will be rewritten into a literature review article.

3 RESULT AND DISCUSSION

In addition to using physical and chemical parameters, algae can also be used as bioindicators, because they are sensitive to certain pollution conditions so that they can be used as a tool to diagnose water quality [16]. Pollution can change the structure of aquatic ecosystems. Increased biodiversity in a community will greatly support the realization of water stability. Basically, an organism can be a bioindicator of water quality. Planktonic organisms can be indicators of water quality both phytoplankton and zooplankton, because plankton have a very fast response to changes in aquatic environmental conditions [11].

Eutrophication is defined as a condition of polluted waters due to nutrient inputs including nitrate (N) and phosphates (P) and other elements in excess that occur gradually. Eutrophication conditions in a long period of time can trigger an explosion of algae growth (blooming algae). High levels of N and P increase the number and type of phytoplankton abundance and massive growth of aquatic plants [3]. The amount of unstable substrate and algae cover in the form of rubble is very concerning because it is difficult for coral larvae to grow [17]. The accumulation of organic matter from food waste and excretions that settle on the bottom of the water triggers a decrease in carrying capacity, especially algae blooms that cause oxygen depletion and poisoning of biota [18].

The high level of activity carried out in the coastal waters of Kupang City is also feared to have a polluting impact on water quality conditions. The potential for pollution needs to be assessed to obtain valid information about the status of water pollution in Kupang Bay.

Water brightness is strongly influenced by several factors, including water depth, weather (sunlight), water quality and the presence of dissolved substances in the waters. The brightness of the coastal waters of Kupang City measured at high tide tends to be higher than at low tide. The low brightness of the water is because the stations are close to areas of port, market, and river activities that bring a lot of sediment, dissolved particles, organic and inorganic materials into marine waters that cause turbid water. Differences in location depth, water turbidity, and observation time at the sampling location are also thought to cause

variations in brightness levels. Brightness is very influential on the life of biota in the sea, where the level of photosynthesis is very dependent on light [19]. Algae are said to be blooming when they reach 106 ind/L [20].

Table 1. Distribution of algae in the Nusa Tenggara region

No.	Location	Name of Species	Divisio
1.	Paradiso Beach, East Nusa Tenggara	*1. Euchema cottonii* *2. Ulva lactuca* *3. Padina boryana* *4. Sargassum decurrens* *5. Ulva rigida* *6. Ulva clahrata* 7. *Valonia ventricosa*	*1. Rhodophyta* *2. Chlorophyta* *3. Phaeophyta* *4. Phaeophyta* *5. Chlorophyta* *6. Chlorophyta* *7. Chlorophyta*
2.	Nunhila Beach, East Nusa Tenggara	1. *Ulva Lactuca*	1. *Chlorophyta*
3.	Batu Kumbung, West Nusa Tenggara	1. *Merismopedia punctata* 2. *Pediastrum boryanum* 3. *Peridinium wisconsinensis* 4. *Coelastra cambricum* 5. *Nitzschia philappanarum* 6. *Microcystis flos-aqua*	1. *Cyanophyta* 2. *Chlorophyta* 3. *Pyrrophyta* 4. *Chlorophyta* 5. *Bacillariophyta* 6. *Cyanophyta*
4.	Tanjung Luar, West Nusa Tenggara	1. *Chaetoceros*	1. *Bacillariophyta*
5.	Bolok Village, East Nusa Tenggara	1. *Euchema cotonii* 2. *Padina sp.* 3. *Sargassum sp.* 4. *Glacilaria sp.* 5. *Ulva reticulata*	1. *Rhodophyta* 2. *Phaeophyta* 3. *Phaeophyta* 4. *Rhodophyta* 5. *Chlorophyta*
6.	Kaung Island, Sumbawa	1. *Kappaphycus alvarezii*	1. *Rhodophyta*
7.	Kupang, East Nusa Tenggara	1. *Kappaphycus alvarezii strain hijau* 2. *Kappaphycus alvarezii strain merah*	1. *Rhodophyta* 2. *Rhodophyta*
8.	Palibo Beach, East Nusa Tenggara	1. *Laurencia papillosa* 2. *Gracilaria salicornia* 3. *Tricleocarpa fragilis* 4. *Tolypiocladia glomerulata*	1. *Rhodophyta* 2. *Rhodophyta* 3. *Rhodophyta* 4. *Phaeophyta* 5. *Phaeophyta*

		5. *Padina boergesenii* 6. *Sargassum cinctum* 7. *Sargassum cinereum* 8. *Hydroclathrus clathratus* 9. *Enteromorpha clathrata* 10. *Halimeda opuntia* 11. *Neomeris annulata*	6. *Phaeophyta* 7. *Phaeophyta* 8. *Phaeophyta* 9. *Chlorophyta* 10. *Chlorophyta* 11. *Chlorophyta*
9.	Sreweh, West Nusa Tenggara	1. *Eucheuma cottonii* 2. *Eucheuma spinosum* 3. *Eucheuma striatum*	1. *Rhodophyta* 2. *Rhodophyta* 3. *Rhodophyta*
10.	East Lombok, West Nusa Tenggara	1. *Sargassum aquifolium* 2. *Laminaria nigrescenc* 3. *Eucheuma cottonii* 4. *Gracilaria sp.* 5. *Gelidium sp.*	1. *Phaeophyta* 2. *Phaeophyta* 3. *Rhodophyta* 4. *Rhodophyta* 5. *Rhodophyta*
11.	Lombok Island, West Nusa Tenggara	1. *Tricleocarpa murayana* 2. *Sargassum cristaefolium* 3. *Sargassum crassifolium* 4. *Sargassum aquifolium* 5. *Hydrochlarus sp.*	1. *Rhodophyta* 2. *Phaeophyta* 3. *Phaeophyta* 4. *Phaeophyta* 5. *Phaeophyta*
12.	Tablolong, Kupang	1. *Padina australis* 2. *Hypnea sp*	1. *Phaeophyta* 2. *Rhodophyta*
13.	Sumbawa, West Nusa Tenggara	1. *Ulva lactuca* 2. *Sargassum polycystum* 3. *Glacilaria gigas*	1. *Chlorophyta* 2. *Phaeophyta* 3. *Rhodophyta*
14.	Pelangan River Village, West Nusa Tenggara	1. *Chlorococcum humicola* 2. *Coscinodisccus lacustris* 3. *Thalassiothrix fruenfeldii* 4. *Rhizosolenia sp.*	1. *Chlorophyta* 2. *Chrysophyta* 3. *Chrysophyta* 4. *Chrysophyta*
15.	Pelangan River Estuary, West Nusa Tenggara	1. *Pleurosigma angulatum* 2. *Rhizosolenia sp* 3. *Chaetoceros van heurckii* 4. *Gyrosigma fascicola* 5. *Gyrosigma strigile* 6. *Thalassiothrix fruenfeldii*	1. *Bacillariophyta* 2. *Chrysophyta* 3. *Bacillariophyta* 4. *Chrysophyta* 5. *Chrysophyta* 6. *Chrysophyta*

The factors that cause water quality conditions in the coastal waters of Kupang Bay, East Nusa Tenggara to be in the category of mild to severe pollution are salinity, DO, temperature, pH, ammonia levels, and nitrate levels. The parameters that have the most influence on the pollution index at the Paradiso and Nunhila beach locations are salinity and water temperature, both locations have salinity values that are below the quality standard, as well as for temperature on Paradiso beach above the quality

standard. Noelbaki beach and Kuka Sulamu beach, the factor that most affects the status of pollution is the concentration of nitrate which is above the quality standard [2].

In Waioti waters, the percentage of dead corals with algae is quite large because this research area is an area with a muddy sand substrate which causes silt carried by currents and waves to cover coral reefs which can cause algae to grow on corals with silt [21].

Nitrate levels of more than 0.2 mg/l can lead to eutrophication, which in turn stimulates rapid algae growth (blooming). The abundance of *phytoplankton* in Gerupuk Bay is what triggered the algae bloom [22].

In Tanjung Luar, West Nusa Tenggara *chaetoceros* is the species with the highest abundance, this species does not produce toxins but when blooming occurs, this type of algae has a harmful effect that can cause irritation that stimulates the formation of mucus in the gills of fish so that it can make it difficult for fish to breathe and eventually die [23].

The waters of Bolok Village are very supportive of algae growth. The type of brown algae *Euchema cotonii* is most widely cultivated by the people of Bolok Village. The results showed that the growth of *Euchema cotonii* in the waters of Bolok Village was in good condition. In addition to brown algae, there is also a type of green algae *Glacilaria* which is used by the community as food. The Bolok Village community gives the name "sea vegetable" to this type of *Glacilaria* algae. The growth of this algae can be seen from the condition of the water substrate that supports the growth of these algae. Brown algae found are *Padina, Euchema Cotonii, Sargassum*. Meanwhile, the green algae found are *Glacilaria, Ulva reticulata.* According to respondents, the condition of seawater in Bolok Village is still categorized as good and this is evident from the development of aquaculture businesses that have been carried out until now. The cultivation business carried out by the Bolok Village community is in the form of seaweed and sponge cultivation. Until now, seaweed and sponge cultivation carried out by the community is still growing well. This is in line with the results of the researcher's research. [24]

Most of the sources of ammonia, nitrate and phosphate pollution in the waters of Depapre District come from community activities, through household domestic waste disposal and the impact of agricultural and plantation activities. In addition, ammonia, nitrate and phosphate in the waters also come from natural sources. Although there have been no cases of eutrophication in the waters of Depapre District, the condition is very worrying because ammonia, nitrate and phosphate in high concentrations in the waters will certainly cause eutrophication which is very dangerous for other marine biota [5].

The difference in diversity values in a water body is influenced by environmental factors, namely the availability of nutrients (nitrate and phosphate) and the ability of each type of phytoplankton when adapting to the surrounding environment. Based on the description above, it is necessary to study the diversity of phytoplankton microorganisms and their relationship to the quality and physical and chemical factors of waters. The assessment of biological quality is very important because its accumulative function can anticipate environmental changes that occur in a particular area [12].

Kupang Regency has the potential of marine resources that are very potential and diverse. For the districts described above, seaweed cultivation is a favorite for coastal residents because the main source of income for fishermen depends on seaweed cultivation. In this case, in addition to controlling the algae planted,

measurements of environmental parameters were also carried out, namely measurements of temperature, water salinity, pH and current speed. The measurement results show that the environmental parameters are in the optimum range for red algae cultivation activities [25].

One of the negative impacts of the algae explosion is the dead coral event in the form of Dead Coral Algae (DCA). The presence of dead corals is thought to be the result of unfriendly and destructive fishing activities in the past. However, this value is relatively lower than that of living corals. The presence of attached algae is also an indication that the coral has been dead for a long period of time [26].

While the positive impact of the existence of a diversity of algae species makes efforts to develop seaweed cultivation in the waters of Buer Sub-district have been carried out with cultivation methods adapted to the characteristics of each water body. Seaweed cultivation using basic stakes has been developed in the waters of Kaung Island. types of seaweed in Sumbawa waters include red algae, green algae and brown algae. These species live in accordance with their natural habitat, especially according to the character of the substrate and waters. Which increases the economy of local residents [27]. One component of coastal ecosystems that is important and has a high contribution to the Indonesian economy is seaweed. The name seaweed is used to refer to marine plants that live on the bottom of the water (*phytobenthos*), large in size (macroalgae). The correct term to refer to marine plants that are popular as seaweed is marine algae [28].

This increase in pollutants will certainly threaten the existence, sustainability of ecosystems and resources in coastal areas both directly (e.g. land conversion activities) and indirectly (e.g. pollution by waste from various development activities). The coastal area of Kupang Bay has been developed for a variety of uses, including tourism, boat harbors, fish landing ports, hotels, and settlements. These activities will affect the quality of coastal waters, which in turn will reduce the usability, productivity, carrying capacity and capacity of aquatic resources and ultimately reduce the wealth of natural resources. Not only that, the influx of various substrates can make algae growth explode and is inevitable. [29] *Molluscs* can also control algae populations and clean seawater. Sea cucumbers are part of the *Echinodermata* phylum which has nutritional value and economic value as food for humans. *Echinodermata* also act as cleaners, where *Echinodermata* eat algae, moss, and detritus [30].

4 CONCLUSION

From the results of the literature study conducted by the author, it can be concluded that the diversity of algae plants found in each region around the Nusa Tenggara region is very diverse, such as consisting of the *Chlorophyta, Cyanophyta, Rhodophyta, Phaeophyta*, and others. This indicates that the fertility of algae in each region is influenced by their respective factors. However, if a polluted substance in the water will cause algae blooming, for example, the higher the diversity of a phytoplankton or substrate that accelerates algae growth will cause algae blooms that become pollutants and destroy the ecosystem of the water area where the algae blooming occurs.

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