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Identification of Brown Seaweed on The North and South Coasts of Java Island by Machine Learning

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Abstract

Seaweed is one of the marine organisms that can be found in almost coastal waters of Indonesia. Brown seaweed is a group of multicellular algae that have adapted to the marine environment. This study uses morphological identification methods for brown seaweed, further facilitated by utilizing machine learning technology. The aim of this research is to compare the identification based on morphological characteristics and by machine learning. The study focused on the North Coast of Teluk Awur and the South Coast of Krakal, Java Island, as the locations for field sample collection, utilizing three stations per water area with the method of collecting images of brown seaweed. The water quality parameters were determined as supporting data of environmental condition. The results of identification with machine learning compared with manual identification gave similar results. These show that on the North Coast, the genus Sargassum was identified with a high accuracy rate of 99.11%, while on the South Coast, the genus Sargassum was identified with an accuracy rate of 99.00%, the genus Padina with an accuracy rate of 99.15%, the genus Turbinaria 98.01%, and the genus Dictyota 96.42%. The growth of brown algae in the North Coast of Teluk Awur and the South Coast of Krakal was influenced by water quality factors such as temperature, salinity, pH, dissolved oxygen, and brightness.

1. Introduction

Indonesia is a vast ocean area and a variety of abundant natural resources with 5.8 million km^2 of coastal area (Rosari and Yasniwati, 2023). Macroalgae are marine biodiversity that can be found in almost all Indonesian waters and have habitats attached to various types of substrates (such as rocks, sandstone, sand, wood, mollusk shells, and epiphytes) (Trono Jr, 1997). Seaweed has three main types of pigments, namely chlorophyll, carotenoids, and phycocyanin (Samad *et al.*, 2021). Seaweed also contains calcite and aragonite which can form cement, so it can be an adhesive for dead coral fragments to withstand the impact of large waves (Hartog, 1972). Seaweed has various divisions, namely green, brown, and red algae.

Phaeophyta, also known as brown seaweed, are a group of multicellular algae adapted in marine environments (Lobban and Wynne, 1981). Adults can grow up to several meters in length (Romimohtarto and Juwana, 2004). Phaeophyta or brown algae are a group of autotrophic multicellular organisms, which belong to the class Phaeophyceae in the division Chromophyta (Aulia *et al.*, 2021).

Seaweed identification is the initial stage to be able to observe the characteristics or characters found in brown seaweed, to understand biodiversity, for scientific research, and useful for aquatic conservation and environmental management. Overall, seaweed identification has a positive impact in various aspects, from natural resource conservation to product development and innovation (Eggertsen and Halling, 2021). The identification needed is with the aim of sustainable management and understanding of marine ecosystems.

Identification done manually will take a long time to adjust morphology to the identification results. Therefore, the use of machine learning is considered more efficient in identifying seaweed, because an automated machine learning system will facilitate the seaweed identification process (Salintohe *et al.*, 2022). This study aims to performing manual identification of brown seaweed genera based on morphology and using Machine Learning. Comparing habitat suitability and water quality of brown seaweed on the North Coast of Teluk Awur and the South Coast of Krakal.

2. Material and methods

2.1 Materials

This research material of brown seaweed genera found on the North Coast of Teluk Awur, Jepara and the South Coastof Krakal, Gunung Kidul. The parameters observed are temperature, pH, salinity, dissolved oxygen (DO), and brightness.

2.2 Methods

The research method used is a survey with purposive sampling techniques, which determining the location of research sites related to research objectives (Sumerah *et al.*, 2020). This method is done by taking brown seaweed directly in the waters. Brown seaweed was identified using machine learning. Identification is carried out using a Web App-based learning system to produce seaweed genus identification data (Sugiyono, 2016).

2.2.1 Sampling site

This research was conducted on the North Coastof Teluk Awur, Jepara Regency, Central Java and the South Coastof Krakal, Gunung Kidul Regency, Yogyakarta. The choice of location on Teluk Awur Coastand Krakal Coastis because both locations have different characters and water quality and diversity of brown seaweed (Figure 1 and Figure 2). The determination of the location point (Table 1) was chosen with consideration and purpose of the study (Rigitta *et al.*, 2015).

Table 1. Brown seaweed sampling coordinates

No	Station	Latitude	Longitude
1	A1	06°37’02.4”	110°38’22.7”
2	A2	06°37’02.9”	110°38’20.7”
3	A3	06°37’04.4”	110°38’19.1”
4	B1	08°14’55.49”	110°59’87.84”
5	B2	08°14’51.51”	110°59’96.23”
6	B3	08°14’50.87”	110°60’04.11”

2.2.2 Water quality sampling procedure

Sampling of water quality carried out is measuring temperature, salinity (refractometer, Hanna), pH (pH meter, digital), dissolved oxygen (DO) (DO meter), and brightness (Secchi disk). Data collection is carried out 3 (three) times at each station.

2.2.2.1 Salinity

Salinity is measured using a refractometer. The step used for salinity data collection is that water samples are taken using drip pipettes, before that calibration is carried out with fresh water and cleaned using tissue, then the water sample is dripped on a prism to be scaled through an eye piece.

2.2.2.2 Temperature data collection

The temperature of the waters is measured using a thermometer. The working step of temperature measurement is to calibrate the thermometer with fresh water and clean it using tissue, then enter the thermometer at the location of the water to be measured the temperature then let stand for a while and see the mercury limit parallel to the pointing number.

2.2.2.3 pH data retrieval

The pH of the waters is measured using a pH meter. The working step of measuring the pH meter is to calibrate the pH meter with fresh water and clean it using tissue, then dip the pH meter into the water then let stand for a while and see the large number shown on the pH meter.

2.2.2.4 DO (Dissolved Oxygen)

DO or dissolved oxygen measurements are carried out using a DO meter. The working step of measuring DO is to calibrate the DO meter, with fresh water and cleaned using tissue then dip the DO meter into the water then let stand for a while and see the large number shown on the DO meter.

2.2.2.5 Brightness

According to Hardan *et al.* (2020), water brightness measurements were carried out using a secchi disk. Secchi disks are tied to ropes that are then slowly lowered into the waters at the study site. Observations were made up to the visual limit of the secchi disk, then measured the length of the rope and recorded the position of data collection.

2.2.3 Brown seaweed sample collection procedure

Seaweed sample collection was carried out by line transect method (Winarya and Dewi, 2014). Transects are spaced 50m apart on each line and moved in parallel. Distance determination is carried out with a roll meter pulled perpendicularly along 100m towards the sea at each observation station. The collection was carried out 3 repetitions to produce representative data.

2.2.4 Brown seaweed identification procedure

Seaweeds were manually identified by some deep observations on morphological keys of characteristics using the Algabase web to determine exactly which genus was found. The results of the identification of the brown seaweed genus were re-curated with research references.

Figure 1. Research site of Teluk Awur in North Coastal of Java

Figure 2. Research site of Krakal in South Coastal of Java

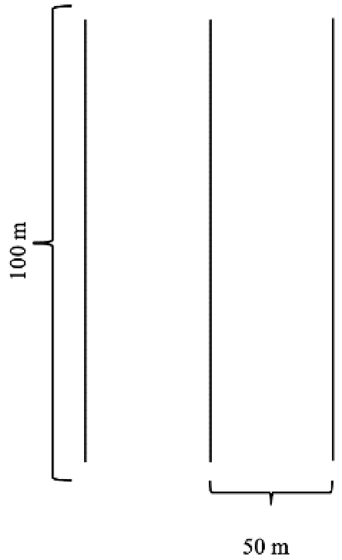

Figure 3. Transect determination at each station

2.2.5 Seaweed identification procedure with machine learning

The brown seaweed obtained was then identified by machine learning methods. This method is done by scanning brown seaweed samples using a Web App application.

2.3 Research scheme flow

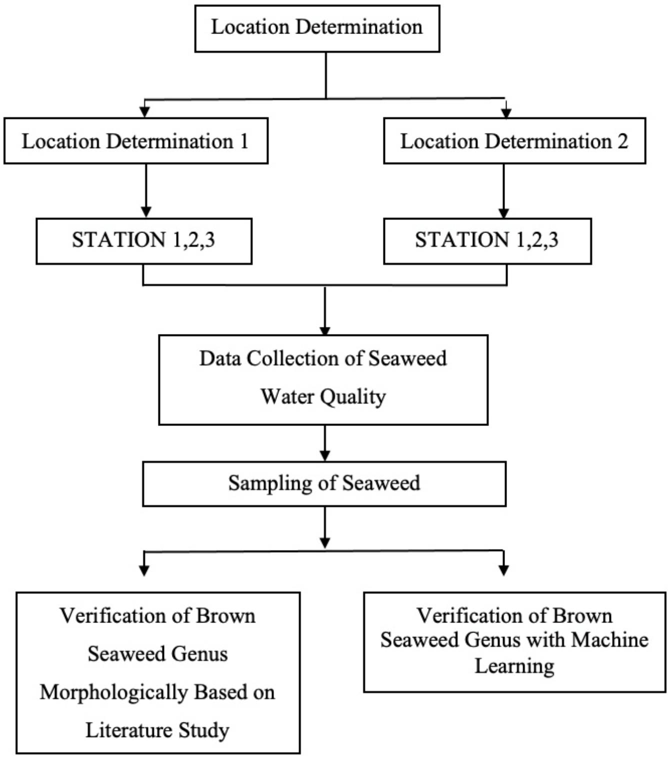

Figure 4. Brown seaweed identification method flow chart

3. Results

The identification results of brown seaweed (Table 2 and Figure 5) found at stations 2 and 3 of Teluk Awur Coast, but not found at station 1, were then verified using Web App application machine learning and manual verification with the Algabase Web application, and also verified using library sources.

Figure 5. Genus of brown Seaweed found on the North Coast of Teluk Awur (Sargassum)

The identification results of brown seaweed (Tabel 3) found at stations 1, 2, and 3 of Krakal Coastwere verified using machine learning Web App application and manual verification with Algabase Web application and also verified using library sources.

The results of identification and verification of seaweed species obtained on Teluk Awur Coastand Krakal Coastcan be seen in the following table.

The results of brown seaweed samples in the waters of the North Coastof Teluk Awur there was 1 genus of brown seaweed (Table 4). There are 4 genus of brown seaweed in South Coastof Krakal (Table 5). Brown seaweed samples were grouped according to the genus. The results of sampling observations on the South Coastof Krakal showed the verification of Sargassum by 99.00%, genus Padina by 99.15%, genus Turbinaria by 98.01%, and genus Dictyota by 96.42%.

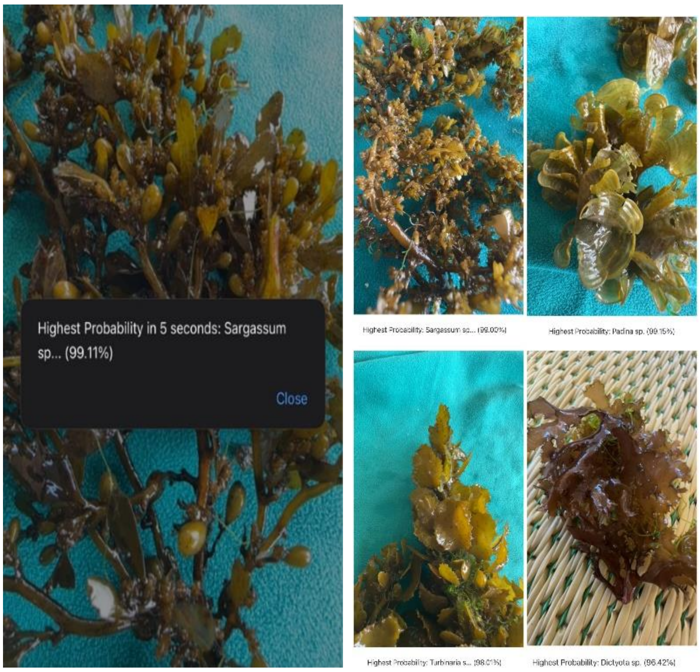

Figure 6. Genus verification of brown seaweed (sargassum) and brown Seaweed genus (Sargassum, Padina, Turbinaria, and Dictyota)

Table 2. Brown seaweed found at each station on the North Coast of Teluk Awur

No	Types of brown seaweed (Phaeophyta)	Station 1	Station 2	Station 3
1	Sargassum		++	+

Description: (+) found, (-) not found

Table 3. Brown seaweed found at every station on Krakal Coast

No	Types of brown seaweed (Phaeophyta)	Station 1	Station 2	Station 3
1	Padina	+	++	++
2	Turbinaria		+	+
3	Dictyota		+	+
4	Sargassum	+	++	++

Explanation: (+) found, (-) not found

Table 4. Manual, references and verification results of North Coast brown seaweed samples of Teluk Awur.

No	Identification Results	Manual	Web App	Identification Guide
1.	Sargassum	Web Algabase	Verified 99,11%	(Atmadja *et al.*, 1996; Sunarernanda *et al.*, 2014)

Table 5. Verification results of South Coast brown seaweed samples of Krakal and Reference for genus identification

No	Identification results	Manual	Web App	Identification guide
1.	Sargassum	Web Algabase	Verified 99,00%	(Atmadja *et al.*, 1996; Sunarernanda *et al.*, 2014)
2.	Padina	Web Algabase	Verified 99,15%	(Atmadja *et al.*, 1996; Codero, 1980)
3.	Turbinaria	Web Algabase	Verified 98,01%	(Atmadja *et al.*, 1996)
4.	Dictyota	Web Algabase	Verified 96,42%	(Atmadja *et al.*, 1996; Aulia *et al.*, 2021)

The results of observations of water quality on the North Coastof Teluk Awur on temperature, salinity, and DO parameters have met quality standards, while pH and brightness parameters still do not meet quality standards (Tabel 6).

Table 6. Results of parameters in the waters of the North Coastof Teluk Awur

Parameter	Station 1	Station 2	Station 3	Standard
Temperature(°C)	31°C	31°C	32°C	26°C- 33°C (Afrianto and Liviawati, 1993)
Salinity (ppt)	25	26	26	15-35 ppm (Aslan, 1991)
pH	7,7	7,5	7,5	8,0 - 8,9 (Aslan, 1991)
DO (mg/L)	6,23	6,8	6,3	> 3 mg/l (Tarigan *et al.*, 2020)
Brightness (m)	1,15	1	1,3	2m (Hardan *et al.*, 2020)
Substrate	Coral fragments	Coral fragments	Coral fragments	

The results of observations of water quality on the South Coastof Krakal on temperature, salinity, pH, and DO parameters have met quality standards, while brightness parameters still do not meet quality standards (Tabel 7).

Table 7. Parameter results in the waters of the South Coastof Krakal

Parameter	Station 1	Station 2	Station 3	Standard
Temperature(°C)	32°C	32°C	31°C	26°C- 33°C (Afrianto and Liviawati, 1993)
Salinity (ppt)	33	33	34	15-35 ppm (Aslan, 1991)
pH	7,9	8,3	8,0	8,0 - 8,9 (Aslan, 1991)
DO (mg/L)	7,4	8,2	8,5	> 3 mg/l (Tarigan *et al.*, 2020)
Brightness (m)	0,47	0,57	0,63	2m (Hardan *et al.*, 2020)
Substrate	Sandstone	Sandstone	Sandstone	

4. Discussion

In this study, the brown seaweed found in Teluk Awur and Krakal belonged to the genera Sargassum, Padina, Turbinaria, and Dictyota, identified morphologically. Sargassum was characterized by dark brown or light brown color (Sridamayani and Nane, 2022). The genus Padina had whitish hairs on the inner side of the lines and exhibited yellowish-brown or light greenish-brown colors (Cotas *et al.*, 2023)). The genus Turbinaria displayed a yellowish-brown color (Atmadja *et al.*, 1996). The genus Dictyota had a thallus with brown to dark brown coloration (Aulia *et al.*, 2021). Morphological identification revealed that brown seaweed has body structures consisting of blade, stipe, air bladder, and holdfast (Sridamayani and Nane, 2022).

The first test results for brown seaweed identification using machine learning showed a verification accuracy of 99.11% for the genus Sargassum at Teluk Awur Beach. The accuracy results for brown seaweed identification at South Krakal Beach were 99.00% for the genus Sargassum, 99.15% for the genus Padina, 98.01% for the genus Turbinaria, and 96.42% for the genus Dictyota. Overall, the verification testing of brown seaweed samples using machine learning demonstrated good functional compatibility. According to research by Malahina *et al.* (2022), taking pictures that clearly show parts of the brown seaweed with a contrasting background is recommended to facilitate the identification process and yield an accuracy rate of 90%-100%.

The brightness of the waters can affect the growth of brown seaweed in the waters of Teluk Awur Coast. The results of brightness measurements on Teluk Awur Coast have a brightness of 1 – 1.3 m and 0.47 – 0.63 m on Krakal Coast, this explains that the brightness compatibility index is quite good for the growth of brown seaweed, although the brightness level is still below the quality standard (Hardan *et al.*, 2020).

The results of measuring the value of sea water temperature on Teluk Awur Coast show the results at station I and station 2, which have a water temperature of 31 ºC, while for station 3, which has a water temperature value of 32 ºC. The temperature in the waters of Krakal Coast shows results at station I and station 2, which has a water temperature of 32 ºC, while for station 3, it has a water temperature value of 31 ºC. According to the Decree of the Minister of Environment number 51 of 2004, the quality standard for the appropriate water temperature value is 26 ºC – 30 ºC. Teluk Awur Coast and Krakal Coast are in accordance with the quality standards that have been set, this does not interfere with an existing ecosystem and biota.

The results of seawater salinity measurements on Teluk Awur Coast and Krakal Coast show the results of salinity values at station 1 25‰, station 2 which is 26‰, and station is 3 26‰ and station 1 33‰, station 2 is 33‰, and station 3 is 34‰. The difference in salinity value results in a body of water can be caused by differences in precipitation and evaporation (Aslan, 1991). According to Aslan (1991) the quality standard for salinity values in waters is 15-35‰. From the measurement of salinity values in the waters of Teluk Awur Coast and Krakal Coast are classified as low from quality standards. This can be caused by the influence of land, such as freshwater supply through river flows and then empties into sea waters.

The results of measuring the degree of acidity on Teluk Awur Coast show values at station I namely (7.7), station 2 (7.5), and station 3 (7.5). pH that is too high or too low can be an inhibiting factor for growth. According to Aslan (1991) Seaweed can grow and develop according to the pH water index of 8.0-8.9. It states that the conditions of the waters of Teluk Awur Coast are quite ideal and can be tolerated by seaweed for growth. Meanwhile, Krakal Coast shows values at station I which is (7.9), station 2 is (8.3), and station 3 is (8.0). According to Aslan (1991) Seaweed can grow and develop according to the pH water index of 8.0 – 8.9.

Teluk Awur has DO at station 1 (6.23) mg/l, station 2 (6.80) and station 3 (6.29). The measurement results of DO (Dissolved oxygen) values at Krakal Coast show the results of DO values at station 1 which is 7.4 mg / l, station 2 is 8.2 mg / l, and station 3 is 8.5 mg / l. Based on Tarigan *et al.* (2020), dissolved oxygen (DO) which is good for marine organisms is in the range of >3 mg / l. This situation supports these plants to digest nutrients efficiently. In addition to metabolism, high DO can help seaweed respiration to grow more optimally. The main parameter that affects the solubility of nutrients in waters is dissolved oxygen (Wafi *et al.*, 2021).

5. Conclusions

Manual identification of brown seaweed shows the same genus as identification using machine learning, with a data verification percentage exceeding 95%. The genera found on the North Coast, Teluk Awur, include only one genus, namely Sargassum, while on the South Coast, Krakal, there are four genera: Padina, Turbinaria, Dictyota, and Sargassum. Based on water quality factors such as temperature, salinity, pH, dissolved oxygen, and brightness, the type of brown seaweed on the North Coast, Teluk Awur, is categorized as having a moderate habitat suitability, while on the South Coast, Krakal, it is categorized as good.

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

PN is doing research ideas, sample image collection, water quality sampling collection, EY is supervising and writing

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Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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