Study of Seawater Quality Status in the Saugi Island Area, Pangkep Regency: Analysis of the Impact on Marine Biota

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Abstract: This research aims to analyze the quality of marine waters in the Saugi Island area, North Liukang Tupabbiring District, Pangkep Regency, and its impact on marine biota. This research uses a descriptive quantitative approach by processing data from field measurements and laboratory tests on several parameters. Furthermore, the test results will be compared with the standard requirements for seawater quality for the needs of marine biota by referring to the Decree of the Minister of the Environment No. 51 of 2004. In addition, a spatial analysis is carried out to see the predicted concentration distribution pattern for each measurement parameter each of these parameters. The research results show that of the 10 research stations, only 4 stations almost meet several seawater quality standards, namely stations 1, 4, 7, and 9. The presence of waste at each station, which is dominated by inorganic waste, plays an important role in reducing the quality parameter values. In conclusion, the quality of seawater on the coast of Saugi Island is not good for marine biota. Therefore, efforts are needed to maintain the cleanliness of the coastal environment thus water quality is maintained, supports the life of marine biota, increases catches, and the potential for sustainability of marine ecosystems
Keywords: Quality status, Marine Waters, IDW, Saugi Island

1. Introduction

Seawater quality is an environmental problem that is still difficult to control. Seawater is the main habitat for marine biota which is vulnerable to pollution (1). Poor seawater quality can limit the growth and development of marine biota and worsen the quality of marine biota (2). Based on BPS data for 2023 in (3), Indonesia produces millions of tons of plastic waste every year and is one of the countries in the world that throws the largest amount of plastic waste into the sea. The amount of plastic waste thrown into the sea from Indonesia every year is 56,333 tons.

Seawater pollution is caused by industrial, agricultural, and plastic waste and can damage ocean ecosystems (1). This is in line with (4) that seawater pollution poses a serious threat to fisheries resources and marine environmental sustainability, as well as marine biota as a whole. This pollution will disrupt the marine food chain, reduce fisheries productivity, and damage marine habitats. According to (5) the marine environment is home to various kinds of organisms, including microorganisms and macroorganisms which depend on each other in a complex food web. Therefore, maintaining the marine environment, especially beach cleanliness, is an effort that must be made to maintain seawater quality for the survival of marine biota.

Several factors can influence seawater quality. Some of these are caused by human activities, such as trash and oil spills, and others are natural, such as algae blooms (6). This factor is reinforced by the statement by (4) that the actions of people who throw rubbish into the sea can affect the quality of seawater. Garbage thrown into the sea can damage coral reefs, mangroves and disrupt the life of others marine biota. Apart from trash, other natural factors such as heavy rain can also cause changes in seawater quality (7–9). Poor seawater quality can limit the growth of marine organisms and cause their growth to be suboptimal.

Research on seawater quality is very important to obtain information about seawater quality. The results of this research can provide information regarding seawater quality which will enable the government and society to determine policies to maintain seawater quality (10). According to the views of (11,12) also emphasizes the same thing apart from resources in the form of marine biota, coastal areas are also rich in human-made biological and non-biological environmental services, so this is effort important to maintain the stability of seawater quality. Furthermore, the Saugi Island Area, Mattiro Baji Village, Pangkep Regency, was chosen as the research location because it has unique characteristics as a coastal area that is the center of marine biota cultivation activities. This island is an area that depends on marine resources as the main supporter of its community economy.

The lack of land to dispose of leftover food and other rubbish in the Saugi Island area of Mattiro Baji village has created a bad perception in the community. The community is confident that this will not hurt water bodies which are the source of life for marine biota and community income. The quality of seawater on Saugi Island, Mattiro Baji Village is known to be poor, with various problems such as accumulation of rubbish, strange odors, and turbidity revealed (13). Seeing this problem, it is important to research to test the quality of seawater, because it affects the condition of marine biota living in seawater. The aim is to determine whether seawater meets water quality standards based on Minister of Environment Regulation Number 51 of 2004.

2. Material and Methods

2.1. Type and Location Research

The type of research used in this research is descriptive quantitative using a spatial approach. Descriptive quantitative is intended as a type of research that analyzes data in the form of numbers which are then explained coherently by referring to the research results that have been obtained (14,15). Furthermore, the spatial approach is a type of approach used to present data spatially to determine the characteristics of an area based on the aspects studied (16). This is important to determine the spatial distribution pattern at the research location, which is presented in the form of mapping.

This research was conducted in the Sapuli Island area, Liukang Tupabbiring Utara District, Pangkep Regency. The sampling points were carried out at 10 points in the Saugi Island area which were determined using purposive sampling. Purposive sampling is intended as a sample determination method that is carried out by considering the characteristics and characteristics of the research location to be studied (17). This can be seen in Figure 1 below.

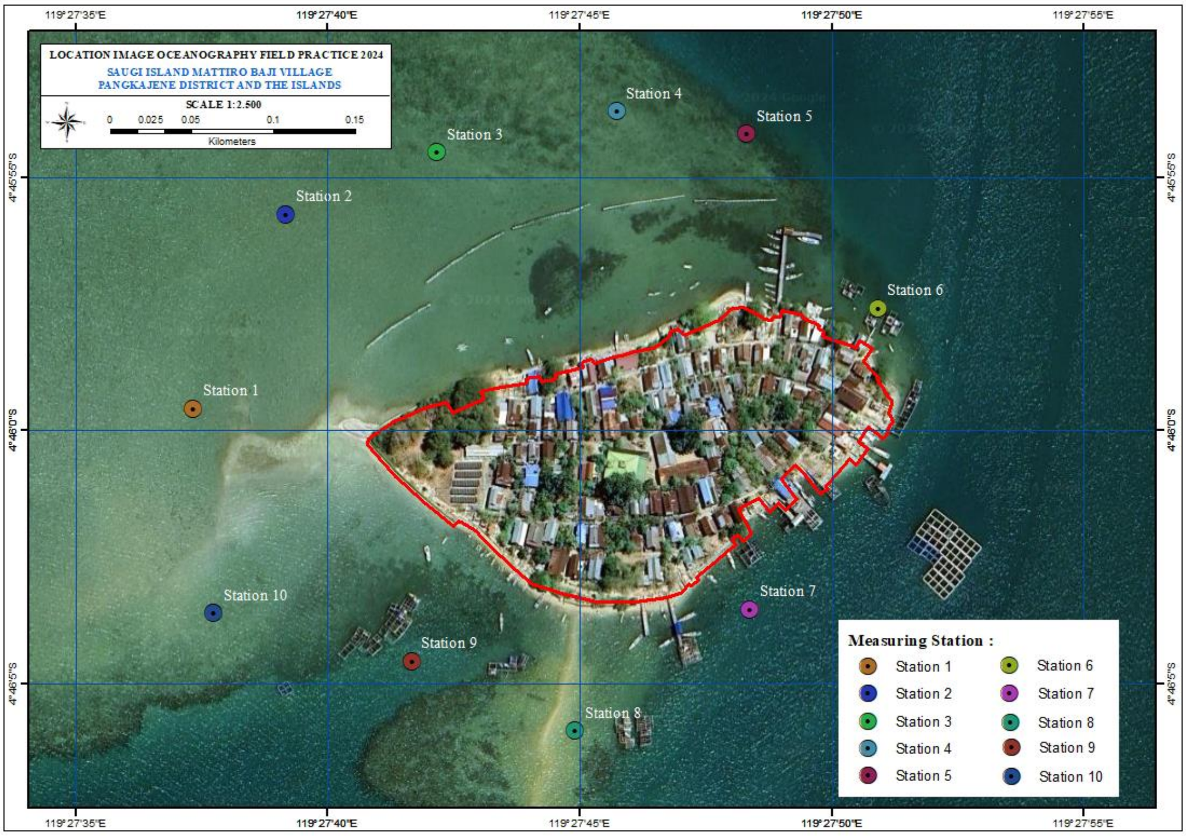

Figure 1. Research Location Map

2.2. Data Source

Data sources used in this research are as follows.

1) Primary data obtained from in-situ sample collection and laboratory testing results. The data includes Temperature, Salinity, PH, Dissolved Oxygen, Garbage, and Marine Biota. The data obtained will be a reference for determining the quality status of marine waters which will be compared with the standard requirements for marine waters for the use of marine biota. Temperature, salinity, and dissolved oxygen parameters were measured 3 times, namely morning, afternoon, and evening. While garbage and marine biota were observed around the waters.
2) Secondary data used in this research is data used to carry out spatial analysis in making interpolation maps to determine the distribution of pollution loads. This data includes:
   a. Geospatial information agency
   b. December 2019 DUKCAPIL Village Limits

c. December 2019 DUKCAPIL District Limits
d. December 2019 DUKCAPIL District Boundaries
e. December 2019 DUKCAPIL Provincial Boundaries
f. MOSAIC BATNAS
g. SAS Planet (Bing Satellite Image Results) 2023

2.3. Data Analysis Techniques

Data analysis used in this research includes determining water quality status and analyzing predictions of the distribution of concentrations for each test parameter using Inverse Distance Weighting (IDW) spatial analysis. The distribution of marine biota was studied using observations and taking pictures of marine biota at each station. This can be seen as follows.

2.3.1. Determination of Quality Status of Marine Water Quality

Determining the quality status of marine waters is carried out by comparing the results of in situ water quality tests based on parameters determined by the Decree of the Minister of the Environment Number 51 of 2004 concerning Seawater Quality Standards. The quality standards used refer to the use of marine waters for marine biota in the Saugi Island area. Each measurement parameter will be compared with the requirements of marine water quality standards for marine biota, whether they meet or do not meet the requirements of these standards. The required water quality standards can be seen as follows.

Table 1. Requirements for Seawater Quality Standards for the Use of Marine Biota

Parameters	Unit	quality standards
Temperature	℃	28-32
Salinity	(‰)	32-34
Potential of Hydrogen		7-8,5
Dissolve Oxygen	mg/L	>5
Trash		No

Source: Attachment to standard requirements for seawater quality based on Minister of Environment *Decree Number 51 of 2004*

2.3.2. Prediction of Concentration Distribution Results from Seawater Sample Measurements

The Inverse Distance Weighting (IDW) method works based on the assumption that each data point influences the area around it, with the weight decreasing as the distance from that point increases (18). In its implementation, the weight is calculated using the inverse of the distance between one data point and another through a certain mathematical formula. One of the main aspects of this method is the power value, which determines the extent to which nearby points influence the interpolation results. Higher exponent values will cause the influence to be more focused on nearby points, creating a simpler and smoother surface. Conversely, lower exponent values will expand the influence over a larger area, producing surfaces with more complex detail.

In analyzing the quality status of marine waters, test result data for each test parameter is entered into the mapping database as input for spatial analysis. This process produces a spatial visualization that depicts the concentration distribution pattern of parameters based on the intensity at each sample point at the research location. The results of this mapping provide a comprehensive picture of the distribution of marine water quality status, which helps in identifying areas that require special attention regarding water quality.

The distribution of marine biota was studied using observations and taking pictures of marine biota at each station. Therefore after the results of the chemical and physical analysis are carried out, it will provide the presence of different marine biota results at each station. Because each marine biota has water quality standards for living, depending on the marine biota that dominates at each station.

3. Results and Discussion

Based on the sample test results and field data obtained in situ from ten sampling points, the results can be presented as follows.

Table 2. Data From Field Data Collection Results

Parameters	Quality Standards	Observation Station									
		1	2	3	4	5	6	7	8	9	10
temperatures (℃)	28-32	31	31	35*	32	33	28,6	31	30	30	39*
Salinity(‰)	32-34	32	35*	34	36*	32	31*	36*	30*	35*	34
pH	7-8,5	6*	6*	6*	6*	6*	6*	6*	5*	8	6*
Dissolved Oxygen (mg/l)	>5	4,2*	0,16*	0,68*	9,4	6	0*	7	2,8*	0*	3,4*
rubbish	Nill	There is*	There is*	There is*	There is*	There is*	There is*	There is*	There is*	There is*	There is*

Source: Data Analysis, 2024
(*) Does not meet the specified quality standard requirements

Based on the data in Table 2 above, it was found that several stations do not meet the seawater quality standards for marine biota that have been set by the Ministry of Environment Number 51 of 2004. This non-compliance can have an impact on the diversity of marine biota [19]. Based on the results of observations in the field, variations in marine biota were found at each research station. This can be seen as follows.

3.1. Seawater temperature

Water temperature data obtained at ten observation stations on Saugi Island ranged from 28.6°C to 39°C. Based on quality standards from the Minister of Environment Decree No. 51 of 2004 for marine biota, the temperature threshold that supports the life of marine biota ranges from 28°C to 32°C [20]. Based on the Minister of Environment Decree on the quality standards for marine biota, the temperature values in the waters of Saugi Island at stations 3 and 10 are not appropriate because they exceed the threshold and other factors cause the temperature to exceed the seawater quality threshold.

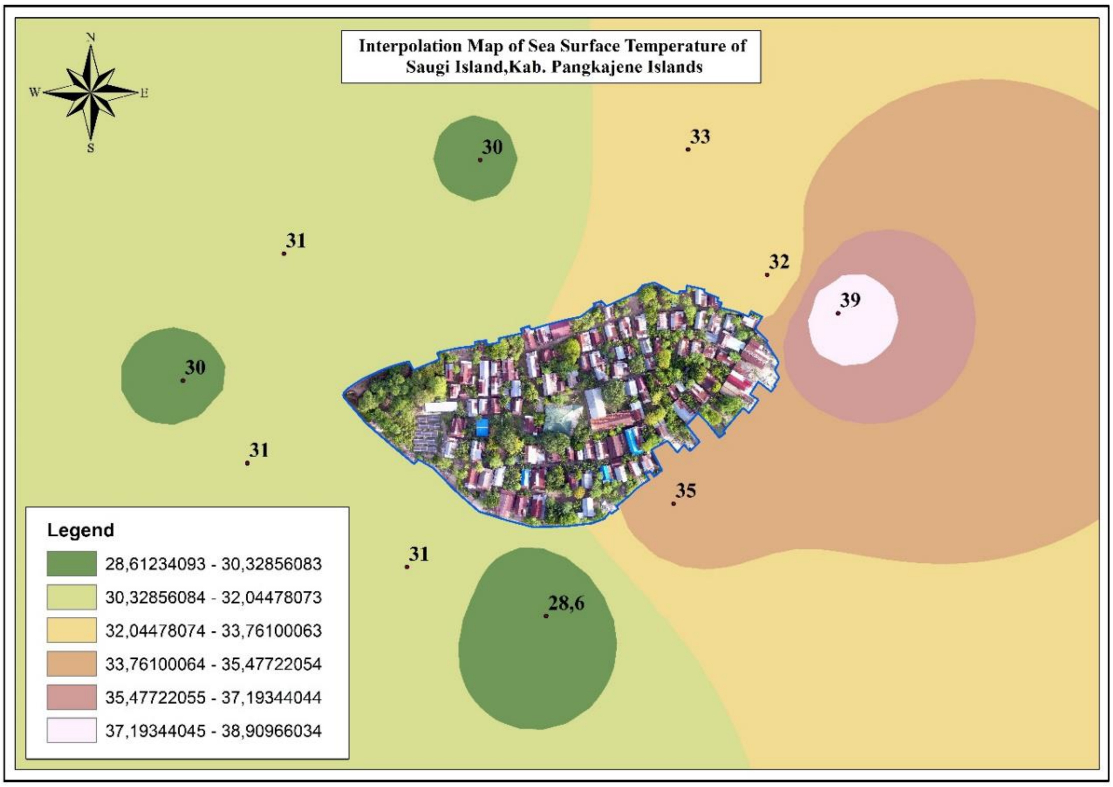

Figure 2. Interpolation Map of Sea Surface Temperature of Saugi Island

Water temperature is one of the key parameters that greatly influences marine ecosystems, especially the life of marine biota. Optimal water temperature is needed to support physiological processes, reproduction, and sustainability of biota habitat. Based on observations made at 10 stations in the waters of Saugi Island, the results were that only 3 stations had water temperatures in accordance with the quality standards stipulated in Minister of Environment Decree No. 51 of 2004, while 7 other stations did not meet these standards.

When compared further, it was found that most stations with water temperatures according to quality standards had a temperature range between 30.5°C to 32.5°C. This range is considered ideal to support the survival of marine biota in the region. However, other stations show temperatures higher than the specified threshold.

The main cause of this inappropriate water temperature is strongly thought to come from the high intensity of sunlight, especially during the day, which causes a significant increase in water temperature (21). This factor can be exacerbated by the lack of vegetation cover around the beach area which can function as natural shade. This condition underlines the importance of managing coastal ecosystems to maintain the quality of the marine environment, including water temperature so that it continues to support the sustainability of marine biota.

3.2. Salinity

Salinity is the concentration of all salt solutions found in seawater. According to (22), salinity is a water quality parameter which states the level of dissolved salt in the water. In research conducted at ten stations on Saugi Island, the salinity ranged from 30‰ to 36‰. There are several stations in the salinity range that exceed and fall below the quality standards by the Decree of the Minister of the Environment Number 51 of 2004, namely the optimal salinity for marine biota is in the range of 33-34 ‰. Stations whose values exceed the seawater quality threshold are stations 2, 4, 6, 7, 8, 9 and stations that comply with seawater quality standards are stations 1, 3 and 10. The high salinity values on Saugi Island are caused by evaporation and temperature at certain hours with temperatures reaching 39°C.

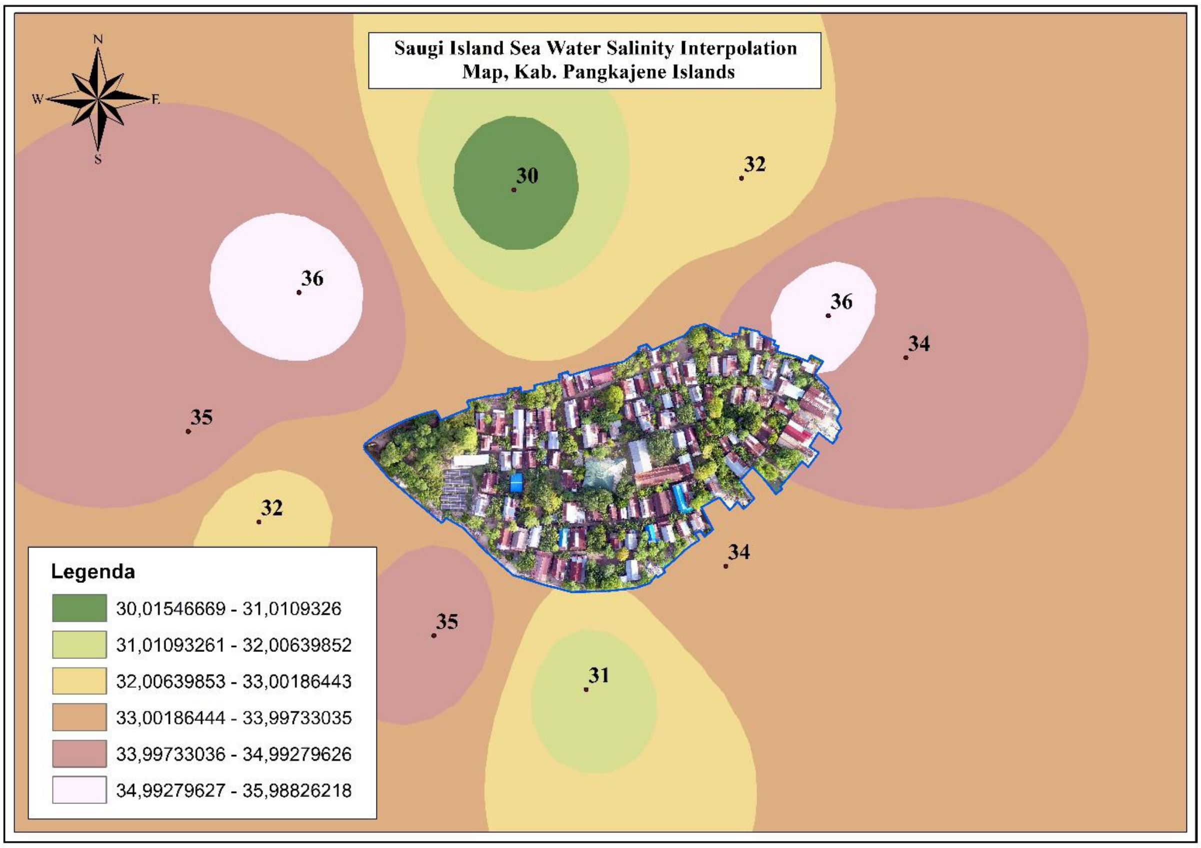

Figure 3. Saugi Island Water Salinity Interpolation Map

Salinity or salt content in water is also an important parameter that is measured to determine the level of viability of marine biota. Salinity is the concentration of all salt solutions obtained in sea air. Differences in water salinity can occur due to differences in evaporation and precipitation (23). The water salinity values measured at the research station ranged from 26.83-35‰. The salinity values are by quality standards, namely stations 1, 3, 5, and 10. The low salinity value at station 8 is thought to be influenced by the input of freshwater from the Pangkajene River which mixes with the flow of seawater near the estuary. (24) explained that the salinity of seawater can differ geographically, one of which is caused by the large amount of fresh river water entering the sea. The high salinity value on Saugi Island is caused by evaporation and temperature at certain hours with temperatures reaching 34°C. According to (24,25) High temperatures cause large amounts of evaporation. The distribution of salinity in the sea is influenced by various factors such as air circulation patterns, evaporation, rainfall, and river flow (26,27).

3.3. *pH*

The degree of acidity or pH is the number of hydrogen ions contained in seawater. The degree of acidity has a crucial role in supporting and maintaining the life of marine biota (19). Based on data from sample test results, the pH of the water at each station is measured using a pH meter (27). The pH value of the waters measured at the research stations ranged from 5–8, only station 9 complies with the quality standards of Ministerial Decree No. 51 of 2004. The high and low pH of the waters is influenced by the levels of CO_2 dissolved in the waters (21). The difference in pH values at each station location is thought to be due to the input of organic and inorganic waste from anthropogenic activities around the sampling point location. The pH values at the observation stations were obtained when compared with the quality standards of Minister of Environment Decree No. 51 of 2004 for marine biota, only station 9 has a normal pH that supports the life of marine biota. But at other stations, there is still marine biota. This is in line with (28) that life in water can still survive if the waters have a pH range of 5-9.

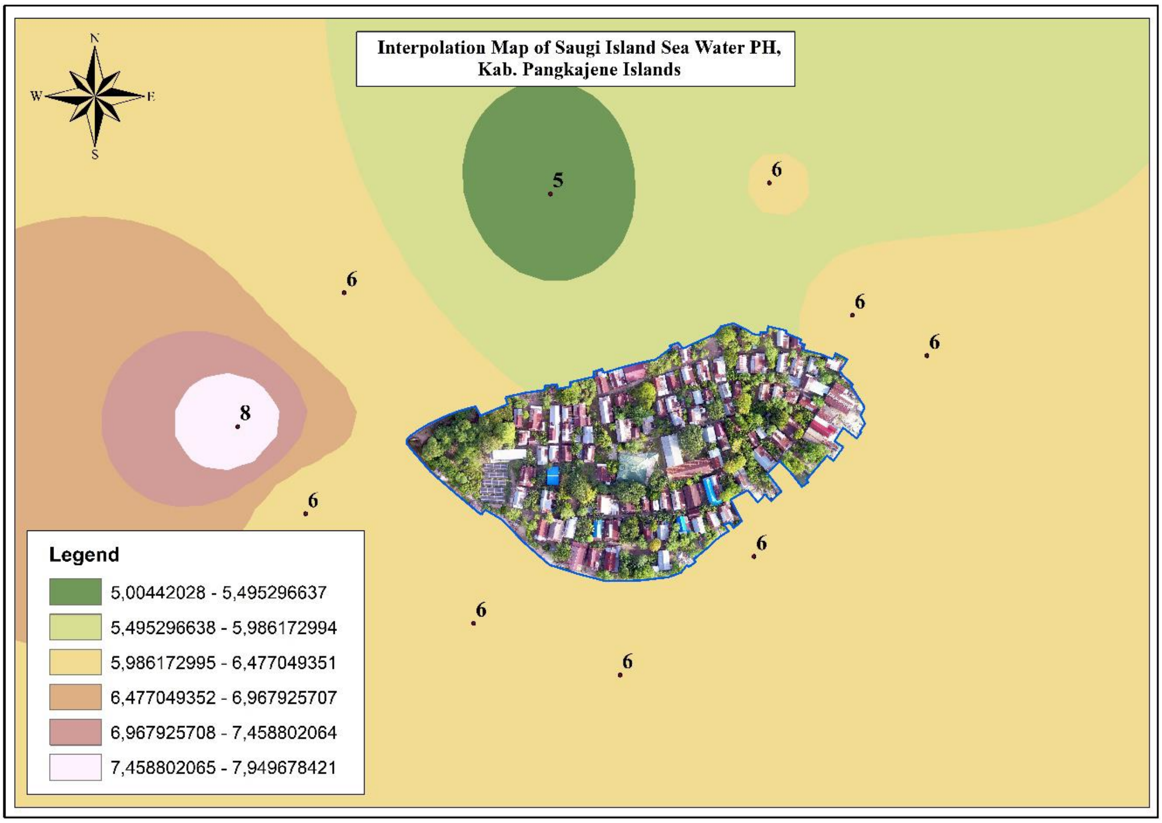

Figure 4. Interpolation Map of Saugi Island Sea pH, Pangkep Regency

The pH values at the observation stations were obtained when compared with the quality standards of Minister of Environment Decree / No. 51 of 2004 for marine biota, there were no stations that reached the standard requirements for seawater quality. The pH range obtained in field measurements is only around 5-9. This range is not by the Ministry of Environment quality standards no. 51 of 2004, only one station complied, namely station 9, but even though the other stations did not comply, there is still a lot of marine biota observed at each station. According to [29], the pH range that is suitable for aquatic organisms is not the same depending on the type of organism. If the pH value is 6-6.5, the diversity of plankton and microbenthos animals will decrease. Apart from that, the high pH value greatly determines the dominance of phytoplankton which influences the level of primary productivity in waters where the presence of phytoplankton is supported by the availability of nutrients in marine waters. The pH value of seawater can change due to natural factors or human activities, which results in an increase in carbon dioxide (CO_2) which can lower the pH [30]. An environment that has a low pH due to detergent waste being thrown into the water, which can cause the pH of seawater to decrease, making it less than ideal for marine biota. From the results of observations in the field, human activity in throwing rubbish and household waste directly into the sea is one of the factors that lowers the pH in the waters of Saugi Island. This is in line with research by [31], that human activities that pollute the sea or marine waters cause the acidity levels in the sea to decrease which can harm marine organisms. The following is a map of the pH values at each measurement station.

3.4. Dissolved Oxygen

Dissolved oxygen or dissolved oxygen is an important factor for the survival of marine biota [32]. The ability of seawater can maintain minimal oxygen concentrations because dissolved oxygen is an indicator of the level of dirtiness of existing waste [33]. Based on research data, all research stations show DO values in the range of 0.16-9.4 mg/l. Differences in dissolved oxygen (DO) values at each observation station are influenced by various environmental factors, such as air temperature, salinity, acidity level (pH), and the presence of waste. Stations with higher air temperatures, such as station 3 (35°C) and station 10 (39°C), tend to have low DO values because the solubility of oxygen in the air decreases with increasing temperature. In addition, high salinity, such as at station 2 (35‰), also inhibits oxygen solubility, resulting in low DO values. Other factors, such as pH below the quality standard (7-8.5) at almost all stations, indicate acidic air conditions, which can interfere with phytoplankton photosynthesis activity, thereby reducing oxygen production in the waters. The presence of waste at all stations also increases the decomposition of organic matter by microorganisms, which ultimately consumes dissolved oxygen significantly.

The Minister of Environment Decree Number 51 of 2004 stipulates that the DO quality standard to support the life of marine biota is >5 mg/L, so the DO values recorded at the research location are only stations 4.5 and 7 which are still suitable or appropriate for the existence of marine organisms**.**

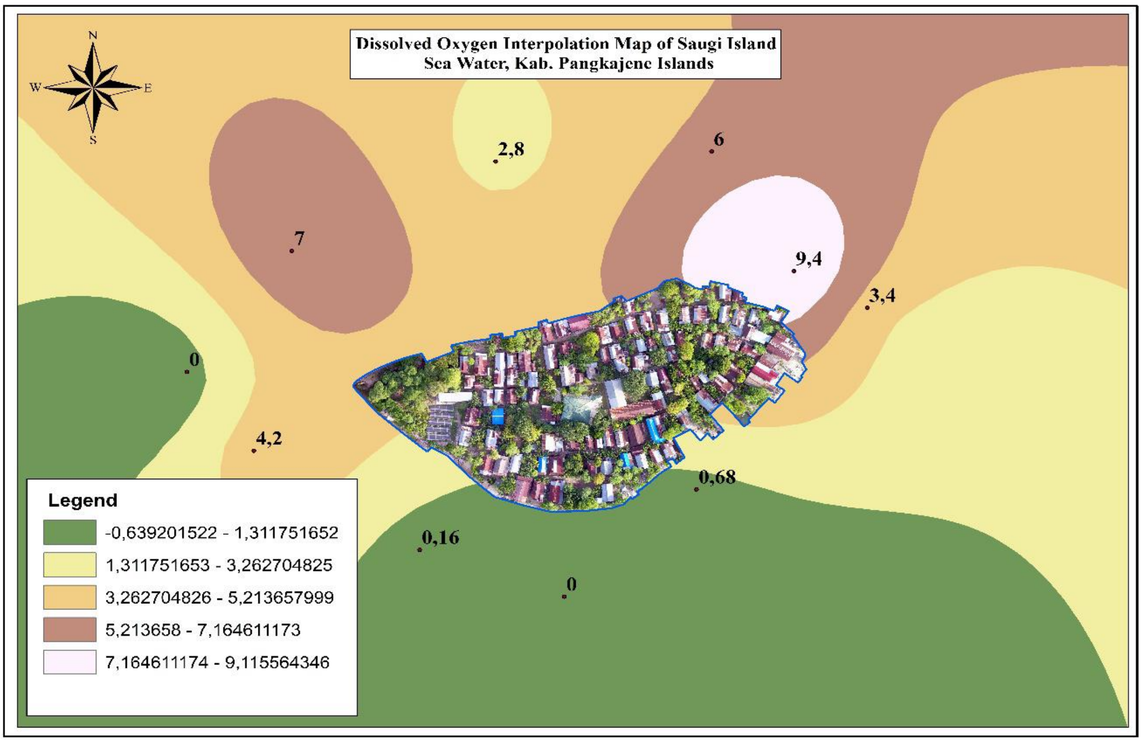

Figure 5. DO Interpolation Map of Saugi Island

Dissolved oxygen (DO) is the amount of oxygen contained in water. Dissolved oxygen is used by aquatic biota for the respiration process, metabolic processes, and for breaking down dissolved substances in water [21,34]. There is a relationship between oxygen nutrition in the marine environment, namely the production of dissolved oxygen in the waters increases but there is a decrease when oxygen is consumed when biological organic matter decomposes [35]. Dissolved oxygen (DO) levels at the research location range from 0.16-9.4 mg/l several stations are below the quality standard threshold, namely <5 mg/l, only stations 4.5 and 7 are in accordance with the quality standards for marine biota life according to Minister of Environment Decree No. 51 of 2004. If we look at the dissolved oxygen levels that are still present at the three observation stations, it can still be said that these waters are relatively unpolluted by organic compounds and are still good for the life of marine biota. This is supported by observations in the field where there is still a lot of biota sea.

According to research conducted by [36], factors that influence dissolved oxygen levels in the sea are temperature, sunlight intensity, and weather. The colder the temperature of seawater, the more dissolved oxygen it contains. This means that high water temperatures contain little dissolved oxygen. Apart from that, if the waste material has a high content in seawater, it will block sunlight from entering the seawater and become a barrier for marine biota to photosynthesize and the dissolved oxygen content will be low [25,37] . According to [25], generally, oxygen levels of 5 mg/l at water temperatures between 20-30 °C are still considered good for fish life. In fact, if the waters are free from toxic compounds or pollution, oxygen levels of 2 mg/l are sufficient to support the life of organisms in the water. From observations at each station, it is known that most of the waters of Saugi Island are polluted from the perspective of measuring dissolved oxygen levels.

3.5. Rubbish

Garbage in the waters has a serious impact on the condition of marine biota and the marine ecosystem as a whole. During the observations made, there was rubbish at every observation station on Saugi Island a lot of rubbish can be seen in Figure 6. The types of waste based on figure 6 consist of inorganic plastic waste and food waste or organic waste sourced from the surrounding community. The amount of rubbish at various stations varies because based on the picture there is rubbish piled up on the beach, and there is rubbish in the sea. The presence of rubbish can be seen at almost all points in quite significant quantities. The impacts involve multiple aspects, from the health of individual organisms to the integrity of the marine ecosystem as a whole (31).

Garbage that enters waters can settle on the seabed or on the sea surface. This can affect organisms that live on or near the seabed. Waste in waters can sediment, become a threat to living organisms, contain chemical contaminants, cause disease and infection, and change the physical properties of water (19,38). Marine organisms can become entangled in or eat plastic waste and other discarded materials. In particular, marine creatures such as fish, seabirds, and marine mammals can suffer physical injury or death due to debris. Garbage in waters can contain dangerous chemicals, such as pesticides, heavy metals, and other chemicals.

Figure 6. Profile of Rubbish in Seawater areas of Saugi Island

Garbage is one of the serious problems currently faced both on land and in the waters, especially on Saugi Island. Currently, rubbish that pollutes waters threatens the health of marine biota, disrupts their reproductive systems, and has the potential to disrupt the marine animal food chain (Kalembiro et al., 2024). The presence of rubbish at every observation station on Saugi Island means that it does not comply with the quality standards of Minister of Environment Decree No. 51 of 2004. According to Qaiyimah et al., (2024) to reduce this negative impact, better waste management is needed, as well as increasing public awareness of the importance of keeping the marine environment clean.

3.6. Impact of Temperature, Salinity, pH, Dissolved Oxygen, and Garbage on marine biota

Marine organisms need optimal temperatures so that their body functions and metabolism run optimally. In this research, the parameters of temperature, salinity, pH, dissolved oxygen and waste are seawater quality parameters that influence the diversity of marine biota at each station. Based on research results, stations that meet temperature parameters, namely stations 1,2,4,5,6,7,8,9, the majority of marine biota that live at stations that meet temperature quality standards based on Minister of Environment Decree Number 51 of 2004, results from field observations namely crabs and sea snails. This is reinforced by the results of research from [22], namely that a temperature value of 28-32℃ is the optimal temperature to support the life of marine biota.

Figure 7. Crabs and Sea Snails

The salinity parameters are met by stations 1, 3, 5, and 10. The majority of marine biota living at stations meet temperature quality standards based on Minister of Environment Decree Number 51 of 2004 as a result of field observations, namely sea cucumbers, starfish, and fish [39]. Meanwhile, at stations that do not meet the quality standards, the value of not having fish is because the salinity of the seawater can affect the fish's hearing and can result in difficulty for the fish in obtaining food and affect the growth and development of the fish [12]. The degree of acidity of seawater can also be influenced by the evaporation of seawater. This is in line with the temperature obtained, namely 39 °C, which results in a lot of evaporation so several stations do not meet the salinity quality standards and based on observations at these stations no fish can be found.

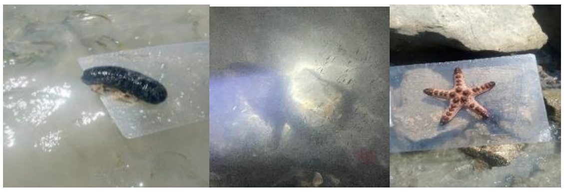

Figure 8. Sea cucumbers, fish, and starfish

The pH parameter is only met at station 9, this affects the existence of coral reefs. Based on field observations, only station 9 has coral reefs while the others do not. This is because the pH suitability of station 9 which is suitable for the life of coral reefs, seaweed, and seagrass beds is around 7-8.5 based on the Decree of the Minister of the Environment Number 51 of 2004. Coral reefs require an optimal pH to grow and develop well. Therefore station 9 is a suitable living place for coral reefs.

Figure 9. Coral reefs

Dissolved oxygen or DO parameters are met by stations 4, 5, and 7, namely the marine biota that live at these stations, namely seaweed and seagrass beds, which dominate based on field observations. This is because seaweed and seagrass beds can live at oxygen levels above 5 based on Minister of the Environment Decree Number 51 of 2004. Dissolved oxygen has an important role in the growth of marine biota because it is needed in the respiration process, exchange of a substance that can obtain energy to develop [40]. Dissolved oxygen comes from the results of the diffusion process between the photosynthesis results of living organisms, such as seagrass beds and seaweed and free air [41,42]. This dissolved oxygen content is very important for the life of marine biota, not only seaweed and seagrass beds but also fish to be able to breathe and carry out metabolism.

Figure 10. Seaweed and Seagrass

Research related to seawater quality on Saugi Island is very important to carry out, so that we can find out whether the condition of seawater quality meets the requirements for seawater quality standards based on Minister of Environment Decree Number 51 of 2004 regarding seawater quality for marine biota or does not meet it. Through this research, it was found that there are waste parameters that cause discrepancies in several other physical and chemical parameters. Through this research, it was discovered that there were waste parameters in the form of plastic and food waste which caused discrepancies in several other physical and chemical parameters. This plastic waste has a bad influence if it is consumed by marine biota because it will contain microplastics which are dangerous if marine biota is consumed by humans, while organic waste that rots in the sea can cause changes in the composition of seawater and changes in its quality which is not good for marine biota to live and develop [1].

Allowing waste to accumulate unchecked will result in a significant decline in seawater quality and a loss of marine biodiversity, ultimately impacting residents' fishing yields. To mitigate this, it is essential to implement proper management of waste storage facilities

4. Conclusion

Based on the test results at ten observation stations on Saugi Island, it can be seen that: (1) Seawater quality parameters meet quality standards for marine biota by Minister of Environment Decree No. 51 of 2004 including temperature at three stations and salinity at four stations. Most of the other parameters, such as pH, dissolved oxygen (DO), and waste condition, do not meet quality standard requirements; (2) From the test results, in general, the quality of seawater in the waters of Saugi Island does not meet the standards required to support the life of marine biota; and (3) Because seawater pollution hurts marine ecosystems and the biota that live in them, it is hoped that the results of this research can become a reference for the government and society in developing effective policies regarding marine environmental management.

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Author Contributions

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