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Analysis of Quality Status and Prediction of the Distribution of Temperature, DO, pH, Salinity, and Brightness of Sea Water in the Saugi Island Area Based on Spatial Inverse Distance Weighting

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Abstract

Marine waters are crucial for maintaining marine ecosystems and achieving sustainable environmental sustainability. This research aims to analyze the quality status and predict the distribution of temperature, brightness, salinity, pH, and dissolved oxygen (DO) concentrations as indicators for assessing marine water quality. The study employs descriptive statistics to process laboratory test results and field measurements of the tested parameters. Marine water quality status is determined by calculating the percentage of limiting parameters and establishing maximum and minimum values for each parameter as benchmarks. The prediction of concentration distribution for temperature, brightness, salinity, pH, and DO is carried out using Spatial Inverse Distance Weighting (IDW) analysis, which illustrates the concentration distribution of each parameter based on data input in ArcGIS Pro software. The findings reveal varying quality statuses at different sampling points, with good conditions at points 4 and 5, where limiting parameter percentages are 22%. Medium quality status is observed at points 2 and 7 (33%) and points 3 and 6 (44%). Poor conditions are noted at points 1 and 8, with a 55% limiting parameter percentage. The study recommends this research as a valuable reference for the community and government to support marine ecosystem preservation and Sustainable marine ecosystem.

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Introduction

Marine waters are integral to establishing and maintaining the delicate balance within the marine environmental ecosystem (Aliviyanti et al., 2022; Najmi et al., 2020). The quality of these waters determines not only the overall health and vitality of the ecosystem—

whether it remains robust and flourishing or becomes compromised and degraded—but also profoundly impacts human activity patterns (Bitta & Chamid, 2021; Sappa et al., 2015). The sea serves as a vital resource that fulfills a wide array of human needs, from recreational and educational pursuits to the critical economic sustenance that many communities rely on for their livelihoods (Harudu et al., 2024; Umasugi et al., 2021; Wibowo & Rachman, 2020). Therefore, it is of paramount importance to prioritize the preservation and careful stewardship of marine waters, ensuring that the environmental ecosystem remains healthy, resilient, and capable of supporting both the diverse forms of life that inhabit it and the human populations that depend on it for their continued well-being and prosperity (Nasrul et al., 2024; Qaiyimah et al., 2024; Saraswati et al., 2017; Siburian et al., 2017; Wetz et al., 2004).

Research findings that have delved into the quality of marine waters in Indonesia reveal a concerning situation, as pollution levels in these waters are still considered alarmingly high (Badrukamal & Dirgawati, 2024; Leparc et al., 2007). This severe pollution is primarily fueled by several factors, including extensive mining activities in ocean areas, the reckless dumping of waste into the sea—both directly and from river estuaries—and the illegal fishing practices that continue to plague Indonesian waters. These activities collectively contribute to the deterioration of water conditions(Dwiyanti Suryono, 2019; Hatzikos et al., 2008; Patty et al., 2021).

As a direct consequence of these harmful practices, the quantity of marine waste is not only increasing but is doing so at an uncontrollable rate, leading to further disturbances in the marine ecosystem. The worsening water conditions have escalated to such a degree that the natural ability of seawater to neutralize pollutants is now at risk of being overwhelmed by the sheer volume of pollutants being introduced. The excessive pollutant load is compromising the ocean's capacity to maintain its natural properties, which are essential for sustaining water quality and the broader health of the marine environment (Muh et al., 2023; Rusdi et al., 2023; Sakinah et al., 2022). Given these alarming developments, it is of paramount importance to pay close attention to the condition of marine waters. This vigilance is crucial not only for the preservation of the marine ecosystem itself but also for ensuring that the environmental balance remains intact, thereby supporting the diverse forms of life that depend on it. By prioritizing the monitoring and improvement of marine water quality, efforts can be made to mitigate further damage and work towards restoring the health and resilience of the marine environment (Harefa et al., 2023; Kaharto et al., 2023; Maharani et al., 2022).

Saugi Island, which is part of a larger archipelago and falls within the jurisdiction of Mattiro Baji Village, located in the Liukang Tupabbiring Utara District of Pangkep Regency, is home to a community whose way of life is intimately connected with the natural resources provided by the surrounding sea. The residents of Saugi Island largely depend on the ocean for their livelihood, with fishing serving as the primary source of income and sustenance for most families. This deep reliance on marine resources shapes the daily activity patterns of the islanders, who engage in various sea-related tasks to support their households. However, despite their close relationship with the environment, the involvement of the Saugi Island community in environmental management and conservation efforts remains relatively limited. One of the most pressing issues on the island is the ongoing practice of waste disposal, which continues unabated in the absence of proper waste management facilities. There is currently no infrastructure in place for the effective collection, sorting, or disposal of waste, which means that residents have few alternatives but to discard their garbage inappropriately (Qaiyimah et al., 2024).

This situation is further exacerbated by a lack of education and awareness among the local population regarding the environmental consequences of improper waste disposal. Many residents are not fully informed about the negative impacts that throwing rubbish into the environment can have, both on the land and in the surrounding waters. This lack of understanding has contributed to the accumulation of large piles of rubbish across the island, which not only mars the natural beauty of Saugi Island but also threatens the health of its marine environment. The unchecked buildup of waste has significant implications for the condition of the island's waters, as pollutants from the garbage can leach into the sea, disrupting marine life and degrading water quality.

Figure 1. The Condition of Garbage in the Saugi Island Area which Impacts the Quality of Marine Water

In light of these challenges, it is clear that the current state of environmental management on Saugi Island requires urgent attention. Without improved waste management practices and increased awareness among the community about the importance of protecting their natural surroundings, the environmental conditions on Saugi Island will likely continue to deteriorate, with serious consequences for both the local ecosystem and the residents who depend on it for their livelihood.

Based on the above, it is important to carry out tests to see the condition of the sea waters in the Saugi Island area, Liukang Tupabbiring Utara District, Pangkep Regency. This research will reveal the quality conditions of sea waters based on the parameters of dissolved oxygen, pH, brightness, and salinity of seawater. This research will have implications for efforts to maintain environmental conditions, in this case, the marine ecosystem as part of the source of livelihood for the people of Saugi Island, Liukang Tupabbiring Utara District, Pangkep Regency.

Materials and Methods

Research Location

This research was conducted in the Saugi Island area, Liukang Tupabbiring Utara District, Pangkep Regency. Data collection was carried out at eight sampling points using purposive sampling. Purposive sampling is a sampling method carried out by considering the conditions and characteristics of the research area (Lenaini, 2021; Ningsih et al., 2020; Obilor & Isaac, 2023). A map of the research location and sampling points can be seen as follows.

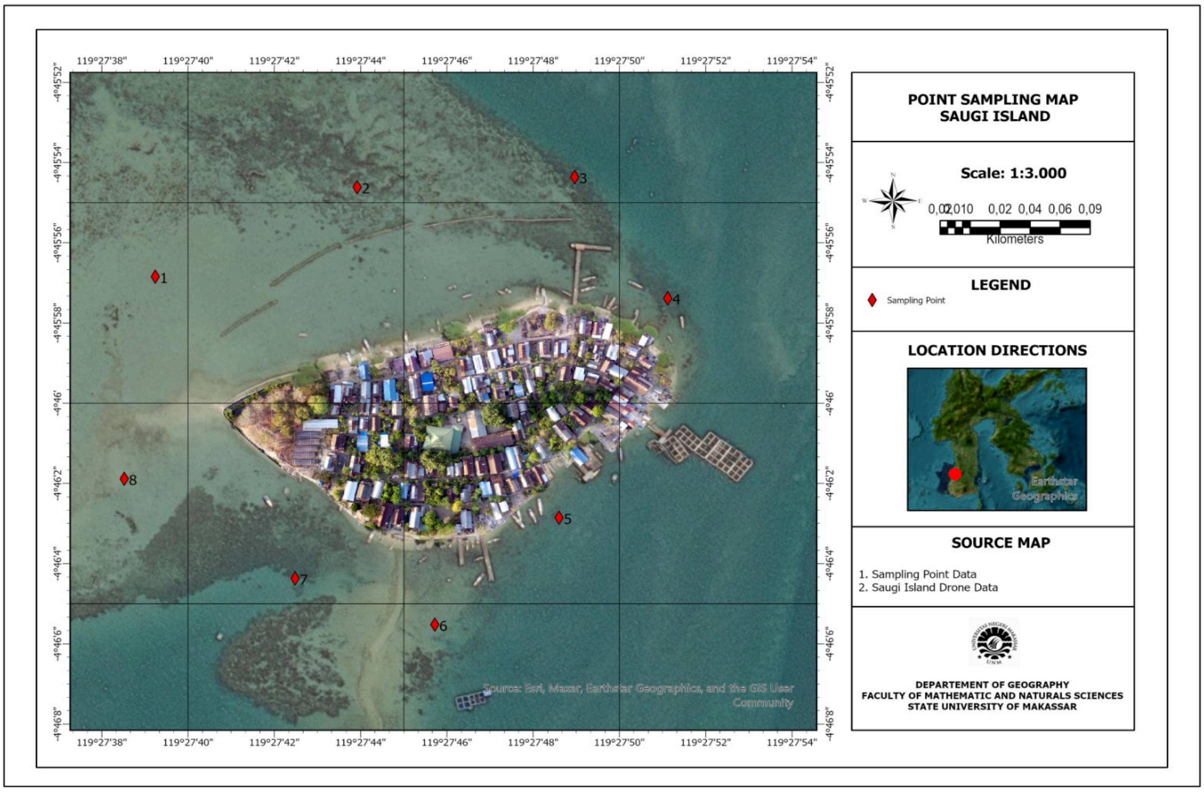

Figure 2. Map of research locations and sampling points

Data Collection

Data collection techniques in this research were carried out by conducting field surveys, laboratory testing/analysis, documentation, and spatial analysis. Data collection was carried out on the four test parameters that we wanted to know. This is done to obtain accurate data which will then be analyzed to obtain the research results you want to know. The data sources in this research are as follows.

a. Primary data consists of measurements taken directly in the field to obtain values for pH, Brightness, Salinity, and Dissolved Oxygen. Samples of dissolved oxygen were collected and subsequently tested in the laboratory using the titration method. Field measurements for pH, Brightness, and Salinity were conducted both in the morning and evening to capture data variability and predict the distribution of these parameters at different times of the day. For the dissolved oxygen parameter, a single sample was collected during the day to assess the oxygen levels in the Saugi Island area across eight sampling points.

b. Secondary data in this research was used to carry out spatial analysis in making maps of sampling points and interpolation maps for each test parameter to determine the distribution of dissolved oxygen levels, pH, brightness, and salinity. The secondary data includes (1) BING MAP Satellite Image Data, (2) Drone Data for the Saugi Island Area, and (3) data from the Geospatial Information Agency.

Data Analysis

Data analysis was carried out to determine the quality status of marine waters based on the parameters of dissolved oxygen, brightness, pH, and salinity using the prediction of the distribution of dissolved oxygen, brightness, pH, and salinity through spatial analysis using geographic information system software.

Determination of the Quality Status of Marine Waters

Determination of quality status is carried out by comparing the sample test results for each parameter tested with the water quality standard requirements. The comparative data used as a reference is seawater quality standard data for marine biota based on the Decree of the State Minister for the Environment No. 51 of 2004 concerning standard requirements for marine water quality for the use of marine biota. The standard requirements for marine water quality for marine biota use can be seen as follows.

Table 1. Marine Water Quality Standard Requirements for Marine Biota

No	Parameters	Quality Standard Requirements
1	Temperature	28-30ºC
2	Brightness	>3-5 m
3	Salinity	33-34 ppt
4	pH	7-8,5
5	Dissolved Oxygen	>5 mg/l

Source: *Minister of Environment Decree No. 51 of 2004 concerning standard requirements for marine water quality*

The data in Table 1 is used as a reference for comparing quality standard requirements with test results for each parameter tested. Next, it is determined at each sampling point which parameters meet and which do not meet the quality standard requirements. After obtaining the comparison results, analysis is carried out using limiting parameters to determine the quality status of marine waters.

*Li*The data in Table 1 is used as a reference for comparing quality standard requirements with test results for each parameter tested. Next, it is determined at each sampling point which parameters meet and which do not meet the quality standard requirements. After obtaining the comparison results, analysis is carried out using limiting parameters to determine the quality status of marine waters.

$$miting\ Parameters = \frac{\begin{matrix}Number\ of\ test\ parameters\ that\ do\ not\\ comply\ with\ standards\end{matrix}}{Number\ of\ Test\ Parameters} x100\% \dots\dots (1)$$

Based on the parameters mentioned above, the quality status of marine waters can be assessed. Quality status is determined based on the maximum and minimum values derived from the processed data. The maximum value indicates good water conditions, while the minimum value reflects poor water conditions. Therefore, the classification of quality status is determined according to the calculation results of the limiting parameters, as identified through the research conducted by (Qaiyimah et al., 2016, 2024)

Prediction of the Distribution of Temperature, DO, pH, Salinity and Brightness

The Inverse Distance Weighting (IDW) method assumes that each data point influences the surrounding area with a weight that decreases with distance. Usually, in the IDW method, this weight is calculated using the inverse value of the distance between the data point and other points using a predetermined mathematical equation. The power value in IDW interpolation determines how much influence closer points have, resulting in a more detailed surface representation. As the power value is increased, the effect will be more localized at closer points, resulting in a less detailed and smoother surface. Conversely, decreasing the power value will cause the effect to spread over a larger area, producing a surface with greater detail. By reducing the power value, the resulting surface will become smoother.

Next, seawater quality data for each laboratory test parameter is entered into a mapping database which will be used as input data for carrying out spatial analysis. The results of this analysis will display spatially the distribution of water quality intensity by referring to data from laboratory tests at the sampling point and data from field measurements.

Results and Discussion

Laboratory Test Results for Sea Water Samples in the Saugi Island area

Based on the results of in situ field measurements and the results of laboratory tests on five measurement parameters, namely temperature, brightness, salinity, dissolved oxygen and pH, the following results were obtained.

Table 2. Results of measurements of seawater quality in the Saugi Island area

Parameter	Time Sampling	Sampling Point							
		1	2	3	4	5	6	7	8
Temperature (^{O}C)	09.00 em	31.7*	32.5*	31.6*	32.7*	32.6*	33.0*	32.3*	31.8*
	4.00 pm	32.5*	33.3*	32.7*	31.7*	32.0*	3.,5*	32.3*	31.8*
Brightness (m (%)	09.00 em	46.0	44.8	51.4	17.0	19.0	17.0	19.0	28.0
	4.00 pm	19.8	28.2	21.0	18.6	17.5	20.8	23.3	23.9
Salinity (ppt)	09.00 em	35*	33	35*	34	34	35*	35*	35*
	4.00 pm	32*	34	29*	33	33	34	34	35*
Dissolved Oxygen (mg/l)	11.00 em	6.26	7.20	8.10	6.06	10.00	2.33*	9.73	6.83
pH	09.00 em	7	7	7	7	7	7	7	7
	4.00 pm	6.25*	5.75*	6.5*	7	7	7	7	6.75*

Source: *2023 Field Measurement and Laboratory Test Results*
(*)Does not meet Quality Standard standard requirements

Saugi Island Marine Water Quality Status

The determination of water quality status is based on a comparison of test results with the required water quality standards, namely the needs of marine biota. The results of this comparison will show that the measurement data for each parameter meets the quality standard requirements or does not meet the standard requirements. The results of this comparison can be seen as follows.

Figure 3. Test results for (a) temperature; (b) brightness; (c) Dissolved Oxygen; (d) Salinity; and (e) pH of the waters of the Saugi Island

The comparison between the test data for each parameter and the water quality standards reveals that several sampling points do not meet the marine water quality standards required for supporting marine biota. Figure 3 shows that for temperature, the test results from both morning and evening indicate values that fall outside the acceptable range, specifically between 28-30°C. In contrast, the seawater brightness tests demonstrate that all samples meet the required standards, with a minimum brightness value of 10% observed both in the morning and afternoon. Salinity measurements, however, show variability, with several samples failing to meet the standard range of 33-34 ppt. Specifically, in the morning, points 1, 3, 6, 7, and 8 did not meet the standards, while in the afternoon, points 1, 3, and 5 fell short. For dissolved oxygen (DO), only one sampling point, Point 6, did not meet the standard, as it had a DO value below the minimum requirement of 5 mg/L. Regarding pH, all morning samples met the standards, but in the afternoon, points 1, 2, 3, and 8 did not meet the quality standard requirements.

The data above is used to classify test results into those meeting or not meeting standards at each sampling point. This classification helps determine the percentage of limiting parameters, crucial for assessing marine water quality. The categorized results are shown in Table 3.

Table 3. Data Grouping of Saugi Island Sea Water Quality Test Results

No	Description	Sampling Point							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Meet Quality Standard Requirements	4	6	4	7	7	5	6	4
2	Does not meet quality standard requirements	5	3	5	2	2	4	3	5
Total		9	9	9	9	9	9	9	9

Source: *2024, data analysis*

Table 3 presents the grouping of data that either meets or fails to meet the quality standard requirements at each sampling point. The data reveals that at Point 1, five samples did not meet the specified quality standards. Similarly, Point 2 has three non-compliant samples, Point 3 has five, Points 4 and 5 each have two, Point 6 has four, Point 7 has three, and Point 8 has five samples that do not meet the quality standards. This data from Table 3 serves as a basis for calculating the threshold percentage used to determine the quality status of marine waters for marine biota. The maximum value derived from these calculations indicates poor water quality, while the minimum value reflects good water quality. The results of these threshold percentage calculations for determining the quality status of marine waters are shown in Table 4 below.

Table 4. Threshold Percentage in Determining Quality Status of Marine Water Quality

No	Threshold Percentage	Quality Status
1	>55%	Bad
2	23-54%	Average
3	<22%	Good

Source: *2024 Data Processed Results*

Additionally, the threshold percentage data is utilized as a reference for determining the quality status at each tested sampling point. The results of the calculations and the assessment of the marine water quality in the Saugi Island area are presented in Table 5 below.

Table 5. Status of Marine Water Quality in the Saugi Island Area

Sampling Point	1	2	3	4	5	6	7	8
Threshold Percentage	55%	33%	44%	22%	22%	44%	33%	55%
Quality Status	Bad	Average	Average	Good	Good	Average	Average	Bad

Source: 2024 Data Processed Results

Prediction of the Distribution of Temperature, DO, pH, Salinity, and Brightness of Sea Water in the Saugi Island Area

The distribution of concentration across each sampling point can be effectively predicted through the use of a geographic information system (GIS), which allows for the creation of a detailed spatial map that accurately represents the area under investigation, focusing on its specific conditions and characteristics. This methodology constitutes a form of spatial analysis that provides a visual representation of real-world field conditions by utilizing and processing collected data.

To achieve a comprehensive mapping of the anticipated concentration distribution at each sampling location, the Inverse Distance Weighting (IDW) interpolation method was applied. This technique takes into account the spatial distribution of data within each region, as processed through the ArcGIS application. By employing IDW interpolation, we can estimate the concentration levels at unsampled points based on the values observed at nearby sampling locations, with the assumption that closer points have more influence on the interpolation results than those further away. The outcome of this predictive analysis is presented through a series of spatial maps and results, which illustrate the anticipated concentration distribution throughout the study area. These results provide valuable insights into the spatial variations and trends within the area, allowing for a better understanding of the distribution patterns based on the processed data and the applied.

A. Temperature

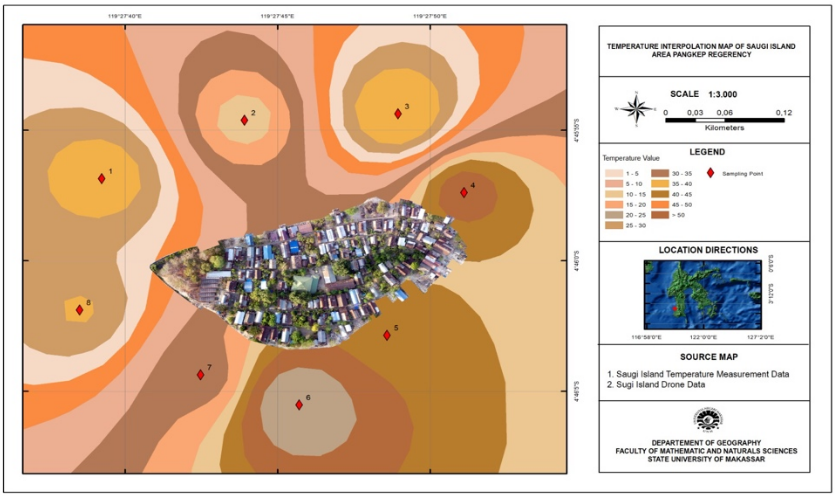

Figure 4. Morning temperature interpolation map for the Saugi Island area

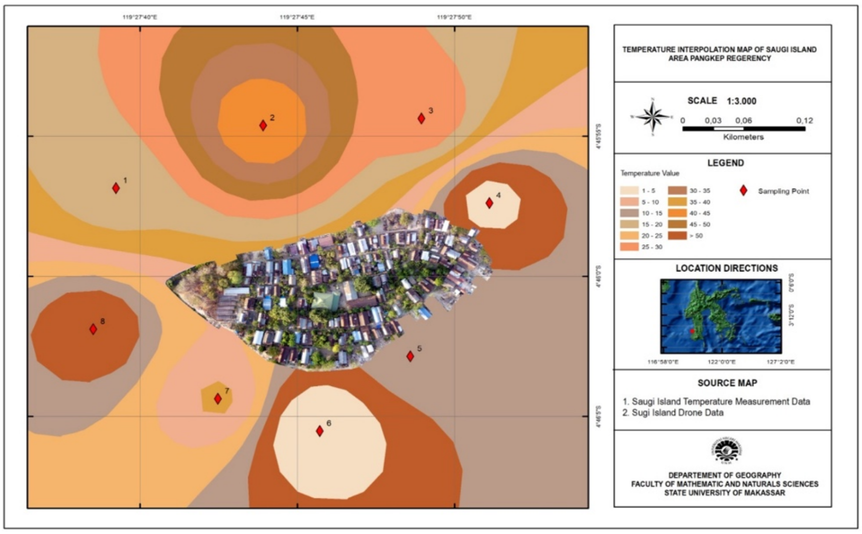

Figure 5. Afternoon temperature interpolation map for the Saugi Island area

B. Brightness

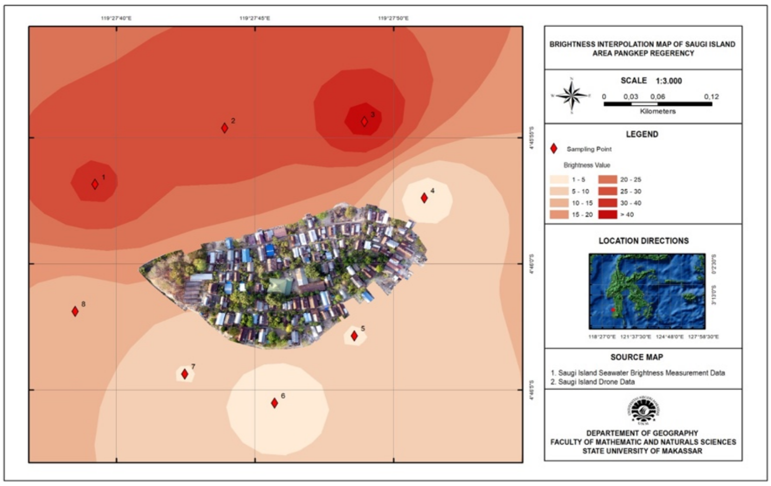

Figure 6. Interpolation map of morning brightness in the Saugi Island are

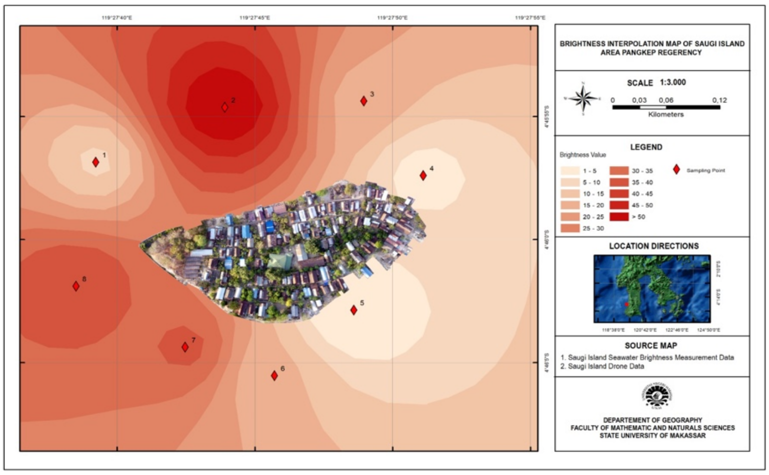

Figure 7. Interpolation map of afternoon brightness in the Saugi Island area

C. Salinity

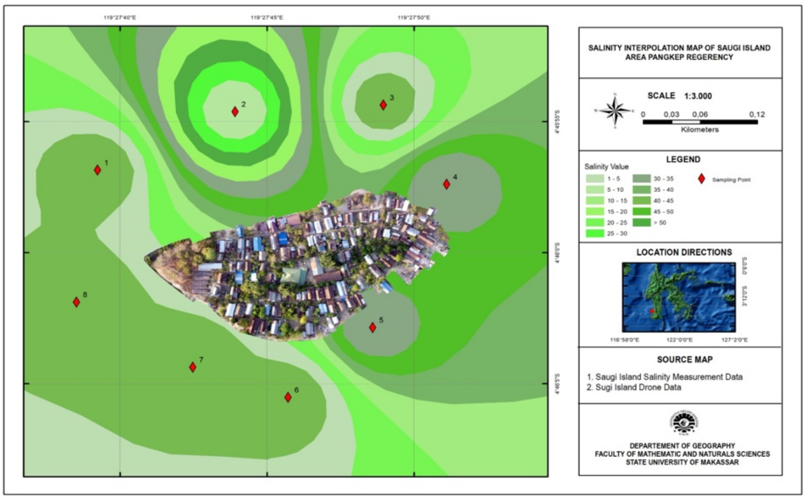

Figure 8. Interpolation map of morning salinity in the Saugi Island area

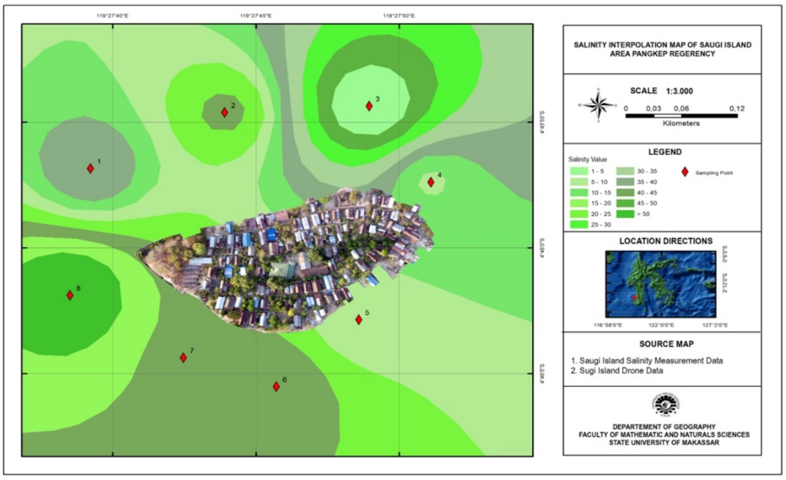

Figure 9. Interpolation map of afternoon salinity in the Saugi Island area

D. pH

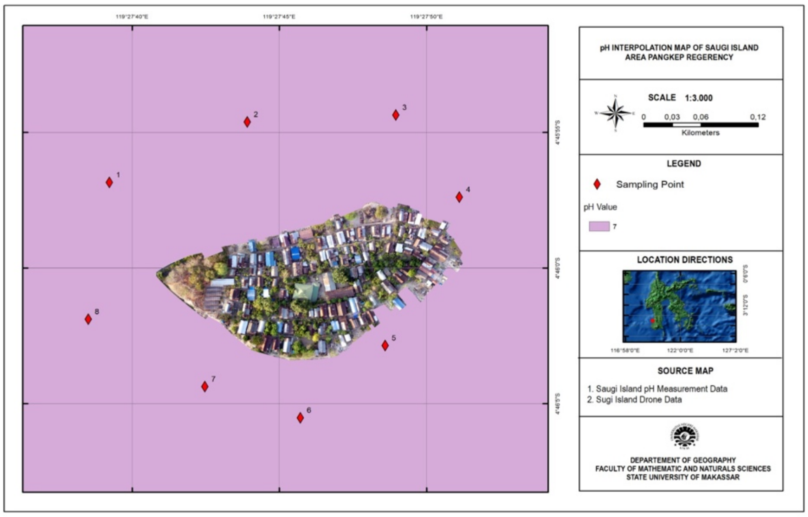

Figure 10. Morning pH interpolation map for the Saugi Island area

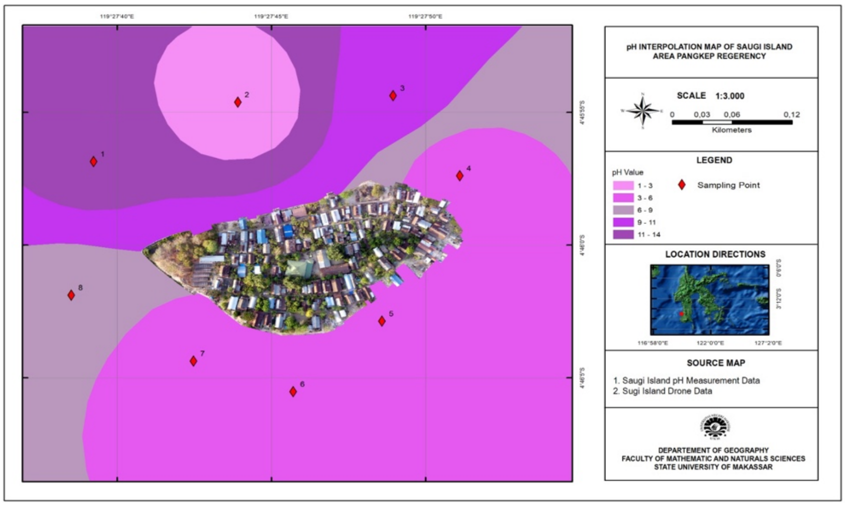

Figure 11. Afternoon pH interpolation map for the Saugi Island area

E. Dissolved Oxygen

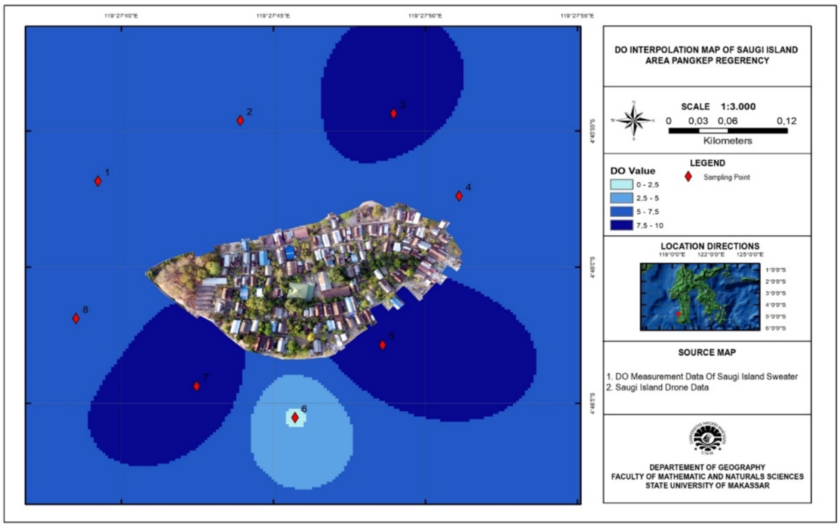

Figure 12. Dissolved Oxygen Interpolation Map of the Saugi Island Area

The spatial analysis using the Inverse Distance Weighting (IDW) interpolation method reveals significant variations in the distribution of temperature, brightness, salinity, pH, and dissolved oxygen (DO) across different sampling points. Morning temperature measurements show Point 6 with the highest concentration and Point 3 with the lowest, while in the afternoon, Point 2 registers the highest temperature and Point 6 the lowest. For brightness, Point 3 has the highest concentration in the morning, with Points 4 and 6 the lowest, but by afternoon, Point 2 has the highest and Point 5 the lowest. Salinity patterns indicate that the highest concentrations in the morning occur at Points 1, 3, 6, 7, and 8, with Point 2 the lowest; this pattern remains similar in the afternoon, where Point 8 shows the highest salinity and Point 3 the lowest. Morning pH levels are consistent across all points, but in the afternoon, the highest concentrations are at Points 4, 5, 6, and 7, with Point 2 having the lowest. Finally, dissolved oxygen (DO) shows the highest concentration at Point 5 and the lowest at Point 4. These variations underscore the dynamic nature of the marine environment around Saugi Island and emphasize the need for continuous monitoring to effectively understand and manage these changes.

Based on the information above, it is evident that sustainable marine resource management requires maintaining the health and preservation of marine ecosystems (Najmi et al., 2020; Qaiyimah et al., 2024). This begins with effective environmental management practices, such as avoiding the exploitation of marine environments that could lead to pollution. In practice, data reflecting the condition of the marine waters around Saugi Island must be taken into account to establish activities that support the preservation of the marine ecosystem (Maharani et al., 2022; Muh et al., 2023). Research conducted by (Hamuna & Tanjung, 2018) indicates that seawater quality is influenced by human activities, such as waste disposal, which increases the concentration of pollutants in the water. Therefore, raising awareness about the importance of protecting and preserving marine ecosystems is crucial for ensuring the sustainability of these environments.

The results of this research are recommended to be used as a source of information and reference material for the community in increasing awareness regarding the importance of protecting marine ecosystems and as information that can be used as a reference in determining and making policies regarding the management of the aquatic environment in the Saugi Island area, Mattiro Village. Baji, North Liukang Tupabbiring District, Pangkep Regency.

Conclusion

Based on the results of the analysis that has been carried out to determine the quality status and predictions of the distribution of temperature, brightness, salinity, pH, and DO concentrations, it can be concluded as follows.

1. The quality status of marine waters in the Saugi Island area can be divided into three classifications based on calculating the percentage of limiting parameters at each sampling point, namely in good, medium, and poor conditions. The sampling points that are in the good category are Points 4 and 5 with a presentation of 22%. Points in the medium category are indicated by points 3 and 7 with a presentation of 33% and points 4 and 6 with a presentation of 44%. Next, those in the bad category are sampling points 1 and 8 with a percentage of 55%.
2. Predictions of the distribution of temperature, brightness, salinity, pH, and DO concentrations show significant variations in distribution and can describe the state of water quality at each sampling point both in the morning and evening. So this can be a reference that provides a clear picture of sampling points that have good, moderate, or poor water quality conditions.

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