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The effect of oceanography parameters on redox potential value in coastal waters of banyuwangi regency

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Abstract
Redox potential is an oxidation-reduction process to determine the extent to which these waters have accumulated nutrients and to assess the presence of oxygen in the coastal waters of Banyuwangi. The method used in this study is a descriptive method and data collection by collecting primary data (temperature, pH, DO, Ammonia, nitrate, phosphate, TOM, plankton, alkalinity and redox potential) and secondary data. The study results show that the results of measuring oceanographic parameters on the coast of Banyuwangi Regency obtained temperature values ranging from 28 – 30˚C, pH is at 7.6 – 8.1, *Dissoved Oxygen* is at 6.097 – 9.83 mg/l, ammonia is at 0.04 – 0.069 mg/L, nitrate is at 5 – 25 ppm, Phosphate is at 0.022 – 0.078, TOM is at 6.32 – 68.256, Plankton is at 169556 – 1350000, alkalinity is at 12 – 196 mg/L, and Redox potential is at 85 – 123 mV. From the analysis of this study pH, phosphate and alkalinity have a positive correlation to redox potential. Temperature, DO, ammonia, nitrate, TOM and plankton abundance values are negatively correlated with redox potential.

Keywords: Redox potential, oceanographic parameters, banyuwangi

Introduction

Indonesia as an archipelagic country with an area of sea waters of more than 75% reaching 5.8 million square kilometers, there are more than 17,500 islands with a coastline about 81,000 km (Riska *et al*., 2020) [16]. According to Law of The Government of the Republic of Indonesia Number 1 of 2014 Coastal areas are transitional areas between terrestrial and marine ecosystems that are affected by changes in land and sea. One of the coastal waters that has very high potential is Banyuwangi coastal located in the east coast of Java Island.

The potential of Banyuwangi Regency coastal is very high, that is aquaculture (Setyaningrum *et al*., 2019) [19], capture fisheries (Diartho, 2020), Fishery Products Processing Industry (Setyaningrum *et a*l., 2020), Marine Tourism (Sugiantoro *et al*., 2017), Sea Transportation (Permadi & Dewantara, 2018) and mangrove ecosystem (Yuniartik, 2021) [25]. According to Muharuddin (2019) [10], Coastal areas are very sensitive to environmental degradation, mainly influenced by processes or activities on land. Given the complex and difficult to interpret changes in water quality.

This water quality measurement is very important to do. Water quality monitoring has three main objectives, namely Environmental Surveillance, which aims to detect and measure the influence caused by a pollutant on environmental quality and find out the improvement of environmental quality after the pollutant is removed, Establishing Water-Quality Criteria, which aims to determine the causal relationship between changes in aquatic ecological variables with physical and chemical parameters, to obtain water quality standards, and Appraisal of Resources, which is the purpose of knowing the picture of water quality in a place in general (Effendi, 2003),

The description of quality consisting aspects of physics, chemistry and biology is related to one another. The influence between one parameter and another is very important to be studied. In addition, redox potential can affect chemical processes that occur in waters. Redox potential (reduction and oxidation) or *Oxidation-Reduction Potential* (ORP) describes the activity of electron (e) in water is the potential of a solution to transfer electrons from an oxidant to a reductant. A material is said to undergo oxidation if it loses electrons and is said to undergo reduction if it accepts electrons.

From this research will be obtained a model of the influence of oceanographic parameters on redox potential and can be used as a reference in water quality management so that the potential of Banyuwangi Regency coastal can be utilized optimally.

Material and methods

The method used in this study is a descriptive method that analyzes data by describing the data that has been collected. Data collection is carried out by collecting primary data (temperature, pH, DO, Ammonia, nitrate, phosphate, TOM, plankton, alkalinity and redox potential) and secondary data. Primary data is data collected by researchers themselves through direct observation from the first source or place where the object of research is carried out, while secondary data is a source of data that does not directly provide data to data collectors, for example through other people or through documents such as references from books, reports, journals, and E-books.

Location and time of research

This research was conducted in June – July 2023. The location of the study was conducted in Banyuwangi Regency coastal, East Java. In this study there are 7 subdistricts, namely Wongsorejo, Kalipuro, Banyuwangi, Kabat, Blimbingsari, Muncar, and Pesanggaran located along the coast of Banyuwangi Regency. In each sub-district, 3 sampling points were taken.

Analysis methods

The analysis used in this study is Multiple Linear Regression Analysis, which is an analysis to measure the magnitude of influence between two or more independent variables on one dependent variable and predict the dependent variable using the independent variable (Thoriq Maulana *et al*., 2015) [23]. The hypothesis tests used in this study are the F test, R-Square, and T test. This model is used to determine the influence of the independent variable on the dependent variable with the following equation:

$$Y = a + b_1X_1 + b_2X_2 + ... + b_nX_n \quad (1)$$

Remaks

Y = Dependent variable (nilai potensial redoks)
a = Constant Value
$b_{1,2,...,n}$ = Regression Coefficient
$X_{1,\ 2,\ n}$ = Independent variable (Temperature, pH, DO, Ammonia, nitrate, phosphate, TOM, plankton, alkalinity and redox potential)

Table 1: Instruments used for water quality parameter measurement

Parameter	Unit	Instrument
Temperature	°C	Thermometer
pH	-	pHmeter
Dissolved oxygen	Mg/L	Winkler
Ammonia	Mg/L	Nessler
Nitrate	Mg/L	Spectrofotometer
Phosphate	Mg/L	Spectrofotometer
Total organic matter	Mg/L	Titrimetric
Plankton	Ind/L	Sedwick rafter cell
Alkalinitas	Mg/L	Titrimetric
Redox potential	mV	ORP meter

Results and discussion

Oceanographic parameters and redox potential

Based on the analysis of measurements of oceanographic parameters and redox potential, the results obtained are the range of temperature values ranging from 28 – 30˚C, pH is at 7.6 – 8.1, *Dissoved Oxygen* is at 6.097 – 9.83 mg/l, ammonia is at 0.04 – 0.069 mg/L, nitrate is at 5 – 25 ppm, Phosphate is at 0.022 – 0.078, TOM is at 6.32 – 68.256, Plankton is at 169556 – 1350000, alkalinity is at 12 – 196 mg/L, and Redox potential is at 85 – 123 mV. For more details can be seen in Table 2 below

Table 2: Oceanographic parameter measurement results

No.	Code	Temperature (° C)	pH	DO (mg/L)	Ammonia (ppm)	Nitrate (ppm)	Phosphate (ppm)	TOM	Plankton	Alkalinity	Redox potential
1	W1	28	7.9	9.57	0.069	5	0.078	7.584	523412	184	108
2	W2	28	7.8	6.097	0.04	5	0.026	6.32	169556	108	103
3	W3	29	7.8	6.6	0.051	10	0.076	10.112	563958	196	102
4	K1	29	7.8	8.04	0.023	10	0.024	20.224	455000	60	102
5	K2	29	7.7	8.32	0.036	7	0.026	36.656	265000	124	107
6	K3	29	7.7	8.13	0.026	9	0.022	37.92	570000	124	106
7	B1	30	7.7	9.34	0.037	10	0.027	11.376	240000	12	106
8	B2	29	7.7	9.75	0.065	5	0.056	25.28	695000	164	123
9	B3	29	7.7	9.34	0.049	5	0.057	37.92	400000	116	114
10	KB1	28	7.8	9.75	0.027	22	0.078	13.904	760000	104	95
11	KB2	28	7.8	8.94	0.017	15	0.041	18.96	875000	116	110
12	KB3	28	7.8	9.07	0.012	10	0.037	25.28	540000	96	101
13	BL1	29	7.7	9.34	0.028	25	0.063	46.768	635000	96	99
14	BL2	28	7.8	6.5	0.027	15	0.059	25.544	405000	124	121
15	BL3	28	7.7	9.29	0.019	15	0.062	37.92	735000	108	116
16	M1	29	7.7	8.94	0.031	10	0.037	18.96	405000	164	98
17	M2	28	7.7	8.13	0.015	15	0.064	1.264	260000	140	110
18	M3	28	7.6	7.72	0.031	10	0.045	3.792	245000	140	109
19	P1	29	8	9.1	0.028	10	0.038	68.256	350000	148	93
20	P2	28	8.1	9.83	0.022	5	0.024	61.936	245000	132	85
21	P3	28	8.1	9.75	0.016	5	0.025	64.464	1350000	132	91

Based on the table above, the temperature and pH values did not have a significant difference in each sampling location is at 28 – 30˚C and 7,7 – 8,1. The temperature value is relatively high because sampling is carried at noon and the intensity of sunlight entering the waters is maximum. According to Hamuna *et al.*, (2018) [4] The temperature in water bodies is influenced by the season, latitude, time of day, air circulation, cloud cover and water flow and depth. The highest temperature is located at point B1 because the location is near the outlet of the vannamei shrimp pond so it is estimated that there is a mass movement of wastewater from cultivation waste that enters the waters. According to Sidabutar *et al*. (2019) [21], The movement of the water mass can cause heat, due to friction between water molecules, so that the temperature of sea water becomes warmer.

Based on measurements, the pH value in the waters of Banyuwangi Regency is close to neutral. According to Daroini & Arisandi (2020) [2], Waters that have a pH close to neutral indicate that the process of decomposition of organic matter by microorganisms is going quite well. According to Decree of the State Minister of Environment Number 51 of 2004 states that a good pH value for marine life ranges from 7 – 8.5. So based on the measurement results in Banyuwangi Regency coastal is still relatively normal.

The value of DO in Banyuwangi Regency coastal ranges from 6,097 – 9.83 mg /L. This value is still within the normal range for aquatic biota's life. According to Decree of the State Minister of Environment Number 51 of 2004 states that the value of good DO for marine life is > 6 mg/l. Furthermore, the value of ammonia ranges between 0.04 – 0.069 ppm. The highest ammonia content is located at point W1 with a value is 0.069 ppm, This is because the location of W1 is close to the outlet of the shrimp farm, the high concentration of ammonia at the inlet station is caused by ammonium ions cannot be nitrified into nitrates due to the unavailability of sufficient oxygen. According to Saktiawan & Rupiwardani (2021) [18], Ammonia comes from landfilling, sewage, and feed residues that are not consumed. Most of the feed eaten, then overhauled for metabolic processes while the rest is removed in the form of solid feces (feces) and dissolved (ammonia). According to Junaidi & Parmi, (2021) [6], The factor that causes ammonia concentration to be high is because there are organic and inorganic nitrogen elements contained in shrimp pond waste and shrimp pond waste is liquid waste derived from feed residues that are not consumed and contain high protein, causing ammonia concentrations to be high.

Based on the results of the study, a fairly high nitrate distribution value was obtained in the water of Banyuwangi Regency coastal. The nitrate value has a scatter value between 5 – 25 mg/l. This is due to the accumulation of nitrate content carried by surface current circulation. This current circulation carries the accumulation of surface nitrate content from around the coastal waters of Banyuwangi Regency. Megawati *et al*., (2014) [9] explained, that the high content of nutrients on the surface can occur due to strong stirring of the bottom of the water, so that nutrients on the bottom of the water are lifted to the surface layer.

The phosphate measurement value ranges from 0.022 – 0.078, the highest value is found at the W1 location where the location is close to the shrimp pond outlet, this is thought to be due to getting nutrient flow from shrimp farming activities. According to Megawati *et al*., (2014) [9] the phosphate content generally decreases the farther towards the sea (offshore), because phosphate sources can come from land or other anthropogenic activities.

The results of measuring the lowest alkalinity value on the coast of Banyuwangi Regency are located at the location of K1 with a value of 60, this is because the location of K1 is close to the river flow that carries substances originating from upstream. According to Prasetyawan *et al*., (2017) [15], The alkalinity value will decrease if there is an input of acidic substances, for example from land through river flows. Furthermore, the TOM value ranges from 1,264 – 68,256. The highest values are located at point P1 adjacent to shrimp ponds and turbid waters and at the time of sampling of high tides. According to Djoharam *et al*., (2018) [3], An increase in temperature leads to increased decomposition of organic matter by microbes.

The effect of oceanographic parameters on redox potential

Based on regression analysis, there is an influence of oceanographic parameters on redox potential values. It can be seen in Table 3 below

Table 3: Results of the simultaneous effect (Test F) redox potential

	df	SS	MS	F	Significance F
Regression	9	230883	25653.67	254.8462	$1.83\ X\ 10^{-11}$
Residual	12	1207.96	100.6633		
Total	21	232091			

Then continued the coefficient of determination (R^2) test, this test is carried out to determine how strong the influence of oceanographic parameters on redox potential values. The results of this test can be seen in Table 4.

Table 4: Redox potential determination coefficient results

R	R square	Sdjusted R square	Std. Error
0.997	0.994	0.907	10.033

Based on the table above, it is known that the value of the coefficient of determination is 0.994, meaning that the variation in changes in redox potential values, influenced by oceanographic parameters of 99.4% of values including the strong category while the remaining 0.6% is influenced by other factors.

Then carried out the T Test or partial test, from this test it is known that all values of the Oceanographic parameter P-value > 0.05 then the oceanographic parameter independently does not have a significant effect on the redox potential value, because each oceanographic parameter cannot stand alone and is interrelated and the results of partial hypothesis testing can be seen in Table 5

Table 5: Partial redox potential test

	Coefficients	Standard error	t Stat	P-value
Intercept	0	#N/A	#N/A	#N/A
Temperature	-6.907441	3.643516	1.895818	0.082318
pH	9.29854	13.00408	-0.71505	0.488259
DO	-2.02041	2.535875	-0.79673	0.441086
Ammonia	-147.82	292.2983	-0.50572	0.622217
Nitrate	-0.87674	0.857889	-1.02197	0.326956
Phosphate	355.5685	262.5899	1.354083	0.200661
TOM	-0.09995	0.150909	-0.66233	0.520279
Plankton	-6.46E-06	9.82E-06	0.65775	0.523117
Alkalinity	0.04294	0.081764	-0.52517	0.60903

In the partial test in this study pH, phosphate and alkalinity have a positive correlation to redox potential, meaning that increasing pH, phosphate and alkalinity in line with increasing redox potential values. Temperature, DO, ammonia, nitrate, TOM and plankton abundance values are negatively correlated with redox potential, meaning that any increase in temperature, DO, ammonia, nitrate, TOM and phytoplankton abundance can reduce redox potential values. If the temperature of the waters is high, then the abundance of phytoplankton in the waters is getting higher as well, then the high temperature also helps the process of phytoplankton photosynthesis which results in higher DO content as well (Novia *et al*., 2016) [13]. The oxidation-reduction potential can be used as a measure of oxygen content in sediments (Safitra, 2022) [17]. In addition to photosynthesis, phytoplankton are also living things that need nutrients to live and multiply. According to Simanjuntak (2009) [22], Phytoplankton need nitrates to grow and multiply, which means that high nitrates affect the abundance of phytoplankton in the waters. So nitrate concentration is positively correlated with phytoplankton abundance.

Increased temperature also leads to increased decomposition of organic matter by microbes (Djoharam *et al*., 2018) [3]. This high organic matter can be the basis for the formation of ammonia through the ammonification process. Ammonification is the process of forming ammonia from organic matter. Furthermore, nitrification is an oxidation reaction, namely the process of forming nitrites or nitrates from ammonia. Ammonium and nitrite compounds are an important part of the nitrogen cycle in nature. Denitrification is the reaction of reducing nitrate to nitrite, nitric oxide, and nitrogen gas. Nitrite can also act as an electron acceptor in the process of becoming nitrogen gas (Hastuti 2011) [5]. The nitrification process is the change of ammonia into nitrate through nitrite, this process is called oxidation (Shen *et al*., 2008) [20], Oxidation is the process of losing electrons (Nolfi-Donegan *et al*., 2020) [12]. The number of electrons is directly proportional to the redox potential so that a decrease in the number of electrons automatically decreases the value of Eh (Najamuddin *et al*., 2020) [11].

TOM is negatively correlated with redox potential values. Total organic matter (TOM), the amount of organic matter, the number of bacteria living in the waters, and the lack of water circulation cause oxygen levels in the waters to decrease (Timko et al., 2015) [24]. This situation can change the condition of the substrate into a reduction environment Organic matter that is too high will cause low oxygen levels in the waters, if low oxygen levels will cause low redox potential values (Saktiawan & Rupiwardani, 2021) [18].

Furthermore, the positive correlation between pH, phosphate and alkalinity to redox potential that occurs is due to the absence of a significant relationship between phosphate and silicate nutrients with phytoplankton and zooplankton does not mean that nutrients do not play a role as food in phytoplankton life, but may be due to nutrient variability and the number of samples is not so large that the correlation is not so visible (Simanjuntak, 2009) [22]. The abundance of plankton will decrease with the higher the pH. If the pH is high or alkaline it will endanger the survival of plankton organisms, because it will cause metabolic and respiration disorders (Novia *et al*., 2016) [13].

The presence of reduced Fe^{+3} ions turns into Fe^{+2} so that it has the opportunity to release OH^- and increase pH and lower redox potential. At low redox potential values, the pH value of water tends to be higher. The value of the degree of acidity along with redox potential indicates the physical, chemical properties of the substrate for the life of benthic organisms (Li & Irvin, 2007) [8]. Alkalinity is closely related to pH, if the alkalinity value is high, the pH value will be higher. Alkalinity values that are not much different indicate that marine waters tend to be stable with alkaline properties. The alkalinity value will decrease if there is an input of acidic substances, for example from land through river flows. Alkalinity can affect changes in the pH of waters and can support the growth rate of microorganisms that can affect the increase in redox potential values in waters (Abril, 2001) [1].

The pH value in a body of water is an indication of the disruption of these waters. The decrease in pH value in a water is characterized by the increasing organic compounds in the waters (Megawati *et al*., 2014) [9]. pH conditions are closely related to carbon dioxide and alkalinity, this is because the higher the pH, the lower the carbon dioxide content in contrast to alkalinity, the higher the pH, the higher the alkalinity value (Prasetyawan *et al*., 2017) [15].

Conclusion

pH, phosphate and alkalinity have a positive correlation to redox potential, meaning that increasing pH, phosphate and alkalinity in line with increasing redox potential values. Temperature, DO, ammonia, nitrate, TOM and plankton abundance values are negatively correlated with redox potential, meaning that any increase in temperature, DO, ammonia, nitrate, TOM and phytoplankton abundance can reduce redox potential values.

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