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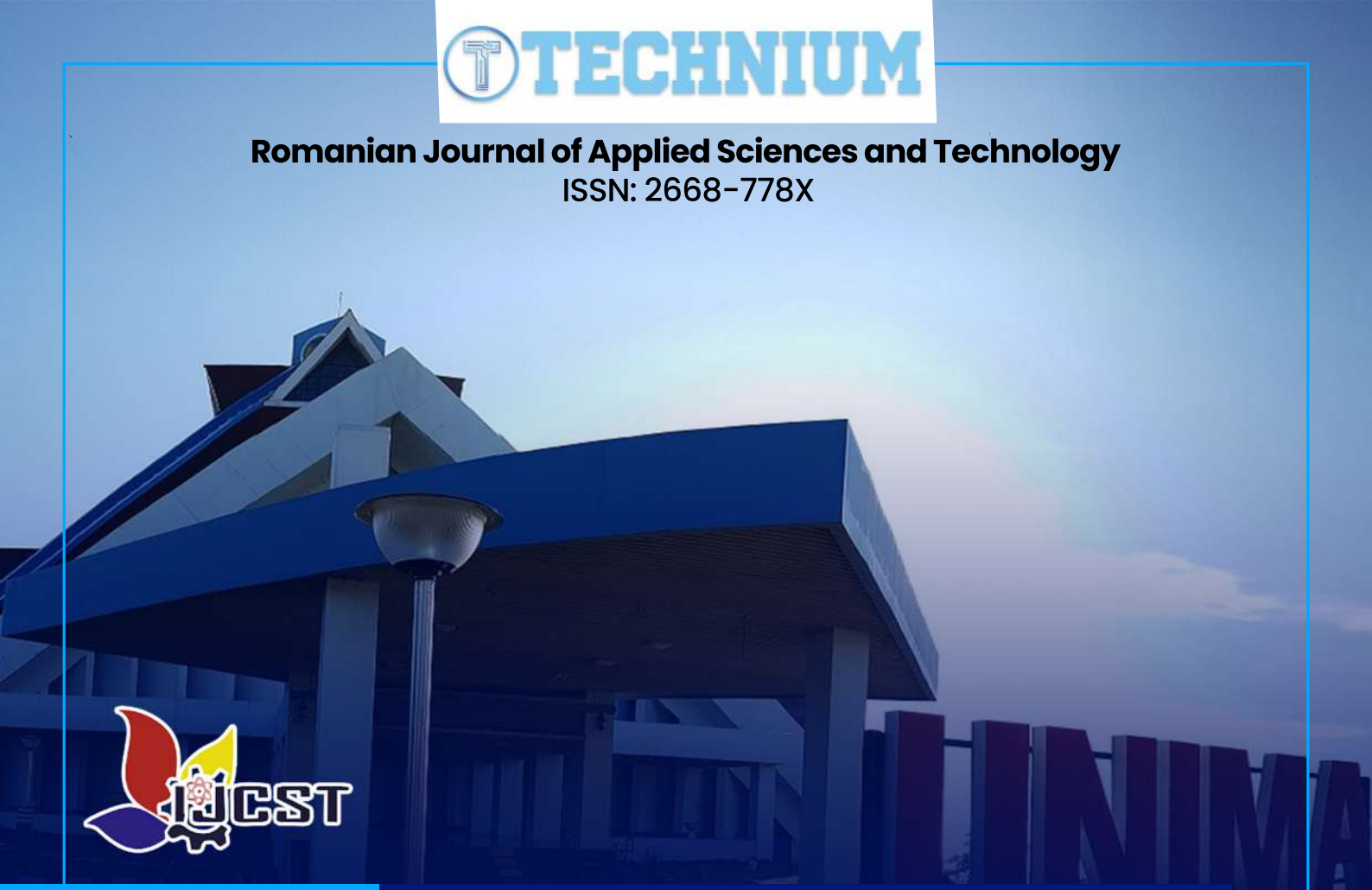

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# Phytoplankton Analysis and Mapping in Tuban Coastal Based on Chlorophyll-A Concentration Value Using Terra Modis Satellite Imagery

*Siti* Zainab[1]*, *Novie* Handajani[1], *Minarni* Nur Trilita[1], *Primasari* Cahya Wardhani[2]

* corresponding author: siti.ts@upnjatim.ac.id

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[1]Department of Civil Engineering, UPN Veteran East Java, Surabaya, Indonesia

[2]Department of Physics, UPN Veteran East Java, Surabaya, Indonesia

**Abstract.** The coast of Tuban is a fairly dynamic area where the lives of fishermen depend on fishing. Ecosystem changes that occur in the coastal area of Tuban greatly affect the fishing effort. The presence of the phytoplankton themselves cannot be sensed directly. However, the green leaf substance present in the bodies of the phytoplankton can be sensed by sensors in the form of the chlorophyll-a content of the water bodies on the coast. In this study, the distribution of chlorophyll-a on the coast will be mapped using Terra Modis satellite imagery and then analyzed by modeling the distribution so that future predictions can be made on handling water quality on the coast of Tuban so that the economy of fishing communities on the coast of Tuban can be improved. The method used for the mapping is Remote Sensing. The result is a liner mathematical model y = 28.012 x, y is Chlorophyll and x reflectance Rrs_488 which is blue with a degree of determination R2 = 0.9535, and the availability of thematic maps of chlorophyll-a content on the coast of Tuban.

## 1 Introduction

Tuban Regency is one of the regencies in East Java in the westernmost region with an area of 183,994.561 Ha. Geographically, Tuban Regency is located at coordinates 111°30'-112°35' East Longitude and 6°40'-7°18' South Latitude. The length of the coastal area in Tuban Regency is 65 km, stretching from the east in Palang District to the West in Bancar District, with an area of sea covering 22,608 $km^2$. Administratively, Tuban Regency is divided into 20 Districts and 328 Villages. The boundaries of the Tuban Regency area are as follows: To the north: the Java Sea; East: Lamongan Regency; Southside: Bojonegoro Regency; West side: Blora Regency and Rembang Regency, Central Java Province Administrative boundaries for Tuban Regency can be seen in Map 6.1 Administrative Boundaries for Tuban Regency. Administratively, Tuban Regency consists of 20 districts. Grabagan District is a new sub-district that is a division of three sub-districts: Semanding, Rengel, and Soko Districts.

The North, South, and East coasts of East Java can be used to categorize its coastal and marine regions. One of the northern coastal regions is the Tuban Regency. East Java's northern coast is a low-lying region with an elevation that is about equal to sea level. Residential areas, aquaculture, tourism, and other activities are frequently carried out in coastal locations. Because various elements, including wind, sea currents, tides, abrasion, sedimentation, and others, affect environmental conditions, using coastal regions effectively necessitates good management [1]

The fishermen who live around the shore of Tuban depend on fishing for their livelihood. The fishing effort is significantly impacted by ecosystem changes in the coastal region of Tuban, where one parameter that may be noticed is the distribution of chlorophyll-a content in the water bodies along the shore. Chlorophyll-a (Chl-a) is a plankton green pigment used in photosynthesis. All phytoplankton contain chlorophyll-a, which weighs approximately 1-2% of the dry weight of algae [2].

The purpose of this paper is to find out the existence of the coast of Tuban Regency, whether it is still within safe limits considering that the availability of natural resources owned by the coast of Tuban has not been exploited properly and correctly, besides that the existence of spots that are believed to contain levels of chlorophyll-a in seawater is not widely known [3,4]. This could be due to the lack of interest in finding and exploring these sources or the existence of technological limitations that have not allowed researchers to make further observations about the feasibility of seawater on the coast [5], where the value of chlorophyll-a in seawater can be used as a reference for fishermen and for related officials to be able to take a policy, relating to the global use of fishing in the coastal areas of Tuban Regency.

The expected results of this research are to provide optimal benefits for the development of science and information systems based on Remote Sensing technology. In addition, it is expected to contribute to the field of Geomatics in the form of mathematical model algorithms that can be used to forecast the next 5 to 10 years' distribution of dissolved chlorophyll-a and oxygen concentrations on the coast of Tuban Regency.

## 2 Literature Review

### 2.1 Data Citra Satellite

The satellite image data used in this study is Terra Modis image data taken from the https://gsfc.modis.ocean color filename:
TERRA MODIS.20190624T031001.L2_LAC_OC.nc
TERRA MODIS.20200630T024501.L2_LAC_OC.nc
TERRA MODIS.20210629T030501.L2_LAC_OC.nc
TERRA MODIS.20220627T024001.L2_LAC_OC.nc
TERRA MODIS.20230609T030000.L2_LAC_OC.nc
T20230609T030000.L2_LAC_OC.nc_subset_reprojected ,

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The image data is image data downloaded for June 2023 as shown in Fig 1.

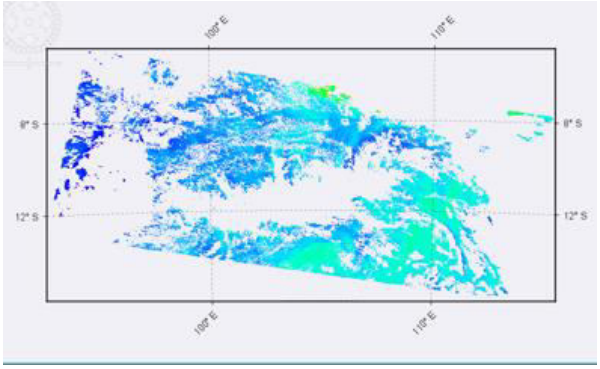

**Fig 1.** Satellite Image Terra Modis 2023

### 2.2 Citra Satellite Modis

MODIS is a sensor carried by the Terra satellite (first known as EOS AM-1) called Terra Modis and also Aqua (first known as EOS PM-1) called Aqua Modis. Terra crosses the earth in the morning from North to South, while Aqua crosses the earth during the day from South to North by crossing the Equator.
The specifications of the Modis sensor are as follows:
Orbit: 705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), sun-synchronous, near-polar, circular
Scan Rate: 20.3 rpm, cross track
Swath Dimensions: 2330 km (cross track) by 10 km (along track at nadir)
Telescope: 17.78 cm diam. off-axis, afocal (collimated), with intermediate field stop
Size: 1.0 x 1.6 x 1.0 m
Weight: 228.7 kg
Power: 162.5 W (single orbit average)
Data Rate: 10.6 Mbps (peak daytime); 6.1 Mbps (orbital average)
Quantization: 12 bits

**Table 1.** Spatial Resolution: 250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36) Design Life: 6 years

| Primary Use | Band | Bandwidth[1] | Spectral Radiance [2] | Required SNR[3] |
|---|---|---|---|---|
| Land/Cloud/ Aerosols Boundaries | 1 | 620 - 670 | 21.8 | 128 |
| | 2 | 841 - 876 | 24.7 | 201 |
| Land/Cloud/ Aerosols Properties | 3 | 459 - 479 | 35.3 | 243 |
| | 4 | 545 - 565 | 29.0 | 228 |
| | 5 | 1230 - 1250 | 5.4 | 74 |
| | 6 | 1628 - 1652 | 7.3 | 275 |
| | 7 | 2105 - 2155 | 1.0 | 110 |
| Ocean Color/ Phytoplankton/ Biogeochemistry | 8 | 405 - 420 | 44.9 | 880 |
| | 9 | 438 - 448 | 41.9 | 838 |
| | 10 | 483 - 493 | 32.1 | 802 |
| | 11 | 526 - 536 | 27.9 | 754 |
| | 12 | 546 - 556 | 21.0 | 750 |
| | 13 | 662 - 672 | 9.5 | 910 |
| | 14 | 673 - 683 | 8.7 | 1087 |
| | 15 | 743 - 753 | 10.2 | 586 |
| | 16 | 862 - 877 | 6.2 | 516 |

## Chlorophyll-a

In oxygenic photosynthesis, chlorophyll-a is the particular type of chlorophyll that is employed. It absorbs most of the energy from violet-blue and orange-red wavelengths of light but poorly from green and near-green portions of the spectrum [6]. Chlorophyll does not reflect light, yet tissues containing it appear green because diffuse reflections from cell walls and other structures make green light richer with reflected light [7]. This photosynthetic pigment serves as the electron transport chain's main electron donor, making it crucial for photosynthesis in eukaryotes, cyanobacteria, and prochlorophytes. The specific Chlorophylls P680 and P700 are positioned in the reaction center, where Chlorophyll-a also transfers resonance energy in the antenna complex [8,9].

## Distribution of Chlorophyll

Although not the only pigment that may be utilized in photosynthesis, chlorophyll-a is necessary for the majority of photosynthetic organisms to release chemical energy. Chlorophyll-a is a pigment that all oxygenic photosynthetic organisms employ, although others, such as chlorophyll-b, are different [10]. The anaerobic photoautotrophic green sulfur bacteria also contain extremely minute amounts of chlorophyll-a. While using some bacteriochlorophyll and chlorophyll-a, these organisms do not create oxygen [11]. Unlike oxygenic photosynthesis, where oxygen is created during the light reactions of photosynthesis, anoxygenic photosynthesis refers to this process. The phytol ester's side chain and hydrocarbon tail are shown in the image Fig.2.

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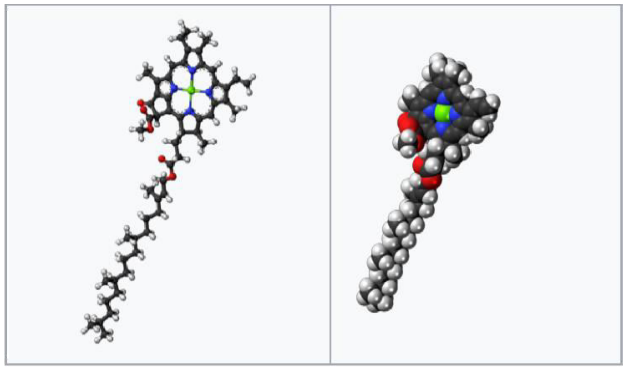

**Fig 2.** The structure of the chlorophyll molecule showing the phytol tail

## 3 Methodology

Terra Modis satellite image data were taken from the webpagehttps://ocean color.gsfc.nasagov/cgi/browes.pl.
With the election time being June 2023, according to the date of collection of secondary data, samples of Chlorophyll-a content from Terra Modis satellite imagery of 40 points along the North coast (Pantura) of Java Island, while Terra Modis satellite imagery data from 2019 to 2022 as a comparison. The following table provides two data sampling points.

**Table 2.** Chlorophyll-a data with field coordinate survey data for 40 sampling points on the coast of Tuban in June 2023

| Point | Longitude | Latitude | Chlorophyll-a | Point | Longitude | Latitude | Chlorophyll-a |
|---|---|---|---|---|---|---|---|
| 1 | 97,96976 | -9,526854 | 0,1100471 | 21 | 109,43941 | -10,777947 | 0,17658758 |
| 2 | 99,24968 | -10,514842 | 0,0954392 | 22 | 109,03163 | -11,024696 | 0,16471891 |
| 3 | 100,09859 | -10,930157 | 0,1152500 | 23 | 108,37979 | -11,479305 | 0,15693307 |
| 4 | 100,878494 | -10,939755 | 0,1100006 | 24 | 109,26485 | -11,670120 | 0,19162405 |
| 5 | 101,35717 | -10,76591 | 0,0802823 | 25 | 109,441246 | -11,319664 | 0,2357964 |
| 6 | 101,77414 | -10,604285 | 0,1075863 | 26 | 109,99393 | -11,053875 | 0,19795218 |
| 7 | 102,25290 | -10,537085 | 0,1220810 | 27 | 110,03536 | -10,769261 | 0,19178145 |
| 8 | 102,59606 | -10,454803 | 0,1171464 | 28 | 109,36433 | -10,311562 | 0,16142046 |
| 9 | 103,06750 | -10,369082 | 0,0958053 | 29 | 108,85147 | -10,063668 | 0,16817361 |
| 10 | 103,64201 | -9,360077 | 0,1477415 | 30 | 107,79228 | -9,876295 | 0,15555963 |
| 11 | 104,20294 | -9,482343 | 0,1313776 | 31 | 105,84453 | -9,468360 | 0,17571835 |
| 12 | 104,43722 | -9,571505 | 0,1094338 | 32 | 105,42479 | -9,280526 | 0,11758601 |
| 13 | 104,68176 | -9,636810 | 0,1191670 | 33 | 105,07616 | -9,245730 | 0,16082023 |
| 14 | 105,01657 | -9,487988 | 0,1779441 | 34 | 104,48161 | -8,931307 | 0,17242908 |
| 15 | 105,45852 | -9,677088 | 0,0726233 | 35 | 104,02729 | -8,767788 | 0,102171816 |
| 16 | 112,345896 | -9,604690 | 0,1466604 | 36 | 103,11245 | -9748561 | 0,10961212 |
| 17 | 112,343811 | -9,896932 | 0,1424725 | 37 | 102,64842 | -10,21739 | 0,11063132 |
| 18 | 112,342892 | -9,893900 | 0,1611279 | 38 | 102,19675 | -10,331317 | 0,11632725 |
| 19 | 112,342080 | -10,11016 | 0,1576863 | 39 | 100,96084 | -10,331317 | 0,08421101 |
| 20 | 112,341721 | -10,426143 | 0,1094338 | 40 | 100,80849 | -10,331317 | 0,08194422 |

*Source: taken from field measurement*

This study used Seadast 7.5.3 software to get the wavelength, Rrs_488 is the blue channel, Rrs_555 is the green channel, and Rrs_678 is the red channel. The reflectance data were processed using Excel software to obtain the best algorithm model, the ideal wavelength, with the chlorophyll in the coastal region of Tuban serving as the dependent variable. The next stage is image cropping, which shrinks the image display area to the required coordinates. The size is intended to be reduced to speed up the processing. Observations are made by designing an Area of Interest (AOI) by figuring out the coordinates for data processing. The coordinates of the research location are 103,008 East Longitude to 110,27 and -7,728 North Latitude to -12,055 South Latitude. The average Chlorophyll-a distribution data were extracted from the Terra Modis image in June 2023. The next process is georeferenced and includes a mathematical model to display a mapping of the distribution of Chlorophyll-a in the research area.

## 4 Results and Discussion

The result of this research that showed in Table 3, it is an algorithm calculation involving linear, exponential, logarithmic, and power mathematical models using Terra Modis Year 2023. For the results of processing with scatter diagrams at the wavelength, Rrs_488 is the blue channel, Rrs_555 is the green channel, and Rrs_678 is the red channel, obtained for variables Chlorophyll-a, the highest correlation is the reflectance Rrs_488 with the Linear Algorithm model with the equation y = 28.012 x with $R^2$ = 0.9535, where the variable y is chlorophyll-a, and x is the band Rrs_488 blue wavelength.

**Table 3.** Model mathematic calculation at Band_Rrs_488 , Rrs_555, Rrs_678 wavelength Chlorophyll-a

| No | Algorithm | Band | Mathematical Model | $R^2$ |
|---|---|---|---|---|
| **1** | **Linear** | **Band_488** | **y = 28,012x** | **0,9535** |
| 2 | Exponent | | $y = 0{,}7144e^{-330{,}9x}$ | 0,1033 |
| 3 | Logarithmic | | y = -0,195ln(x) - 0,8963 | 0,1067 |
| 4 | Power | | $y = 3E\text{-}05x^{-1{,}603}$ | 0,0982 |
| 5 | Linear | **Band_555** | y = -2E-06x + 0,1422 | 0,009 |
| 6 | Exponent | | $y = 0{,}1375e^{-2E\text{-}05x}$ | 0,0083 |
| 7 | Logarithmic | | y = 0,0013ln(x) + 0,1483 | 0,0267 |
| 8 | Power | | $y = 0{,}1422x^{0{,}0078}$ | 0,264 |
| 9 | Linear | **Band_678** | y = -3E-06x + 0,147 | 0,0019 |
| 10 | Exponent | | $y = 0{,}1402e^{-1E\text{-}05x}$ | 0,0020 |
| 11 | Logarithmic | | y = -0,008ln(x) + 0,1986 | 0,0145 |
| 12 | Power | | $y = 0{,}2027x^{-0{,}052}$ | 0,0155 |

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**Table 4.** Chlorophyll-a data with reflectance Rrs_488 year 2019-2023

| Pin | Chlorophyll-a 2023 (mg/m$^3$) | Chlorophyll-a 2022 (mg/m$^3$) | Chlorophyll-a 2021 (mg/m$^3$) | Chlorophyll-a 2020 (mg/m$^3$) | Chlorophyll-a 2019 (mg/m$^3$) |
|---|---|---|---|---|---|
| 1 | 0,1100471 | 0,10645 | 0,14902 | 0,1244293 | 0,14544 |
| 2 | 0,0954392 | 0,21900 | 0,12521 | 0,2625285 | 0,14835 |
| 3 | 0,1152500 | 0,17435 | 0,14768 | 0,1841509 | 0,11608 |
| 4 | 0,1100006 | 0,22393 | 0,13894 | 0,2221912 | 0,13524 |
| 5 | 0,0802823 | 0,21984 | 0,14292 | 0,1110396 | 0,11771 |
| 6 | 0,1075863 | 0,12499 | 0,15704 | 0,0989384 | 0,09810 |
| 7 | 0,1220810 | 0,12880 | 0,15345 | 0,1037005 | 0,12168 |
| 8 | 0,1171464 | 0,14236 | 0,14045 | 0,1374269 | 0,11289 |
| 9 | 0,0958053 | 0,13743 | 0,19894 | 0,1383233 | 0,10958 |
| 10 | 0,1477415 | 0,17160 | 0,37161 | 0,1194432 | 0,11098 |
| 11 | 0,1313776 | 0,18409 | 0,33060 | 0,1164739 | 0,09603 |
| 12 | 0,1094338 | 0,19328 | 0,26359 | 0,1070059 | 0,09440 |
| 13 | 0,1191670 | 0,19244 | 0,24561 | 0,1200595 | 0,10857 |
| 14 | 0,1779441 | 0,23228 | 0,25760 | 0,1225805 | 0,10813 |
| 15 | 0,0726233 | 0,20040 | 0,30096 | 0,1054372 | 0,11804 |
| 16 | 0,1466604 | 0,18107 | 0,28130 | 0,1071739 | 0,10857 |
| 17 | 0,1424725 | 0,25261 | 0,32987 | 0,1209558 | 0,10745 |
| 18 | 0,1611279 | 0,29267 | 0,40556 | 0,1366986 | 0,10129 |
| 19 | 0,1576863 | 0,12975 | 0,19894 | 0,1215161 | 0,13608 |
| 20 | 0,1094338 | 0,12084 | 0,34651 | 0,1083504 | 0,11916 |

**Table 5.** ANOVA Test Chlorophyll-a from 2019-2023 with the Linier mathematical

| Source of Variation | SS | df | MS | F | P-value | F-crit |
|---|---|---|---|---|---|---|
| Between Groups | 0,060657 | 19 | 0,003192 | 0,645375 | 0,859252 | 1,718026 |
| Within Groups | 0,395732 | 80 | 0,004947 | | | |
| Total | 0,456389 | 99 | | | | |

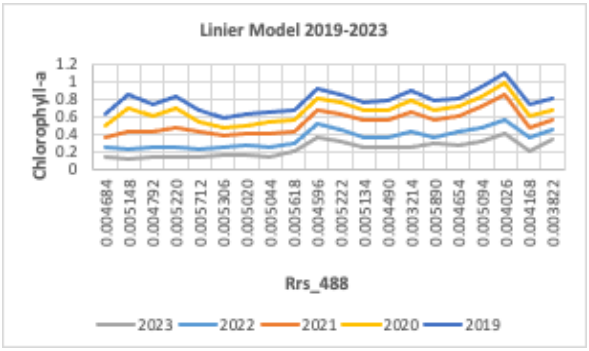


**Fig 3.** The line graph shows chlorophyll-a levels from 2019-2023

An ANOVA test was carried out to determine whether there was a significant difference from 2019 to 2023. The results of the test are as follows: F count = 0.645375 < F table = 1.718026, in the same way, analyzed through P-value = 0.859252 > 0.05 Ho is accepted, meaning that there is no difference in chlorophyll-a levels from 2019 to 2023. The following shows the thematic map.

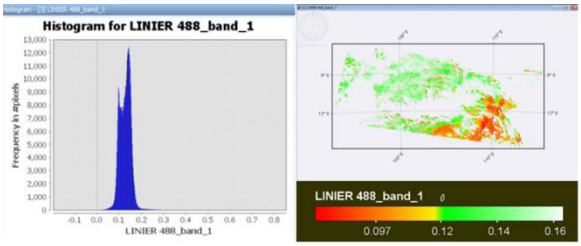


**Fig 4.** Chlorophyll-a Thematic Map of the Tuban coastal area in 2019-2023

The orange color shows lower chlorophyll content than green. Chlorophyll is higher when approaching land because land or rivers contain many nutrients. Below is a histogram of the chlorophyll thematic map from the Terra Modis satellite imagery.

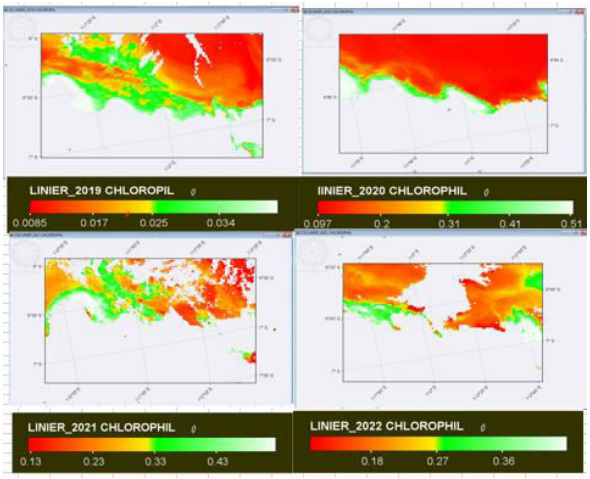


**Fig 5.** Chlorophyll-a Histogram and Chlorophyll-a Thematic Map of the Tuban coastal area 2023

Figure 5 shows that towards the blue color, the Chlorophyll is getting lower, while towards the red and green colors, the Chlorophyll is getting higher. According to the Decree of the State Minister for the Environment Number 51 of 2004 concerning Seawater Quality Standards, it is called natural, meaning that natural conditions are the normal conditions of an environment, varying at any time (day, night and, season) [1,9,11].

## 5 Conclusion

From distribution Chlorophyll-a throughout the coastal area of Tuban, the identification results show a range between 0,0802823 mg/m$^3$ to 0,2357964 mg/m$^3$. Algorithm model of Chlorophyll-a in the entire coastal area of Tuban y = 28,012 x and the degree of determination $R^2$ = 0.9535 obtained from the wavelength/reflectance Rrs_488. The results of the ANOVA test analysis for the calculated F count = 0.645375 < F table = 1.718026, in the same way analysed through P-value = 0.859252 > 0.05 Ho is accepted, meaning that there is no difference in chlorophyll-a levels from 2019 to 2023.

## References

[1] S. Salmin, Oseana **30**, 21 (2005).
[2] P. K. Koner, IEEE Transactions on Geoscience and Remote Sensing **59**, (2021).
[3] S. Patty, JURNAL PESISIR DAN LAUT TROPIS **3**, 1 (2015).

*Technium: Romanian Journal of Applied Sciences and Technology*
*Vol. 16, 424-429, October, 2023*
*ISSN: 2668-778X*
*www.techniumscience.com*

[4] S. I Patty and N. Akbar, Jurnal Ilmu Kelautan Kepulauan **2**, 1 (2018).
[5] A. Yulan, P. I. A. Anrosana, and A. A. Gemaputri, Jurnal Perikanan **15**, 78 (2013).
[6] T. Susana, Indonesian Journal of Urban and Environmental Technology **5**, 33 (2009).
[7] D. S. Yolanda, F. F. Muhsoni, and A. D. Siswanto, Jurnal Kelautan: Indonesian Journal of Marine Science and Technology **9**, 93 (2016).
[8] H. Horas P, R. Abdul, and L. Irman, Oseana **10**, 138 (1985).
[9] H. P. Hutagalung, A. Rozak, and I. Lutan, Oseana **10**, 138 (1985).
[10] R. Richard and S. Sunarto, Geoscience **1**, 1 (2010).
[11] M. N. L. H. MNLH, *Keputusan Menteri Negara Lingkungan Hidup Nomor 51 Tahun 2004* (2004).