



Analysis of Variance and Correlation Study of Chlorophyll-a in North and South Coast of Lombok Island Using Aqua MODIS Image Data

Hendrata Wibisana¹, Siti Zainab², Zetta Rasullia K³ . Muhammad Rusdi⁴

¹Civil Engineering Department, University of Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia;

²Civil Engineering Department, University of Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia

³Construction Management Laboratory, University of Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia

⁴Remote Sensing dan Cartography Laboratory, Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia

*Corresponding author email: hendrata2008@gmail.com

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Abstract – Chlorophyll-a mapping is widely used in the coastal environment. The mapping results can be utilized as guidance for fishing activities. The presence of chlorophyll-a in phytoplankton is much investigated concerning the existence of fish as a source of livelihood for fishermen around the globe. One method extensively developed is the use of satellite imagery to map the chlorophyll-content in the coastal region from a small area to a global scale, such as Aqua MODIS image data. This study aims to monitor the distribution of chlorophyll-a on the north coast and south coast of Lombok island. Analysis of variance and parametric statistical tests with t-distribution was utilized to examine the correlation between the two types of chlorophyll-a distribution of the coast area, Lombok Island. The result shows that the distribution of chlorophyll-a concentrations on the north coast and the south of the coast is not the same abundance; the south coast of Lombok island has smaller variances, with the concentration distribution is relatively the same. It differs from the north part; the distribution shows less diversity. This result indicates that a reasonably wide interval wherein some coordinates has a relatively diffuse chlorophyll-a concentration with a sufficiently high distribution level. Analysis of variance result also shows that both the north and south coasts have different fertility levels for their coastal waters, which are characterized by the growth rate of chlorophyll-a on the surface water along the coastal region examined.

Keywords: Analysis of Variance, Chlorophyll-a, Lombok Island

Introduction

Chlorophyll-a is the primary pigment used to capture light energy during photosynthesis. Chlorophyll is a chemical compound that can be detected by utilizing remote sensing data. All plants contain chlorophyll, and it is widely used for detecting Chhlophyl-contained organisms in water bodies. Chlorophyll abundance in the water can indicate a healthy level of waters, especially in the marine environment (Prihatin et al., 2018). The chlorophyll abundance can be detected indirectly by detecting the existence f phytoplankton, which widely spread in the ocean at a time when the optimum seawater conditions for the growth of phytoplankton. Detection of chlorophyll-a directly can be carried out by utilizing reflectance captured by the sensor of satellite image data. Satellite sensors are responsible for catching electromagnetic waves reflected by various objects on the surface of the sea can sort the wavelength captured by the sensor into a source of information in the form of surface reflectance data from satellite images. It is widely acknowledged that remote sensing uses spectral radiance or reflectance to define the intensity of light as a diagnostic measure (Sugianto et al., 2019), which can later be used as a source of data for mapping chlorophyll-a content in the marine or coastal environment, e.g., Saleh et al. (2019).

Indonesia, as a maritime country, requires distribution data from the chlorophyll-a. As a country that has a long coastline, the distribution map of chlorophyll-a as one of the parameters for detecting the presence of phytoplankton is very much needed, where phytoplankton is one part of the food chain in the aquatic environment. And for fishermen who have a livelihood in capture fisheries, the data on the existence of fish that can be consumed is essential because not every part of the ocean area has a population of fish in the same amount so that by knowing the existence of fish populations precisely at the site with coordinates that have been mapped, fishing activities for fisheries catching fisheries become something of high economic value because later the optimal catch will be obtained.

Many technologies can be developed to monitor and detect the presence of chlorophyll-a in the sea (Liu et al., 2017; Nneti Onyia et al., and Sala et al., 2018), one of which is a remote sensing technology that uses sensor technology and with multispectral capabilities (Cole et al., 2018; Grobler et al., 2013; van der Meer et al., 2012), multitemporal and high spatial resolution (Miura et al., 2008; Petitcolin & Vermote, 2002), the selection of satellite imagery as a vehicle for detecting water quality is indispensable.

Remote sensing technology makes it possible to accurately detect changes occurring at sea level, such as the distribution of chlorophyll-a, by calculating the algorithms from channels owned by satellite imagery (Lewis & Brown, 2001; Wibisana et al., 2016). Moderate-resolution imaging spectro-radiometer (MODIS) algorithms have is useful remote sensing data in sea data extraction, according to some researchers, e.g., Li et al. (2018), Cadars et al. (2004), and Maged and Mazlan (2009). Research on the distribution of chlorophyll-a has been carried out with results that show the fact that satellite imagery has a proper channel to detect the presence of chlorophyll-a at sea level, and many channels are at the wavelength of visible light or known as RGB (red-green-blue).

For this reason, the aim of this research was carried out to detect and map the chlorophyll-a content on the coast of Lombok Island, West Nusa Tenggara. Also, it would be seen whether there was a significant difference between the aquatic environment on the north coast of Lombok Island and the water environment on the south side, where it is known that for the north coast of the island of Lombok it is influenced by the Bali sea while the south side is controlled by the movement of the south coast, which is flanked by the continent of Australia.

Materials and Methods

Lombok Island is one of the Island of West Nusa Tenggara Province. The Lombok island is bordered by the island of Bali in the West part, the island of Sumbawa in the East, the Bali Sea in the north, and the continent of Australia in the south. The research coordinates on the island of Lombok are 113.7654° to 114.2347° East Longitude and -8.3214° to -9.5427° South Latitude (Figure 1)

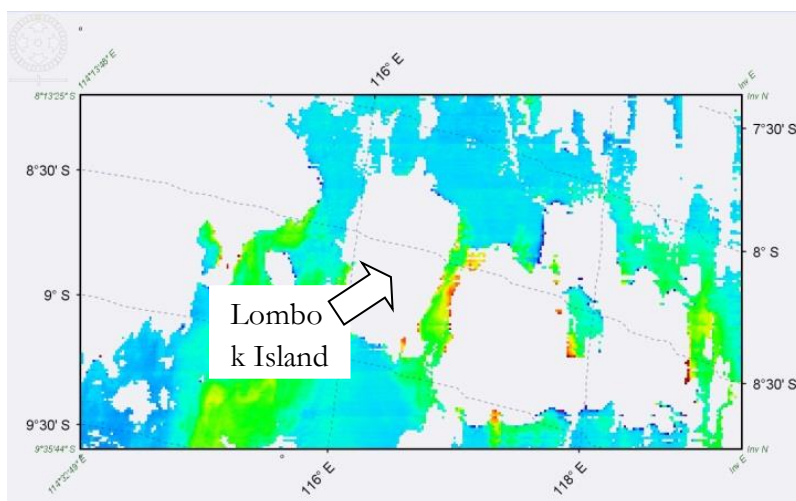


Figure 1. The Map of Lombok Island (NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group, 2017)

The satellite image used for this study is the Aqua MODIS satellite image taken on the webpage <http://oceandata.sci.gsfc.nasa.gov/>, the file from the satellite image is A2017215061500.L2_LAC_OC.nc which was acquired on October 16, 2017, and A2017215062100.L2_LAC_OC.nc, which was acquired on October 10, 2017, these two satellite images are the result of Level 2 processing and have a resolution of 1 km.

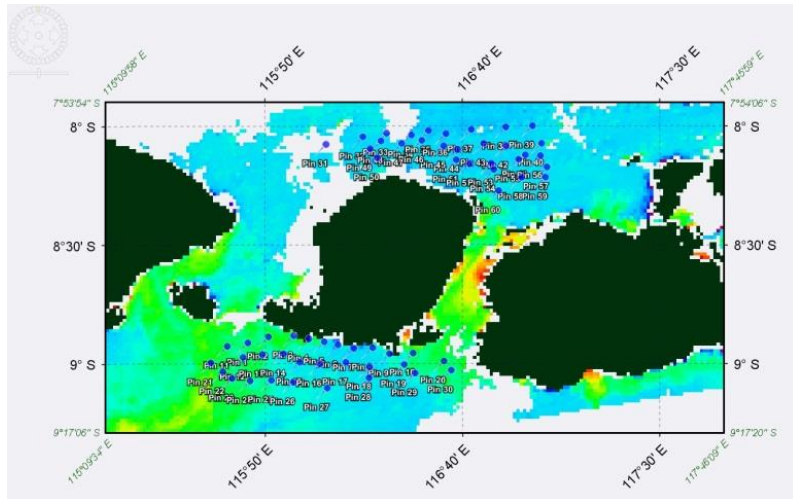


Figure 2. Sample point location at North and South Lombok Island (NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group, 2017)

Result

The results show that the mapping of chlorophyll-a concentration can be seen in Figure 3., for the northern part of the island of Lombok, while for the south part is shown in Figures 4.

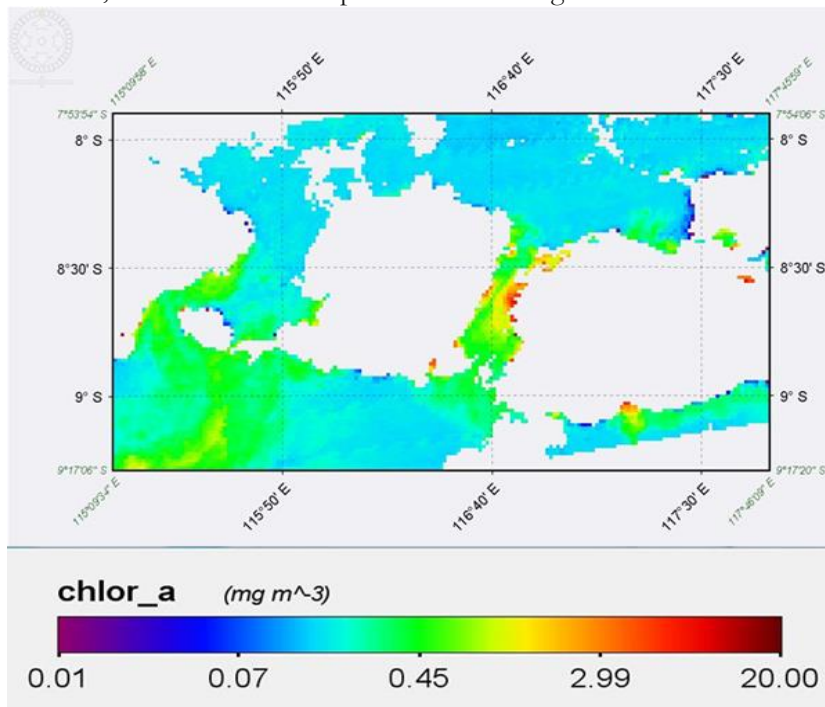


Figure 1. Thematic map of chlorophyll-a concentration around Lombok island in Northside

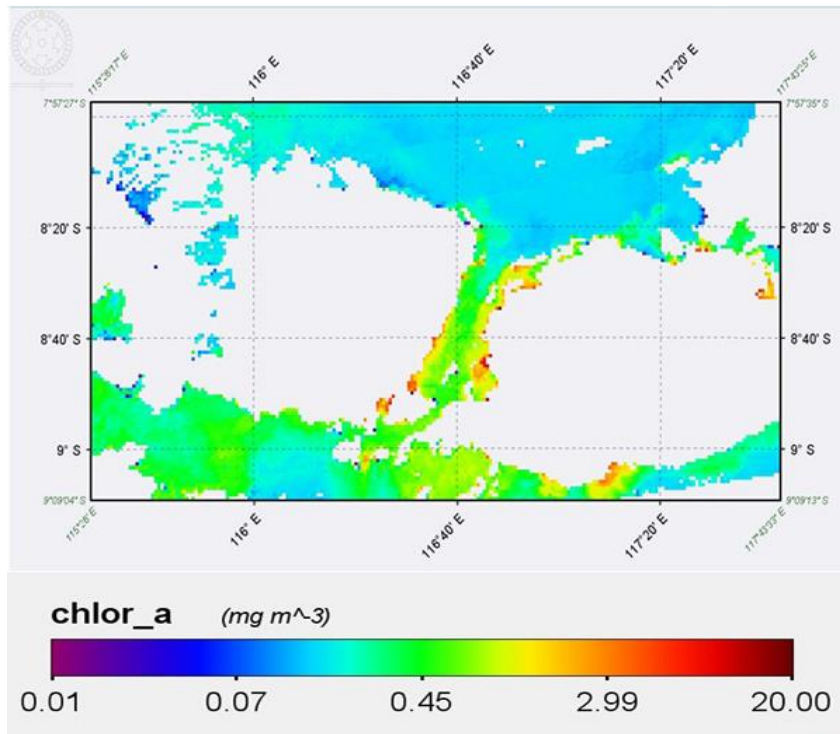


Figure 2. Thematic map of chlorophyll-a concentration around Lombok island in Southside

Figure 3 shows that the Northern side of Lombok island is dominantly blue compared to the green one, where blue color is the chlorophyll-a concentration interval of 0.07 to 0.45. In contrast, the histogram picture (Figure 5) shows the distribution of chlorophyll-a concentration in the north part of the beach. Figure 4 represents the south part of the island of Lombok, more dominant in green color. Thus, it can indicate in this area; there is a concentration of chlorophyll-a, which is represented in the interval of 0.4 to 1.0 mg / m³. The distribution of this concentration value can also be seen in Figure 6, illustrating the histogram of chlorophyll-a concentration in the south part of the beach.

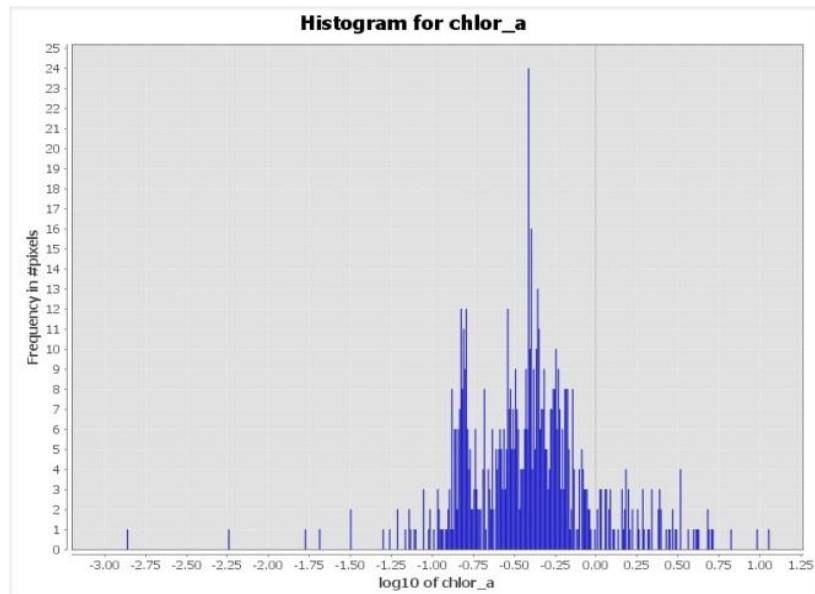


Figure 3. Histogram of chlorophyll-a concentration in Northside of Lombok island

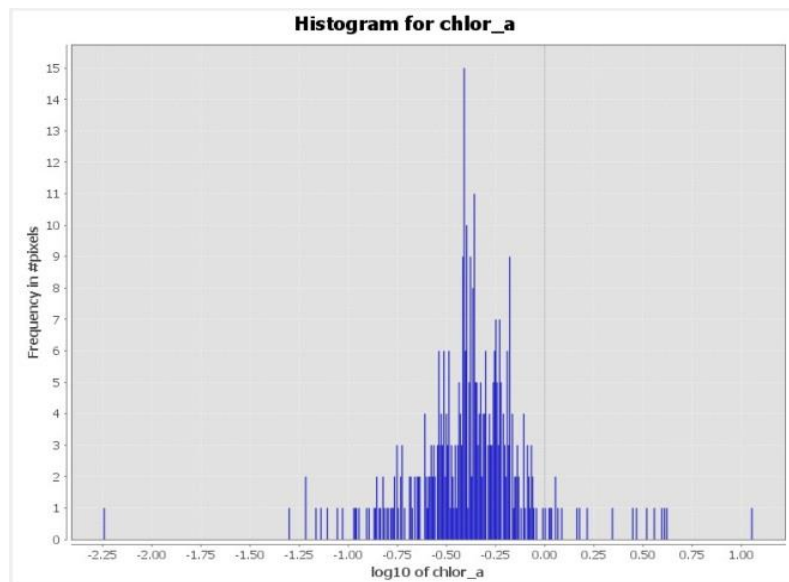


Figure 4. Histogram of chlorophyll-a concentration at Southside of Lombok island

The distribution of chlorophyll-a concentration on the north side of the coast has a minimum value of 0.137 mg / l and a maximum of 0.675 mg / l; the average value shown is 0.214 mg / l with a standard error of 0.0132, as shown in Table 1.

Table 1. Descriptive statistic of chlorophyll-a concentration on October 10, 2017

<i>chlor_a</i>	
Mean	0,214034489
Standard Error	0,013237907
Median	0,16477831
Standard Deviation	0,10254039
Sample Variance	0,010514532
Kurtosis	6,305676661
Skewness	2,314980582
Range	0,5396307
Minimum	0,13567127
Maximum	0,67530197
Sum	12,84206936
Count	60
Largest(1)	0,67530197
Smallest(1)	0,13567127
Confidence Level(95,0%)	0,026488992

Table 2. Descriptive statistic of chlorophyll-a concentration on October 16, 2017

<i>chlor_a</i>	
Mean	0,255574056
Standard Error	0,023900405
Median	0,16424686
Standard Deviation	0,177250148
Sample Variance	0,031417615
Kurtosis	3,456157832
Skewness	1,976231375
Range	0,76068706
Minimum	0,12231274
Maximum	0,8829998
Sum	14,05657308
Count	55
Largest(1)	0,8829998
Smallest(1)	0,12231274
Confidence Level(95,0%)	0,047917427

The results of descriptive statistics for the distribution of chlorophyll-a in data collection on October 16, 2017, show a minimum value of 0.122 mg / l and a maximum value of 0.883 mg / l, as seen in Table 2. The table also shows the average value of the chlorophyll-a concentration of 0.255 mg / l with a standard error of 0.024.

Table 3. T-test statistic of chlorophyll-a concentration in the North and Southside of Lombok island on October 10, 2017

	<i>chlor_a</i> (North)	<i>chlor_a</i> (South)
Mean	0,32430	0,18663
Variance	0,04670	0,00871
Observations	27	27
Pearson Correlation	-0,12411	
Hypothesized Mean Difference	0	
f	26	
t Stat	2,91037	
P(T<=t) one-tail	0,00365	
t Critical one-tail	1,70562	
P(T<=t) two-tail	0,00731	
t Critical two-tail	2,05553	

The T-test result (Table 3) shows differences in the average of chlorophyll-a concentration on the north and south part of the coastal area in Lombok Island on October 10, 2017. The variance value indicates the same amount for the North part of the variance from chlorophyll-a is 0.0467 while on the south part, e shows a value of 0.00871. Thus, it can be assumed that the south side has a smaller variance compared to the Northside, or it can be assumed that the distribution of chlorophyll-a concentration on the south part is relatively more uniform.

Discussion

Evenly spread it out of the chlorophyll-a content in the coastal area will have a beneficial impact on fishermen. This is due to the presence of consistent content in the beach area so that fishermen do not need to search for fish by sailing the boat for long distance from the beach; the longer their sail, the more they use fuel for their motorboat. The shorter distance travel of the fishermen in the shore area will reduce the cost of spending on energy consumption.

From Table 4, it can be explained that the concentration of chlorophyll-a on the northern part of Lombok island has a considerable value of concentration variation because in this area is influenced by currents originating from the Sulawesi islands. It differs from the southern part of the island of Lombok, where the concentration of chlorophyll-a has equitable distribution where this phenomenon is marked by the results of statistical variance that is so small that it can be assumed that at some point, the data collection has the same distribution of concentration, influenced by currents originating from the coast of northern Australia. This finding has demonstrated the suitability of the Chlorophyll concentration mapping in the coastal area of Lombok Island. These points are in line with the results of Acker et al. (2008) as well as the findings presented by Daqamseh et al. (2019) for measurement of chlorophyll-a mapping at the sea surface. Due to the limitation of time collectin the satellite image data, this study does not represent seasonal concentration in Lombok Island, but only representing the variation between the north and south part of the island in which two different sea affected the Lombok Island coastal area, the Indian Ocean in the south and Bali sea in the north part of the island. This surrounding sea may affect the concentration of chlorophyll in the coastal area of the region.

Table 4. T-test statistic of chlorophyll-a concentration in the North and Southside of Lombok island on October 10, 2017

	<i>chlor_a (North)</i>	<i>chlor_a (South)</i>
Mean	0,27251	0,15499
Variance	0,01573	8,13E-05
Observations	27	27
Pearson Correlation	-0,2478	
Hypothesized Mean Difference	0	
df	26	
t Stat	4,7724	
P(T<=t) one-tail	3,06E-05	
t Critical one-tail	1,7056	
P(T<=t) two-tail	6,128E-05	
t Critical two-tail	2,05553	

Conclusion

The study shows that the capabilities of aqua MODIS satellite images in providing chlorophyll-a concentration values with the use of OC3 standard algorithms. The descriptive statistics indicate that the average concentration for October 10 was 0.214 mg / l, with a standard error of 0.013. Meanwhile, data of October 16, 2017, is 0.255 mg/liter, with a standard error of 0.0239. The t-test results in the calculated t value are more excellent than the critical t-value for both the chlorophyll-a concentration of October 10 and October 16. This result indicates that statistically, with an alpha error rate of 5%, a difference in the chlorophyll-a concentration in the north and south sides of the island of Lombok for data sampling on October 10 and on October 16, 2017, the calculated t value is greater than the critical t value. The temporal analysis gives an illustration of the distribution of chlorophyll-a concentration on the coast of Lombok island is not evenly distributed.

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