Optimalisation of remote sensing algorithm in mapping of chlorophyl-a concentration at Pasuruan coastal based on surface reflectance images of Aqua Modis

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Abstract: Chlorophyll-a is one of the parameters used to detect the presence of fish populations, as well as one of the parameters to state the quality of a water. Research on chlorophyll concentrations has been extensively investigated as well as with chlorophyll-a mapping using remote sensing satellites. Mapping of chlorophyll concentration is used to obtain an optimal picture of the condition of waters that is often used as a fishing area by the fishermen. The role of remote sensing is a technological breakthrough in broadly monitoring the condition of waters. And in the process to get a complete picture of the aquatic conditions it would be used an algorithm that can provide an image of the concentration of chlorophyll at certain points scattered in the research area of capture fisheries. Remote sensing algorithms have been widely used by researchers to detect the presence of chlorophyll content, where the channels corresponding to the mapping of chlorophyll –concentrations from Landsat 8 images are canals 4, 3 and 2. With multiple channels from Landsat-8 satellite imagery used for chlorophyll detection, optimum algorithmic search can be formulated to obtain maximum results of chlorophyll-a concentration in the research area. From the calculation of remote sensing algorithm hence can be known the suitable algorithm for condition at coast of Pasuruan, where green channel give good enough correlation equal to $R^2 = 0,853$ with algorithm for Chlorophyll-a (mg / m³) = 0,093 (R (-0) Red - 3,7049, from this result it can be concluded that there is a good correlation of the green channel that can illustrate the concentration of chlorophyll scattered along the coast of Pasuruan.

1. Introduction

Chlorophyl-a is one of the parameter who is needed for the analysis and detection of the quality of the water body. With the enough of chlorophyll-a concentration in the body of water that it could be said that the water was in a good condition where the ecosystem in the water still in a where the aquatic ecosystem can take place well without significant disruption. Research on the content of chlorophyll-a in the sea and coastal areas has been done (Duan, 2010; George, 1976; Gitelson, 2008), as is the calculation of chlorophyll-a concentration directly or indirectly by measuring the volume of phytoplakton in the waters (Cao, 2006; Odermatt, 2012). The chlorophyll-a concentration on the coast has an influence on the continuity of the food chain, which by knowing the amount of chlorophyll-a...
concentration that can be known also the amount of phytoplankton distribution, and phytoplankton itself is required by small fish as a source of food. To detect and mapping the distribution of chlorophyll-a, this can be done either by using Remote Sensing application (Song K., 2013; Silulwane, 2010; Uitz J., 2006; Millan N., 1997), where in the last 10 years the use of various sensors has been developed for MODIS, MERIS or SEAWIFS or Landsat, to the use of high-resolution remote sensing (Qi L., 2014; Siswa nto E, 2013). One of the obstacles of developing countries such as Indonesia is the limitation of existing technology, where the development of satellite technology has not developed significantly because this technology requires relatively expensive funds and Indonesia does not yet have satellites to monitor the natural resources as it is already owned by some developed countries. The coverage area that can be reached by sensors from satellite imagery is very broad and has a high advantage compared to the way the manual in the field that takes a long time and a high error rate. Therefore, this study aims to utilize MODIS satellite image data as a tool to map chlorophyll distribution and to find the optimum algorithm of aqua modis channels that exist in the basic color range that is red, green and blue respectively.

2. Material and Method
The research done with the sample of the area are in north coastal of Pasuruan as a case study where this area known as an fishery area, and the images of satellite used it with Aqua Modis Level 2 with 1 km resolution as it shown in Figure 1.

Name of the images: Aqua Modis; Date of acquision: 3 Maret 2017
File ID of images: A2017062062000.L2_LAC_OC.nc

Figures 1. Aqua Modis composite images at location

In Figure 1 it appears that the original image of aqua Modis that was acknowledged in March 2017 has a resolution of 1 km and the visible color is the composite color of the Aqua Modis image which come from the the wavelenght of 413 nm, 534 nm and 667 nm.

Data collection was conducted during the daytime on the coast of Pasuruan as much as 1 liter with a depth of 20 cm from sea level and taken to the laboratory on Friday, March 3, 2017. The number of data retrieval points are 10 spots spread over the coast of Pasuruan shown in Figure 2. For the determination of chlorophyll concentration performed according to the standard measurement of chlorophyll concentration.
3. Result and Discussion

The results of laboratory measurements for chlorophyll are shown in Table 1 following coordinates of field data retrieval in degree minute units.

Table 1. Data chlorophyll-a with coordinate degree minute second (DMS)

| No | Latitude        | Longitude        | Chlor-a (mg/l) |
|----|-----------------|------------------|----------------|
| 1  | 7°38'25.40"S    | 112°58'35.01"E   | 0.51           |
| 2  | 7°38'49.25"S    | 112°59'4.17"E    | 0.34           |
| 3  | 7°39'9.40"S     | 112°59'29.66"E   | 0.48           |
| 4  | 7°38'41.57"S    | 112°59'46.35"E   | 0.18           |
| 5  | 7°38'53.02"S    | 113° 0'6.83"E    | 0.26           |
| 6  | 7°38'29.78"S    | 113° 0'20.83"E   | 0.52           |
| 7  | 7°38'52.82"S    | 113° 0'48.48"E   | 0.59           |
| 8  | 7°38'13.56"S    | 113° 0'47.34"E   | 0.64           |
| 9  | 7°38'35.84"S    | 113° 1'4.57"E    | 0.49           |
| 10 | 7°38'16.34"S    | 113° 1'28.72"E   | 0.24           |

Table 1 shows that the chlorophyll content in 1 liter of sample water varies considerably but none exceeds the quantity of 1 milligram per liter of sample water and also the difference between each of the picking points is not too large considering the coverage area being studied is only limited to Pasuruan coastal, so that it is sufficient to provide minimal variation for the distribution of chlorophyll-a concentrations.

Table 2. The blue channel (443 nm) algorithm for chlorophyll-a

| No | Algorithm                                                                 | $R^2$  |
|----|---------------------------------------------------------------------------|--------|
| 1  | $\text{Chl-a} = 36.091 \times R(-\text{blue}) - 1.8559$                     | 0.171  |
| 2  | $\text{Chl-a} = 0.00404 e^{111.26 \times R(-\text{blue})}$              | 0.23   |
| 3  | $\text{Chl-a} = 2.2758 \ln(R(-\text{blue})) + 6.7103$                    | 0.176  |
| 4  | $\text{Chl-a} = -9E+06 \times (R(-\text{blue}))^3 + 2E+06 \times (R(-\text{blue}))^2 - 104035 \times R(-\text{blue}) + 2129.1$ | 0.379  |
| 5  | $\text{Chl-a} = 1E+08 \times R(-\text{blue})^{0.9978}$                  | 0.229  |

From the statistical analysis using scatter trend analysis, it can be seen that some empirical models developed on each channel in the satellite image for the Blue channel, Green channel and Red channel as follows, for the blue channel at 443 nm wavelength shown in Table 2 The correlation value of $R^2$ for
the chlorophyll algorithm does not show significant results where the highest value obtained in the form of Cubic model (polynomial power of 3) is $R^2 = 0.379$.

For the Green channel, the values after calculation with statistic to obtain the chlorophyll algorithm are shown in Table 3 where the correlation value shows the increase than the blue channel before, on the Green channel the trend of correlation analysis is shown in the model with $\text{Chlor-a} = 2E+06 \times 4.9115$ algorithm with $R^2$ value of 0.589.

Table 3. The Green channel (531 nm) algorithm for chlorophyl-a

| No | Algorithm | $R^2$ |
|----|-----------|-------|
| 1  | $\text{Chl-a} = 39.484 \times R(-\text{green}) - 1.3779$ | 0.552 |
| 2  | $\text{Chl-a} = 0.0028e108.87 \times R(-\text{green})$ | 0.58 |
| 3  | $\text{Chl-a} = 1.7757 \times \ln(R(-\text{green})) + 5.9088$ | 0.557 |
| 4  | $\text{Chl-a} = 144336 \times (R(-\text{green}))^3 - 2209\times (R(-\text{green}))^2 + 1158.9\times R(-\text{green}) - 19.913$ | 0.569 |
| 5  | $\text{Chl-a} = 2E+06 \times R(-\text{green})^{4.9115}$ | 0.589 |

Table 4. The Red channel (667 nm) algorithm for chlorophyll-a

| No | Algorithm | $R^2$ |
|----|-----------|-------|
| 1  | $\text{Chl-a} = 49.932 \times R(-\text{red}) - 1.2318$ | 0.843 |
| 2  | $\text{Chl-a} = 0.0046e^{134.32 \times R(-\text{red})}$ | 0.843 |
| 3  | $\text{Chl-a} = 1.6178 \times \ln(R(-\text{red})) + 5.9399$ | 0.838 |
| 4  | $\text{Chl-a} = 829919 \times (R(-\text{red}))^3 - 80214\times (R(-\text{red}))^2 + 2623.3\times R(-\text{red}) - 28.635$ | 0.853 |
| 5  | $\text{Chl-a} = 1E+06 \times R(-\text{red})^{4.3774}$ | 0.848 |

Table 4 shows the algorithm for chlorophyll-a in the red channel with a larger correlation value where the highest correlation is obtained in the form of Cubic algorithm with $R^2 = 0.853$, it is indicates that the red channel has a better correlation than the blue or the green channel. Mapping the spread of chlorophyll-a concentration has shown in Figure 3, where it for the concentration distribution was made in 3 classes, white color indicates the absence of chlorophyll data in the area.

![Figures 3](image)

**Figures 3.** The spread of chlorophyl-a concentration at coastal Pasuruan and near it after processing with SEADASS
4. Conclusion

From the pattern of distribution that occurred around the coast of Pasuruan, it can be concluded that the concentration and distribution chlorophyl-a is random and the concentration is smaller from Pasuruan toward the Sidoarjo beach, more chlorophyll is collected around the Madura strait area flanked by Pasuruan beach and Pamekasan Madura beach. The optimal algorithm which are building using the Aqua Modis sensor 1 km resolution obtained that the best condition is owned by the Red channel with the correlation value $R^2 = 0.853$, the equation form of algorithm is $\text{Chlor-a} = 829919*(R(-\text{red}))^3 - 80214*(R(-\text{red}))^2 + 2623.3*R(-\text{red}) - 28.635$

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