Mapping and Analysis A Distribution of Sulfate Concentration at The Sea Surface of Madura Strait Using Geographic Information System (GIS) Based on Landsat 8 OLI Data

Muhsi Muhsi¹, Bangun Muljo Sukojo², Muhammad Taufik², & Pujo Aji³

¹Department of Information System, Universitas Islam Madura (UIM), Pamekasan, Indonesia, 69317, E-mail: muhsi@gmail.com
²Department of Geomatics Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, 60111, E-mail: bangunms@gmail.com, taufik_m@geodesy.its.ac.id
³Department of Civil Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia, 60111, E-mail: pujoaji@gmail.com

Abstract. For concrete planners and salt farmers know the distribution of sulfate in sea water becomes very important as a basis for the manufacture of concrete and as a planning analysis of salt-making. Based on this need to be done mapping the distribution of sulfate concentrations in surface sea water. In addition to the way the analysis in the laboratory, suspected sulfate can be done using an estimation algorithm as a remote sensing technique that results are presented in the form of geographic information systems. With remote sensing techniques will be obtained regional information sulfate at the sea surface since using Landsat 8 satellite recording results. The mapping of sulfate in the straits of Madura Island with Landsat 8 OLI imagery on July 26, 2018, obtained the minimal value was 2078.89 and the maximal value 2429.89. The highest sulfate concentration is in the Ujung-Kamal port area. When using SNI 2847: 2013 / ACI 318M-11 sulfate exposure in the Madura Strait includes a class of S2 with severe severity.

Keywords: Mapping, Remote sensing, Sulphate, GIS, Madura Strait, Landsat 8 OLI

1. Introduction

The needs for sulfate information in seawater is very important as a parameter of an aggressive environment. Among them is a concrete preliminary information for planners to determine exposure to sulfate in the coastal areas as the basis for selecting the appropriate mix of material required SNI 2847: 2013 / ACI 318M-11. Also used for initial information salt farmers in planning the location of the most appropriate salt production to obtain better production quality since a sulfate is one of salt impurity. There are two methods for analyzing the content of elements or compounds in seawater including sulfate. The first is directly take samples of sea water on the surface to then be laboratory tested the content of elements or compounds with a variety of methods and tools used. Including sulfate compounds which are analyzed by the laboratory using the Gravimetric (with ignition or drying of residue) method, Turbidimetric method and Automated methylthymol blue method. (Standard Methods, 4500, 20th edition). The second is indirect, that is by remote sensing techniques through satellite recording images on the sea surface itself.
This applied research is intended to implement the sulfate estimation algorithm to map the distribution of sulfate concentration in the Madura Strait waters presented in the form of Geographic Information Systems (GIS). Model mapping using the raster data in pixel values of Landsat 8 OLI/TIRS be presented in color degradation of the high and low concentrations of sulfate corresponding in every point. Through the SIG, the sulfate concentration distribution in seawater of Madura Island can be used as a basis for making reinforced concrete based on its exposure class in order to maintain of durability. And finally with the results in the form of a mixture of reinforced concrete recommendations are most appropriate, are expected to contribute in the preparation of the master plan the manufacture of reinforced concrete that will be used in seawater, especially the coast of Madura Island.

2. Methodology

This study is an applied research by implementing a sulfate estimation algorithm with the intention of describing a map of the distribution of sulfate concentrations on the sea surface of the Madura Strait. Quantitative data from sulfates are explored qualitatively resulting sulfate exposure class information based SNI 2847: 2013 made by the National Standardization Agency (BSN) or ACI 318M-11 are The Building Code Requirements for Structural Concrete.

2.1. Study Area

The study was conducted in the Madura Strait is geographically located on 7°16’36” Lat - 7°17’20” Lat and 112°56’27” Long - 114°8’48” Long (Figure 1). Since in the strait which tends to be built with concrete materials and coastal easily contaminated by industrial and domestic waste. On the other hand most of the coast there are salt-making land.

![Figure 1. Study area](image-url)
2.2. Data and Processing

The image data used is Landsat 8 OLI imagery with a resolution of 30m x 30m. Landsat 8 OLI imagery is ordered through the page [http://earthexplorer.usgs.gov/](http://earthexplorer.usgs.gov/) at Path : 118, and row : 065 in folder Landsat Collection 1 Level-2 (On-Demand), were Landsat 8 OLI/TIRS C1 Level-2 taken on July 26, 2018. And next the Landsat 8 Level-2 imagery downloaded on the page [http://espa.cr.usgs.gov/](http://espa.cr.usgs.gov/). The Landsat 8 OLI imagery Level-2 that has been downloaded on the page ESPA does not need atmospheric correction. Since it has been done using the internal algorithm by USGS. Thus then performed the conversion of the value of Digital Number (DN) be Rrs sea surface. The process is the calibration by simply dividing the DN value of the pixel to 10000 thus becoming surface reflectance value. Then the results are subdivided by the constant PHI (π) to be Rrs sea surface. Of the several bands on Landsat 8 OLI, only band 5 (NIR) will be used as input data into the algorithm.

Objects earth's surface was recorded Landsat 8 in digital images will be selected before interpreted. Election herein is intended to simplify and speed up the processing since it will reduce the number of pixels in the pixel information while eliminating the unneeded. Mapping the distribution of sulfate concentration in area waters only do so we need a separation between the pixels of land and water. In these conditions there is an algorithm for separating land pixels with water pixels in Landsat 8, that is NDWI (Normalized Difference Water Index). The NDWI algorithm NDWI (Formula 1) will change the image pixel value becomes greater than 0 for water areas and smaller than 0 for land areas [9]. This process is performed after the image pixel value is Rrs and prior to the estimation algorithm implementation. Furthermore, the image processing results with NDWI used as a basis for mapping the sulfate in the Madura Strait to be analyzed. So that the estimation algorithm for the sulfate will only calculate the pixel value above 0 (Formula 2).

\[
NDWI = \frac{Rrs_{b3} - Rrs_{b5}}{Rrs_{b3} + Rrs_{b5}}
\]

(1)

Where :
NDWI : Normalized Difference Water Index
Rrs : Reflectance remote sensing
b3, b5 : band 3 and band 5 of Landsat 8 OLI imagery

\[Rrs \text{ of water} = NDWI > 0? Rrs(\lambda) : 0\]

(2)

Where :
Rrs : Rrs of water to be mapped
NDWI : Normalized Difference Water Index
\(\lambda\) : wavelength

Furthermore, the implementation of Muhsi's research estimation algorithm was implemented (Formula 3) which is a result of the development of the previous algorithm [10].

\[
\hat{Y} = 3055.5(X)^{0.049}
\]

(3)

Where :
\(\hat{Y}\) : estimation variable (sulfate)
X : predictor variable (Rrs of NIR)
The results of the algorithm implementation visually map the distribution of sulfate concentration at the sea surface of Madura Strait presented in geographic information systems. Before the implementation of the algorithm is done cropping the image according to the study site in order to facilitate and easy the process of making maps. All image processing, algorithm implementation and mapping processes are processed using software SNAP Desktop (Sentinels Application Platform).

3. Remote Sensing in Mapping Sea Surface Elements
Remote sensing science being applied in almost every activity related to terrestrial, both in the field of petroleum, agriculture, marine and other natural resources. Applicatively remote sensing technology will not be separated from the presence of sunlight as a source of earth energy that will provide an electromagnetic signal to be recorded by the camera sensor recorder. Remote sensing data were used to estimate the elements at sea surface or object on Earth's surface may use the AOP (Apparent Optical Properties) is the spectral reflectance of the object or the value of IOP (Inherent Optical Properties) is a light absorption value of an element that is portrayed [6]. AOP or IOP data usage will depend on the availability of the data itself or object what would be suspected. Based on these data is then compiled statistic models as estimation algorithm from the elements at sea. The use of remote sensing techniques (algorithm) to suspect elements in seawater has been implemented such as sea surface temperature, sea surface salinity, chlorophyll-a and TSS (Total suspended solid) and sulfate at the sea surface. Through remote sensing techniques of extraction of data from the digital image of the earth's surface will be more effective because they are territorial, temporal and spatial aspects of more can be well managed as needed. Furthermore, the algorithm is implemented on satellite imagery to map elements of the estimated. The imagery used is the result of recording a satellite or other vehicle that has a characteristic wavelength equal to wave at the time of the model was made. The results can be presented in the form of geographic information systems to make it easier to interpret.

4. Result and Discussion
The image of the downloaded from the page of the USGS / ESPA in file formats geotif. In the downloaded folder, there are seven bands with 30mx30m spatial resolution and some supporting files since the image results from an order scene in the grayscale image format (Figure 2).

![Figure 2. Landsat 8 OLI Image of Madura Strait (http://earthexplorer.usgs.gov/)](http://earthexplorer.usgs.gov/)
Of the seven bands that will be used only band 5 (NIR) only to map sulfate in sea surface. Then the image of band 5 (NIR) Landsat 8 OLI calibrated to get the Rrs value. The result is a gradient color for the spread of Rrs both aquatic and terrestrial (Figure 3). Due to be estimated is sulfate in the waters then the separation between aquatic and terrestrial Rrs the results as shown in Figure 4.

![Figure 3. Rrs value distribution of land and water in the Madura Strait](image)

In Figure 3 shown that both the mainland pixels (MADURA and JAVA Islands) and the water has a value of Rrs. While in Figure 4. The only pixels waters that have value while pixels mainland Rrs does not have (white).

The estimation algorithm (Formula 3) is implemented in an image has a value Rrs (Figure 4). Rrs value as a predictor variable (x) is entered into the estimation algorithm equation. The result is a gradation distribution of sulfate concentrations in sea level as shown in the Figure 5.

![Figure 4. Rrs value distribution only in the waters of Madura Strait](image)
Figure 5. Distribution of sulfate concentrations in the Madura Strait waters

In Figure 5 shows that the spread map sulfate concentration in sea water using five color classes. This is used to show details of the class of sulfate exposure in the Madura Strait waters. Color grade is shown in Table 1.

Table 1. Value gradation and sulfate each color class

| No. | Color [R,G,B]    | Sulfate values       |
|-----|------------------|----------------------|
| 1   | 152,216,232      | 2078.89 – 2110.55    |
| 2   | 152,206,22       | 2111.93 – 2157.35    |
| 3   | 225,229,0        | 2158.72 - 2253.70    |
| 4   | 255,51,0         | 2255.08 – 2355.56    |
| 5   | 0,255,0          | 2356.93 – 2429.89    |

In each class has a different number of pixels that shows the distribution of sulfates are most numerous in-class color of sulfate distribution. For more details, like in figure 6.

Figure 6. Graph manipulation class color of sulfate
In Table 1 and Figure 6 shows that the value of the lowest and highest sulfate mapping results are 2078.89 and 2429.89. While the highest number of first distribution of sulfates that are in the fourth color grade is 29% with a range of values sulfate 2255.08 - 2355.56, the second highest in the third color class is 27% with a range of values sulfate 2158.72 - 2255.70, the third highest is the fifth color grade is 21% with a range of values sulfate 2356.93 - 2429.89, the highest is the second color grade is 13% with a range of values sulfate 2111.93 – 2157.35 and the least is the color class unity is 9% with a range of values sulfate 2078.89 – 2110.55. From the results of the mapping, based on SNI 2847: 2013 / ACI 318M-11, the distribution of sulfates in the waters of the island of Madura including exposure class S2 with severity is severe since the condition is in the range of 1500-10000 ppm. However, when viewed from the quartile in the range 1500-10000, the value of sulfate is still in the first quartile value. Where the value of the first quartile in the range of severe sulfate exposure level is 3635, while the maximum sulfate at the sea surface from the Island of Madura estimation algorithm implementation is 2429.89.

The value of the highest sulfate in Madura Island waters are located in coastal areas, especially in the port area of Ujung-Kamal. Since the sea water in areas contaminated by sewage or industrial laboratories whether paper, textiles, metals and households by local people or boats that leans in the harbor. Due to natural factors such as oxidation of organic compounds containing sulfate are not too obtrusive seen from the distribution of the concentrated sulfuric highest in rural areas only. In addition the ship fuel spill mixes with the surrounding water affects water reflectance. While in rural areas can be affected by other coastal estuaries, rainfall with high intensity because it affects the behavior of acid or people around that dump waste.

5. Conclusions

Presentation of distribution information sulfate concentration in the Madura Strait sea surface using geographic information systems has shown that berdasarkan image dated July 26, 2018 the value of sulfate lowest and highest 2078.89 and 2429.89. The highest concentration is in the water area of the port of Kamal-Ujung. Since it is contaminated by various industrial waste or household. Based on ISO 2847: 2013, the distribution of sulfates in the waters of the island of Madura including exposure class S2 with severity is severe.

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