The Mapping of Ground Water Salinity Using Imagery Data of Aqua Modis Satellite In Kwanyar Bangkalan Area

Siti Zainab¹, Novie Handajani², Hendrata Wibisana³
¹,²,³Civil Engineering Department, Faculty of Engineering, UPN Veteran East Jawa Jalan Raya Rungkut Madya, Gunung Anyar, Surabaya, Indonesia

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

Abstract. Salinity is one of the known parameters by water quality researchers as one of indicator to determine the health of water bodies in an area. Whereas soil salinity is an indicator that shows whether the land is suitable for cultivation of rice fields, ponds or for cultivating other crops, or whether the quality of the soil is not good for planting crops. This study aims to map the distribution of groundwater salinity in the Kwanyar Bangkalan area on Madura Island. Since this area is a fairly sloping coastal area, thus there is possibility that the intrusion of seawater will have a significant impact on the distribution of soil salinity. Given the wide coverage area a method that is able to provide solutions in the form of remote sensing technology is used by utilizing Aqua MODIS satellite imagery in the form of a reflectance value calculated by a remote sensing algorithm of groundwater salinity. The results of the calculation are in the form of a thematic map of soil salinity, which statistically has insignificant distribution, which is included by fairly small variance value with an alpha value 5%, the conclusion is that the use of satellite imagery is able to provide updated information in the field of soil salinity mapping for the coastal area.

1. Introduction
Groundwater salinity is one of the parameters in determining the quality of soil. As one of the parameters, groundwater which has a high salinity value will cause growing plants to have difficulty reproducing, this is because with a high salinity value, the salt content in the soil also increases so that it will cause disturbances in the function of plant roots in absorption of materials like food in the form of nutrient molecules needed by plants to grow. The same thing also happens for the pond environment where with a high salinity content, the water from the pond will be an excess of minerals which will cause organisms or living things in the water to die quickly because the environment is not suitable for the environment in which the living things are supposed to grow (1,2).

Research on groundwater salinity has been carried out by experts both in agriculture and in civil engineering where civil engineering experts need a salinity value to determine the quality of the soil to be used to build a building or road where the requirements that must be met are good quality of soil that is strong enough to be used as a support for the building above it.

Remote sensing is also widely used in exploring the salinity value of groundwater, this is possible because remote sensing technology will allow monitoring of a wider area and a shorter time than if observation per point of location will take a long time, mapping groundwater salinity also many have used remote sensing technology like this (3–6).

The satellite imagery used also varies depending on the level of accuracy desired for monitoring groundwater salinity, the most commonly used sensors are the MODIS sensor (7–9), the VIIRS sensor...
(10,11) and the OLI sensor in Landsat (12–14). Satellite imagery of this kind is widely used because it is free and has a large recording area even though the resolution is still coarse because the size per pixel is 1 kilometer or 500 meters for Aqua MODIS satellite imagery, while Landsat has a per pixel size of 30 meters.

This study aims to map the salinity concentration value of groundwater using remote sensing technology. As material for recording used Aqua MODIS satellite imagery which was obtained free of charge from the website https://oceancolor.nasa.gov/ in April 2020.

2. Methodology

To map the soil salinity, this study used Aqua MODIS satellite image data, which has taken from this site: https://oceancolor.glfc.nasa.gov/ with file name MOD09A1.A2020217.h29v09.006.data. The image data is image data Level 2, which has been downloaded for August 2020 as seen on Figure 1.

Figure 1. Display image of Aqua MODIS on August 2020

Figure 1 show the whole Image of Aqua MODIS on August 2020, to facilitate the data processing, the image of Aqua MODIS was cropped thus that made the process of analysis was more manageable. Figure 2 shows the view of Aqua MODIS image after cropping process; it shows the study location of Madura Island with coordinate points and original image color.

Figure 2. Display of Aqua MODIS image after cropping process
After cropping process of Aqua MODIS image, it been given composite color. The display of composite color of Aqua MODIS satellite image is shown on Figure 3. Follow by the correction process of projection with UTM coordinate. Reflectance data of Satellite image wavelength for the purposes of analyzing the algorithm model is given in Table 1.

![Figure 3. Display of composite color of Aqua MODIS satellite image](image1)

![Figure 4. Display of Aqua MODIS image after the process of UTM projection correction.](image2)
Table 1. Reflectance data of image satellite wavelength

| sur_refl_b01= Rrs_667 nm | sur_refl_b03= Rrs_553 nm | sur_refl_b04= Rrs_443 nm |
|---------------------------|---------------------------|---------------------------|
| 0.2078                    | 0.1888                    | 0.1988                    |
| 0.1055                    | 0.1273                    | 0.1168                    |
| 0.3655                    | 0.34                      | 0.3402                    |
| 0.0965                    | 0.0461                    | 0.0807                    |
| 0.0871                    | 0.0486                    | 0.0811                    |
| 0.0549                    | 0.0259                    | 0.055                     |
| 0.0933                    | 0.1188                    | 0.105                     |
| 0.0627                    | 0.0317                    | 0.0595                    |
| 0.0685                    | 0.0352                    | 0.0612                    |
| 0.0613                    | 0.0299                    | 0.0602                    |
| 0.2957                    | 0.278                     | 0.2763                    |
| 0.1068                    | 0.0822                    | 0.1046                    |
| 0.084                     | 0.0979                    | 0.0942                    |
| 0.1033                    | 0.1294                    | 0.1217                    |
| 0.0816                    | 0.1039                    | 0.0939                    |
| 0.1047                    | 0.0615                    | 0.0934                    |
| 0.067                     | 0.0199                    | 0.0538                    |
| 0.0833                    | 0.0379                    | 0.0664                    |
| 0.4653                    | 0.4352                    | 0.4468                    |
| 0.1055                    | 0.1273                    | 0.1168                    |

The above data is an image satellite wavelength data/reflectance on, Rrs_667 nm, Rrs_553 nm, Rrs_443 nm which will be calculated by correlating the salinity in situ data to determine the best algorithmic model and wavelength.

Below on Figure 5 shows the Histogram of wavelength band_01 from Aqua MODIS image or Rrs_667, Figure 6 is Histogram of wavelength band_03 from Aqua MODIS image or Rrs_553 and Figure 7 is Histogram of wavelength band_04 from Aqua MODIS image or Rrs_443.

Figure 5. Histogram of wavelength band_01 = Rrs_667 from Aqua MODIS image
3. Result And Discussion

Obtained data from Table 1, then proceed into algorithm calculation of remote sensing using 4 mathematical models, that are algorithm lineer, exponential, logarithmic and power.

Data were analyzed using scatter diagram on wavelength Rrs_667 nanometer, it was obtained that value which has highest R2 was Linier model \( y = 15.758x - 0.0646 \) with \( R^2 \) value 0.5632 as seen on Table 2.

| No | Algorithm | Mathematical Model | R2   |
|----|-----------|--------------------|------|
| 1  | Linier    | \( y = 15.758x - 0.0646 \) | 0.5632 |
| 2  | Exponent  | \( y = 0.8539e^{4.598x} \)  | 0.4878 |
| 3  | Logarithm | \( y = 2.2362\ln(x) + 6.948 \) | 0.4254 |
| 4  | Power     | \( y = 6.9827x^{0.677} \)   | 0.3966 |
At wavelength of Rrs_553 nm was obtained algorithm model with best $R^2$ value 0.4808 model Algorithm Linier $y = 14.31x + 0.2984$, shown on table 3 below.

| Table 3. Algorithm of remote sensing at wavelength Rrs_553 nm |
|---------------------------|--------------------------|-----------------|---|
| No | Algorithm | Mathematic Model | $R^2$ |
|----|-----------|-------------------|-----|
| 1  | Linier    | $y = 14.31x + 0.2984$ | 0.4808 |
| 2  | Exponent  | $y = 0.973e^{1.956x}$ | 0.3738 |
| 3  | Logarithm | $y = 1.1784ln(x) + 4.8436$ | 0.2512 |
| 4  | Power     | $y = 3.3669x^{0.3197}$ | 0.1881 |

On wavelength Rrs_443 nm obtained $R^2$ best value was 0.5408 with model algorithm Linier $y = 16.869x - 0.175$, as shown on table 4.

| Table 4. Algorithm of remote sensing at wavelength Rrs_443 nm |
|---------------------------|--------------------------|-----------------|---|
| No | Algorithm | Mathematical Model | $R^2$ |
|----|-----------|-------------------|-----|
| 1  | Linier    | $y = 16.869x - 0.175$ | 0.5408 |
| 2  | Exponent  | $y = 0.8382e^{4.814x}$ | 0.4475 |
| 3  | Logarithm | $y = 2.1609ln(x) + 6.7778$ | 0.3828 |
| 4  | Power     | $y = 6.1977x^{0.6241}$ | 0.3248 |

The recapitulation of those three tables above shows that the best algorithm model is linear regression model with wavelength at Rrs_667 nanometer obtained $R^2$ value 0.5632, the highest value is on Linier model $y = 15.758x - 0.0646$. These data is employed as a basis to do the validation of salinity value toward those four algorithm models.

In situ salinity validation of 5 latest data that were from pin 15 until pin 20 using wavelength Rrs_667, with 4 models; linear regression, exponential, logarithmic and power, is shown on table 5 below.

| Table 5. Validation of Salinity value on several mathematical models |
|---------------------------|--------------------------|-----------------|---|
| Salinity (o/oo) | Linear | Exponent | Logarithmic | Power |
| 0.78 | 1.586 | 1.382 | 1.902 | 1.515 |
| 0.36 | 0.992 | 1.162 | 0.904 | 1.120 |
| 0.56 | 1.249 | 1.252 | 1.391 | 1.298 |
| 7.91 | 7.268 | 7.254 | 5.237 | 4.160 |
| 1.76 | 1.598 | 1.387 | 1.919 | 1.523 |

The comparison of correlation mathematic model with insitu data is shown in table 6 below.

| Table 6. Comparison of correlation mathematic model with insitu data |
|---------------------------|--------------------------|-----------------|---|
| Salinity (o/oo) | Linear | Exponent | Logarithmic | Power |
| Salinity (o/oo) | 1 | | | |
| Linear | 0.99347 | 1 | | |
| Exponent | 0.98968 | 0.998200 | 1 | |
| Logarithmic | 0.98664 | 0.988442 | 0.97760 | 1 |
| Power | 0.99335 | 0.999286 | 0.99522 | 0.99346 | 1 |
Result of correlation analysis is shown on table 6. The comparison of correlation is shown on table 5 with the highest correlation value on Linier algorithm model with correlation value 0.99347 classification is Very strong positive correlation with best reflectance Rrs_667. Thematic salinity map with Linier algorithm model at wavelength Rrs_667 is algorithm model \( y = 15.758x - 0.0646 \) shown on Figure 8 as Thematic Salinity Map with linear algorithm and Figure 9 is the distribution Histogram of Salinity distribution with linear algorithm.

![Thematic Map of Salinity with Linear Algorithm](image)

**Figure 8.** Thematic Map of Soil Salinity with linier algorithm

![Histogram of Salinity distribution value with linier algorithm](image)

**Figure 9.** Histogram of Salinity distribution value with linier algorithm

4. **Conclusion**

Aqua MODIS satellite image could be utilize to do the analysis of coastal area salinity, despite its wide coverage, however it still could give good reflectance towards the study area. Besides that the distribution of salinity that occur is evidently to have best correlation, this is shown with mathematic
model of linear regression $y = 15.758x - 0.0646$ where $y$ is Salinity and $x$ is reflectance value with wavelength $Rrs_{667}$.

5. References

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