Waters Quality Assessment on Physical-Chemical Parameters Using Remote Sensing Technologies: Criteria for Total Suspended Solids and Waters Transparency

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Abstract. Waters territory is an area that has a large enough natural resource potential. This region has undergone many changes in function to be able to provide benefits and a large contribution in improving the community's economy, but economic activities that convert aquatic land into industrial areas, tourism, and settlements have caused a fairly severe deterioration in waters quality. Some parameters determining the quality of waters include Total Suspended Solid (TSS), and Water Transparency. The development of remote sensing is increasingly rapid making this technology more effectively used for wide coverage areas. This research aims to analyze the concentration level of TSS distribution and waters transparency by using remote sensing data. The results of data processing showed the range of suspended solids in the research area ranged from 9,706 to 16,193 mg /L, and the range of waters transparency is from 3.6536-4.8278 m. The results of the waters quality index processing data from this research based on parameters used are classified into 3 classes; high waters quality, moderate waters quality, and low waters quality. Waters quality in this research which has low waters quality and moderate waters quality is around the island, while most of the results have high waters quality.

Keywords: Total Suspended Solid, Water Transparency, Water Quality

1. Introduction

Waters pollution is defined as the entry or inclusion of living things, substances, energy or other components into waters by human activities (Duan & Takara, 2019) so that the quality of waters drops to a certain level that causes waters to no longer function in accordance with its designation (Schweitzer & Noblet, 2018; El-Zeiny & El-Kafrawy, 2017). Polluted waters can be measured based on physical parameters and chemical parameters. Physical parameters usually include color, odor, turbidity, and taste. While chemical parameters include pH, temperature, Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS), Total

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Dissolve Solid (TDS), copper, iron and ammonia (Sebestyén et al, 2017; Ratnaningsih et al 2019).

Total suspended solids (TSS) are suspended materials with a diameter of> 1 μm that are held in Millipore paper with a pore diameter of 0.45 μm (Yanti et al 2016; Manoppo & Budhiman, 2017; Kurniadin & Jaelani, 2016) TSS consists of mud, fine sand, and micro-organisms which are mainly caused by soil erosion. Total Suspended Solid (TSS) describes the amount of suspended material or particles which usually has a bad impact on waters quality because it reduces the penetration of sunlight into the waters column (Kim et al 2017). Measurement of suspended sediment in-situ is one alternative to find out environmental conditions based on environmental parameters (Kurniadin & Jaelani, 2016).

Brightness waters is the level of waters transparency (Lubis et al, 2018; Olmanson et al, 2016). By knowing the brightness of the waters we can find out the possibility of the process of assimilation in waters, which layers are not turbid, and which is most turbid (Deutsch eta al, 2018). Waters that have a low transparency value during normal weather can provide a clue or an indication of the number of particles suspended in these waters (Lubis et al, 2018). Waters transparency can be observed visually using a Secchi disk (Olmanson et al, 2016; Lubis et al, 2018; Yanti et al 2016), but visual observation requires quite a long time if the research area has a wide scope (Wicaksono et al 2016; Anurogo et al, 2019).

Remote sensing is the process of gathering information without direct contact with the object under research carried out using an airplane or satellite (Danoedoro, 2012; Anurogo et al, 2018). The development of remote sensing is increasingly rapid making this technology more effectively used for ecosystems with wide coverage areas (Wicaksono et al 2016; Danoedoro, 2012; Anurogo et al, 2019). Remote sensing is able to provide information and synopsis description because it plays an important role to map, monitor, and evaluate coastal and marine areas at the same time (Yanti et al 2016; Lubis et al, 2017). Satellite imagery is a remote sensing technology that can describe the appearance of objects on earth that have different spatial and temporal resolutions. One application of remote sensing data is to know the distribution of TSS concentrations and waters transparency (Yanti et al 2016; Kurniadin & Jaelani, 2016).

The existence of TSS in waters can affect the ecosystem contained therein. The remote sensing method will assist in conducting a spatial TSS analysis of a particular area without direct contact with the research area. Estimating the distribution of TSS will be carried out using an algorithm formula (Yanti et al 2016; Manoppo & Budhiman, 2017). Based on this background, this research aims to analyze the concentration level of TSS distribution and waters transparency in Piayu Waters. Piayu waters are one of the sea transportation routes used by the surrounding community for daily life. The turbidity level in Piayu waters is caused by several factors such as community activities whose main activities are as fishermen and using it as aquaculture land. Excessive erosion caused by the expansion of residential areas, plantations located around the coast which also affects the value of TSS in these waters..

2. Methods

This research is located in Tanjung piayu waters. Tanjung Piayu is located in the Sei Beduk sub-district. Sei Beduk sub-district of Batam City is one of the 12 Sub-Districts in Batam City. This sub-district was formed concurrently with the formation of the Batam sub-district based on Law no. 53 of 1999. Tanjung Piayu is geographically located at 0 ° 55 - 1 ° 55 North, 103 ° 45 - 104 ° 10 East. The research location is shown in Figure 1.

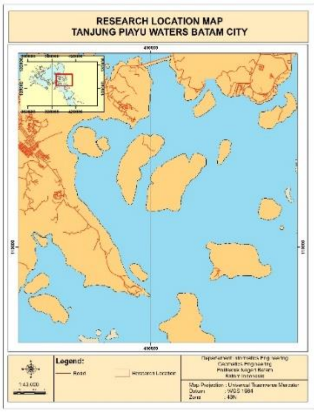


Figure 1. The research location map

Remote sensing data processing is performed using two analyzes, including digital analysis and visual analysis (Anurogo et al, 2017). Digital data analysis is the processing of image data in two dimensions, while visual analysis is carried out by the introduction of object elements (distribution patterns) drawn through image elements through elements of image interpretation and are presented in the form of thematic maps (Yanti et al 2016; Anurogo et al, 2018). Both data processing results are then used as a basis for field sampling (in-situ data collection) (Kurniadin & Jaelani, 2016; Ratnaningsih et al 2019). Data processing results are then performed correlation regression analysis to determine the appearance of remote sensing image data on in-situ data (Guimarães et al, 2019; Anurogo et al, 2019; Manoppo & Budhiman, 2017). The first data processing stage is by downloading Landsat 8 image data which will be used as a processing reference data, then the two data are carried out radiometric correction and geometric correction.

Geometric correction in Landsat imagery is an effort to correct recording errors geometrically and is done by translation, rotation, or scale shifting (Danoedoro, 2012). Geometric errors occur because there are no ideal conditions on a sensor when recording objects in the field. As a result, the size, position, and shape of the image do not match the actual conditions in the field. The non-systematic rectification process on geometric correction starts with collecting the necessary data such as GPS data for making ground control points (GCP) (Anurogo et al, 2017). Radiometric Correction is a technique for improving satellite imagery to eliminate atmospheric effects that cause changes in digital number (DN) values on earth's surface image recordings (Wicaksono et al 2016; Yanti et al 2016). The stages of calibration and changes in values on radiometric corrections can be seen in Figure 2.

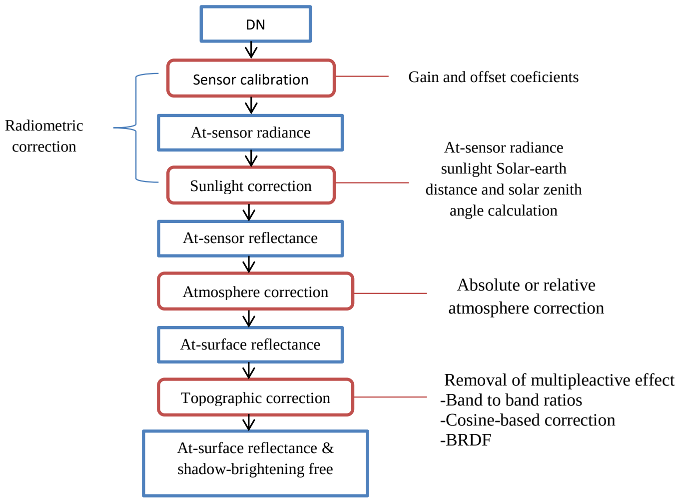


Figure 2. Radiometric Correction Scheme (Anurogo et al, 2018)

The error of DN is caused by the influence of the sun's elevation angle and the distance of the earth's sun. The radiometric correction process uses the equations below (Danoedoro, 2012; Anurogo et al, 2018):

DN to Radiance

$$L_\lambda = \left(\frac{L_{max} - L_{min}}{QCAL_{max} - QCAL_{min}}\right) \times (Q_{cal} - QCAL_{min}) + L_{min} \quad \text{.........................(1)}$$

L_λ	= spectral radians (W/(m2 .sr.µm)
Q_{cal}	= digital number (DN)
$QCAL_{min}$	= the minimum pixel value that refers to LMINλ (DN)
$QCAL_{max}$	= the maximum pixel value that refers to LMAXλ (DN)
L_{min}	= the minimum radian spektral (W/(m2 .sr.µm)
L_{max}	= the maximum radian spektral (W/(m2 .sr.µm)

Radiance to reflectance

$$\rho\lambda = \frac{\pi . L\lambda . d^2}{ESUN\lambda . \cos \theta_s} \quad \text{..(2)}$$

$\rho\lambda$	= reflectance value
π	= mathematical constant (3,14159)
d^2	= distance of the sun - earth (astronomical unit)
$ESUN\lambda$	= average exoatmospheric solar irradiance (W/m2.sr.µm)
θ_s	= sun zenith angel (degree)

Dark pixel substraction

RC=R-Rsi…………………………………………………….(3)

RC	= surface reflectance
R	= TOA reflectance
RSI	= spectral value used for offset

Remote sensing image data after geometric and radiometric corrections, the image is then processed using TSS Algorithm and waters transparency Algorithm that has been determined. The Algorithm used in remote sensing data is used as an approach to the object under research. TSS algorithm (Kurniadin & Jaelani, 2016) and waters transparency algorithm (Olmanson et al, 2016; Deutsch et al 2018) in this research use:

$TSS(mg/L)=1.5212*(\log Rrs(\lambda 2)/(\log Rrs(\lambda 3)))-0.3698$…………………………….(4)

$SDT(m)=1.135*L1/L2-3.193$……………………………………………..(5)

Where the TSS algorithm uses the comparison of the green channel and the red channel while the brightness of the waters uses the comparison of the blue channel and the green channel in Landsat 8 image data. Waters quality is obtained by combining these two parameters (TSS concentration and waters transparency).

3. Results And Discussion

The first index transformation performed on processing this data after geometric correction and radiometric correction is the total suspended solids transformation. Transformation of Total Suspended Solids (TSS) is used as an approach to find actual suspended solids in the field by making the transformation data as a reference for in-situ field data collection. The TSS transformation image is shown in figure 3.

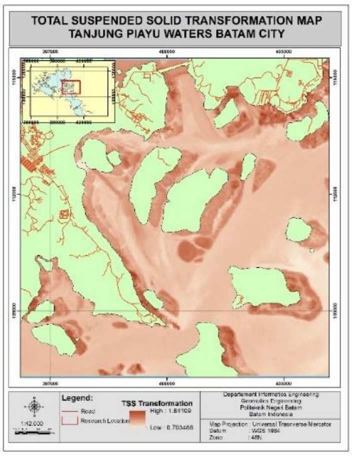
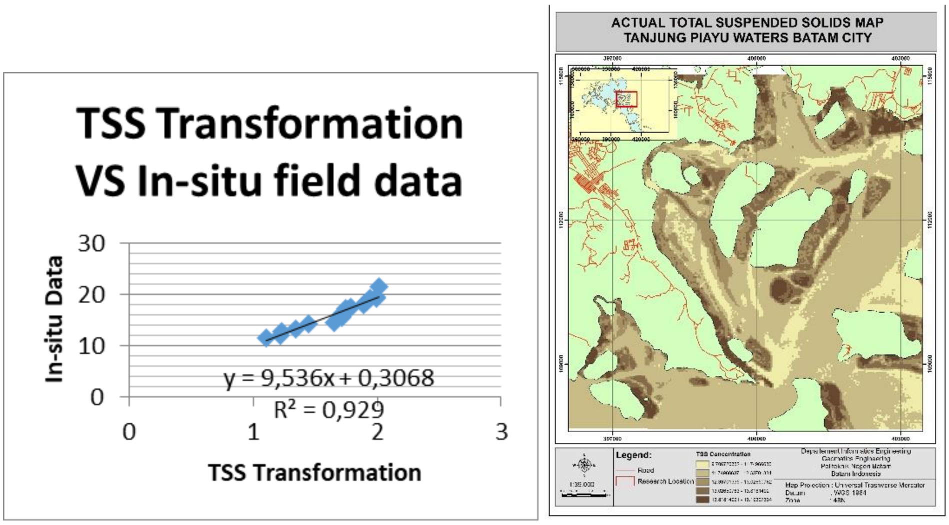


Figure 3. The TSS transformation image

The transformation results show the range of TSS transformation values obtained ranged from 0.7-1.84. The distribution of TSS transformation values is then used as a reference for in-situ field data collection. The value of TSS transformation and the results of in-situ TSS field measurements are then performed correlation regression analysis to see the relationship between the two variables. The relationship between the two variables is represented in R2 and the formulation Y = aX + b. The Y = aX + b formulation is then used to create a TSS concentration distribution model from remote sensing image data to in-situ field data. The results of data processing show that the relationship between the two variables gets the formulation y = 9.536x + 0.3068 with an R2 value of 0.929. The 2-dimensional matrix of the relationship between these two variables and the actual TSS distribution that results from the estimation of remote sensing image data in the in-situ field data is shown in Figure 4 and Figure 5.



(a) (b)

Figure 4. (a) The 2-dimensional matrix variables, (b) The actual TSS distribution

The results of the actual distribution of TSS concentrations indicate that in the research area, the range of suspended solid loads ranges from 9,706-16,193 mg / L.

The next image data processing performed in this research is the transformation of waters transparency. The steps for processing waters transparency transformation are the same steps as TSS transformation. This waters transparency transformation is also used as an approach to get the actual waters transparency value in the research area. Transformation of waters transparency is also used as a basis for in-situ field data collection, then the two data are analyzed by correlation regression analysis to obtain the distribution of waters transparency appearance from the extraction of remote sensing image data. The distribution of actual waters transparency in the research area is shown in Figure 5.

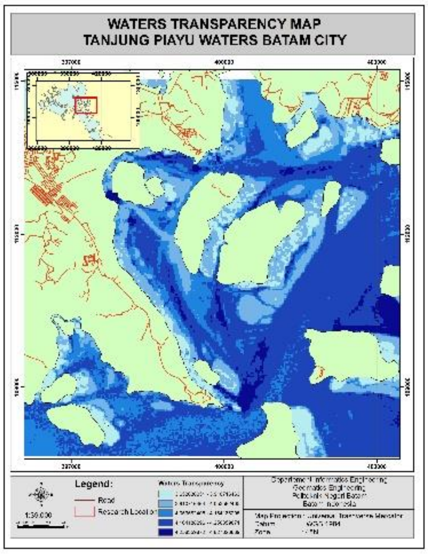


Figure 5. The distribution of actual waters transparency

The data processing results of waters transparency show that in the research area, the level of waters transparency has a range between 3.6536-4.8278 m.

Waters quality in this research uses two parameters as a reference. The parameters used to determine the quality of settlements in this research are the concentration of Total Suspended Solids (TSS) and waters transparency. The two parameters are then overlaid to get a mapping unit of waters quality. The mapping unit is then given a score to get an index of waters quality. Waters quality distribution results from image data processing and field data based on the waters quality index shown in Figure 6.

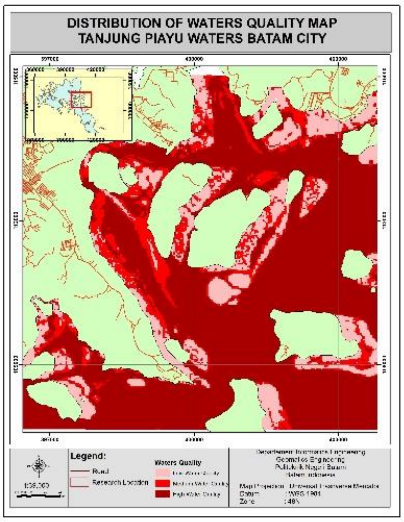


Figure 6. Waters quality distribution

The results of data processing about waters quality indicate that in the research area based on the parameters used the majority of waters quality is still included in the category of high waters quality. This is because the parameters used are Total Suspended Solid (TSS) and waters transparency, while the transport of suspended solid material does not reach the middle of the sea only around the island and waters transparency is a parameter whose change is directly proportional to TSS

4. Conclusion

The distribution of waters quality using the extraction of remote sensing image data in this research was obtained using two parameters. The first parameter used is the Total Suspended Solid (TSS) parameter. The results of data processing showed the range of suspended solids in the research area ranged from 9,706 to 16,193 mg / L. The second parameter used in this research to find waters quality is waters transparency. Based on the results of data processing, the distribution of waters transparency in the research area ranged from 3.6536-4.8278 m. The results of the waters quality index processing data from this research based on parameters used are classified into 3 classes; high waters quality, moderate waters quality, and low waters quality. Waters quality based on TSS and waters transparency in this research which has low waters quality and moderate waters quality is around the island, while most of the results of this research have high waters quality based on TSS parameters and waters transparency.

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