

Study of total suspended solid concentration based on Doxaran algorithm using Landsat 8 image in coastal water between Bodri River estuary up to east flood canal Semarang City

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Study of total suspended solid concentration based on Doxaran algorithm using Landsat 8 image in coastal water between Bodri River estuary up to east flood canal Semarang City

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Abstract. The water quality in the northern coastal waters estuary of Central Java has been polluted at a moderate to severe level. Water quality monitoring efforts for evaluating the condition of dissolved sedimentation can be done through total suspended solid methods by analysing the remote sensing imagery. Total suspended solid (TSS) is measured by suspended material (diameter > 1 μm) which retained in the millipore filter with a 0.45 μm pore diameter. The purpose of this research is to assess the distribution of TSS concentrations in the research location. This study was conducted using Landsat 8 image data on August 9th, 2018. TSS concentration values were obtained through linear regression tests Doxaran algorithm which is the most suitable algorithm with the field condition. The results showed that: 1) The appropriate empirical algorithm for mapping TSS concentrations is the Doxaran algorithm with the TSS equation = $1.0248x - 10.503$, 2) Distribution of TSS with the range >75 mg/l mostly concentrated in center and west of the study area, while the concentration with range <75 mg/l is concentrated in the east, and 3) Distribution of TSS is affected by the movement of currents driven by the wind towards the west and southwest and partly collected in the western part of the study area.

1. Introduction

The sedimentation process in river estuaries affects the level of water pollution itself, because the material transported not only comes from the process of soil erosion, but also mixes with industrial waste and household waste, as well as liquid and other solid materials [1]. These materials are then suspended in the waters of the estuary which causes turbid waters and decreases water quality. One of the efforts in the monitoring of water quality is by using the estimation method Total Suspended Solid (TSS). Total Suspended Solid is suspended material (diameter > 1 μm) which is retained in millipore filters with a pore diameter of 0.45 μm [2]. The cause of TSS in the main waters is soil erosion or s erosion which is carried to the body of water. Suspended and dissolved materials in the waters are not toxic, but if excessive, especially TSS, can increase the value of turbidity; which in turn will inhibit the penetration of sunlight into the water column and ultimately affect the photosynthesis process in the waters [2]. From these explanations, TSS can be considered as an initial indicator in evaluating water-soluble sedimentation in the study area.



The coastal area between Bodri River in Kendal Regency to East Flood Canal in Semarang City has many rivers flowing into the northern coastal waters of Central Java such as the Bodri River, Brangsong River, Bringin River, Garang River (West Flood Canal) and Babon River. These rivers flow through densely populated areas such as Semarang City and Kendal Regency. It gives the possibility that the flow of the river that passes through the city carrying the organic material and non-organic that can affect water quality and increase the capacity of sedimentation in the estuary of the river flow, which is in the waters of the north coast of Central Java [3].

The northern coastal waters of Central Java have many economic potentials in various sectors, such as tourism, marine fisheries (capture fisheries and marine aquaculture along the North Coast of Central Java), coastal cultivation (ponds), and transportation, such as Tanjung Mas Port in Semarang City and the Kendal Ferry Port in Kendal Regency. If the quality of water in coastal waters is disrupted by sedimentation from organic, non-organic, or other materials, it can disrupt the economic activities in the northern coastal areas of Central Java [3], for example fishing activities.

In Garang Watershed, there were various kinds of pollutants such as pesticides originating from agricultural activities. There are also Cr, that comes from mining, electroplating, textile, and tannery industries such as textile, tofu, bakery, and biscuit industries, and there is heavy metal in fish, Pb, which may be because the area was polluted by the industrial activities. Pb is very dangerous for the health. Heavy metal residues in the contaminated sediments can accumulate in microorganisms, such as aquatic flora and fauna, which may enter the food chain and lead in human health problems [4].

The quality of the coastal waters of the city of Semarang is highly influenced by several large rivers that empties, where the rivers are tipped at Ungaran Mount. There is one large river that crosses the city Semarang city and empties into the Java Sea, the West Flood Canal River, where the river is the mouth of the Garang River and the Kreo River. The two rivers carry pollutants originating from domestic waste so that they can pollute the coastal waters of Semarang City [5]. Thus, liquid and solid waste that comes from domestic waste in Semarang city and Semarang Regency directly enters the sea through the Canal Flood, so it has the potential to reduce the quality of sea water in coastal waters of Semarang City [6].

This study aims to determine the distribution of TSS (Total Suspended Solid) concentrations based on Doxaran's empirical TSS algorithm using Landsat 8 imagery in coastal waters between Bodri River and East Flood Canal Semarang City [7]. Doxaran algorithm is used because this algorithm is most suitable to be applied in the research area compared to other TSS algorithms [8].

2. Research Method

The research was conducted on August 9th, 2018. The research location was located at coordinates 110 ° 10'E longitude and 6 ° 50'41"S latitude to 110 ° 26'E longitude and 6 ° 56'S latitude. The research location was taken in the waters along the coastline between the mouth of the Bodri River and the East Flood Canal. The research variable is the distribution of TSS concentrations in waters along the coastline between the estuary of the Bodri River and the East Flood Canal. It is essential to use cloud-free satellite image. Selection of cloud-free image data becomes the main requirement for the evaluation results to be done has a high accuracy value [9]. Especially if the imagery has medium spatial resolution, such as Landsat 8 Operational Land Imager (OLI) in 30 m resolution [10]. Landsat 8 Remote Sensing imagery Path 210 Row 65 with the acquisition date on August 9th, 2018 was used in this research. Software that was used in the image processing were ER Mapper 7.0, and ArcGIS10. The estimation of TSS concentration was carried out using the Doxaran empirical algorithm [11], as follows:

$$\text{TSS (mg/l)} = 5,1271 \times \exp(27 \times \text{Red Band Reflectance}) \quad (1)$$

3. Research Results and Discussion

3.1 Image Restoration Stage.

Image restoration includes geometric correction, radiometric correction and image masking. The results of correction are described as follows.

a. Geometric Correction.

The RMSE value after geometric correction is 0.222 pixels, which means that the error value is 0.222×30 meters = 6.7 above ground, and still within the tolerance limit.

b. Radiometric Correction. Radiometric correction was done by the following formula:

$$((\text{Mult Band} * \text{Band Image Reflectance}) + \text{Reflectance Add Band}) / \text{Sun Elevation (Cos } z) \quad (2)$$

Then the formula is as follows:

$$\text{Radiometric Correction} = ((0.00002 \times i1) + - 0.1) / 0.79606211 \quad (3)$$

Where $i1$ is the band input that will be corrected.

3.2 TSS Accuracy Test Results of Doxaran Algorithms Stage.

TSS calculation results with Doxaran Algorithm need to be tested carefully by taking field samples and so on in laboratory tests. TSS calculation results from the Doxaran algorithm are correlated with laboratory test results. Based on the results of a simple linear regression test, the Doxaran algorithm is the best algorithm with an R value (correlation) of 0.956 and the calculation of the determination coefficient (R^2) is 0.915 (91.5%), then the new equation is $TSS = 1,0248x - 10,503$. The strong correlation indicates that the TSS results from the Doxaran algorithm have a TSS value that is almost the same as the TSS value of the results of laboratory tests of water samples.

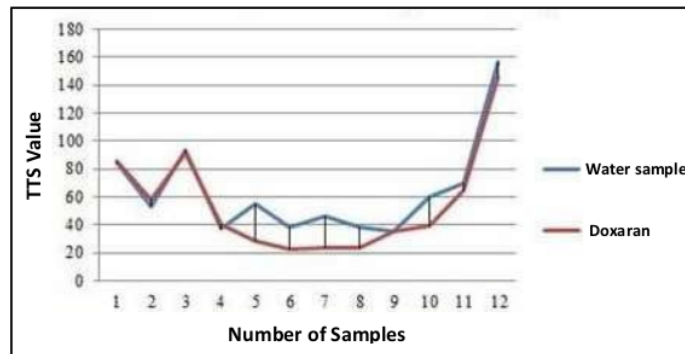


Figure 1. Relationship of Linear Regression Test Results Graph

The TSS concentration results from the estimation of the Doxaran algorithm have a tendency to the same pattern as the TSS concentration in the field, but at some points there are significant differences (Figure 1). The difference in TSS concentration results from taking water samples with TSS results from the estimation of the Doxaran algorithm can be caused by differences in sampling time resulting from water sampling with image recording time and haze factor (scattering of small particles) contained in the air. Water sampling conducted at 09:00 am until 12:00 pm, while the image recording time on the metadata of Landsat Satellite 8 acquisition images on August 9th, 2018 shows at 02:47 A.M or at 14:47 WIB.

3.3 TSS Classification Analysis Based on the Doxaran Algorithm Stage.

Map of the distribution of TSS concentrations from the Doxaran algorithm can be seen in Figure 2. TSS concentration values on the map were divided into 7 classes to see the distribution of concentration

values ranging from 25 mg / l to > 150 mg / l (Table 1). The following is the area of each TSS class based on the Doxaran algorithm.

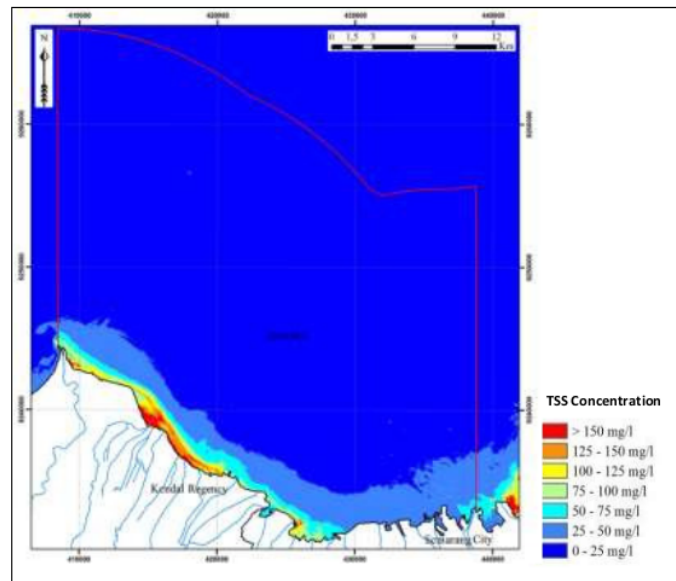


Figure 2. TSS concentration distribution map from the Doxaran algorithm at Bodri and east canal estuary in dry season of 2018

The TSS concentration in class 1 of the study area has the most dominant area, which is 677.23 km² which occupies 86.75% of all study location waters. This is because in class 1 the TSS value produced through the TSS Doxaran algorithm ranges from less than 25 mg / l, is deep sea water so that the sedimentation distribution does not move to the class 1 region, then this class is considered not included in the area affected by the movement suspended sediment.

Table 1. Class TSS Concentration

Class	Range of TSS Values	Color	Area (Km ²)
1	0-25 mg/l	Dark Blue	677,23
2	25-50 mg/l	Blue	72,32
3	50-75 mg/l	Light Blue	14,75
4	75-100 mg/l	Green	7,12
5	100-125 mg/l	Yellow	3,86
6	125-150 mg/l	Orange	3,36
7	>150 mg/l	Red	2,04

Class 2 (25-50 mg / l) has an area of 72.31 Km² of the total area of the study area. Class 2 is spread evenly but has different distribution variations. In the eastern part of the class 2 study area began to be concentrated at a distance of 700-800 meters from the coastline, but in the waters around the West Flood Canal class 2 covers all waters that cover the river mouth. In the central and eastern part of the study area, class 2 begins to concentrate at a minimum distance of 700 meters - 1 kilometer from the coastline.

Class 3 (50-75 mg / l) has an area of 14.75 Km² of the total area of the study area, and most dominates around the waters of the East Banjir Kanal River estuary. The waters covering class 3 are mostly concentrated and spread evenly in the middle to western waters of the study area, with a distance of 300-500 meters from the coastline. Class 4 (75-100 mg / l) has an area of 7.12 Km² from the total area of the study area. Class 4 is mostly concentrated in the waters around the central part of the study area that enters the waters of the Semarang city, with a distance of less than 300 meters from the coastline, and the eastern waters of the study area with a distance of 400 meters from the coastline.

Class 5 (100-125 mg / l) has an area of 3.85 Km² from the total area of the study area. Class 5 is concentrated in the western part of the study area in the waters of Kendal Regency with a distance of less than 500 meters from the coastline, and is spread most dominantly on the east side of the river Bodri estuary in an area directly adjacent to the coastline of less than 200 meters. Class 6 (125-150 mg / l) has an area of 3.35 Km² of the total area of the study area. Class 6 is only found in the western part of the study area that is in the waters of Kendal Regency. Class 6 is predominantly concentrated in the southeast of the Bodri River estuary up to a distance of 100-300 meters from the coastline.

Class 6 also has a small portion at the mouth of the Bodri River. Class 7 has an area of 2.04 Km² of the total area of the study area, only spread in the waters in the western part of the study location that entered the waters of Kendal Regency. Class 7 also has a small portion in the southeast of the river Bodri estuary with a distance of less than 200 meters to the waters bordering the coastline.

3.4 Determination of Field Sample Points

Purposive sampling technique was applied in which the results of the classification of sedimentation classes based on the color of Landsat 8 RGB 432. This image will be used to determine the point of the samples obtained in the field considered to represent the waters of sediment cells (Figure 3).

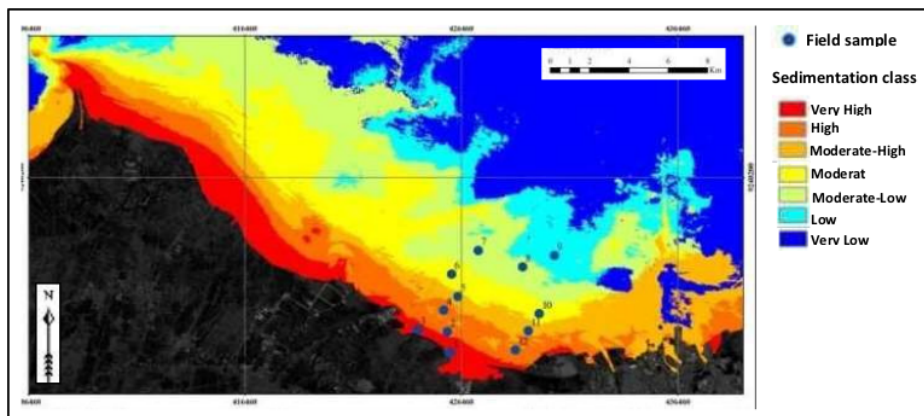


Figure 3. Sample Reference Point Map by Sedimentation Class

3.5 Water Sampling Points and Water Sample Results

There are 12 water sampling points showed in the table 2. Water samples were taken at a depth of 20 cm to 30 cm below sea level. TSS distribution with a high concentration value (more than 75 mg / l) is collected more in the middle and west of the study location. This is influenced by the flow of river estuaries in these locations, such as the estuary of the Bringin River and the Plumbon River in the west and southwest of the central part of Semarang City, and the Blorong River, Bendo and Buntu Rivers in Kaliwungu District, Kendal District. In addition, sediments can also be carried away by ocean currents which are affected by wind direction.

Table 2. Sample Location of TSS Values

No.	Coordinate of Sample Points		TSS Result of Water Sampling (mg/l)
	X	Y	
1	110°19'30''	06°56'24''	85
2	110°19'23''	06°56'11''	53
3	110°18'54''	06°56'11''	93
4	110°19'27''	06°55'40''	37
5	110°20'26''	06°55'43''	55
6	110°20'51''	06°55'17''	38
7	110°21'21''	06°55'07''	46
8	110°21'34''	06°55'38''	37
9	110°21'29''	06°56'11''	35
10	110°21'24''	06°56'45''	60
11	110°21'08''	06°57'10''	70
12	110°19'42''	06°56'50''	156

High TSS concentrations are found more in the waters of Kendal Regency, such as at the mouth of the Blorong River. This raises the suspicion that there is some sedimentation material and other TSS forming in the eastern part of the study location (the mouth of the East Banjir Kanal River) which is carried along the coast along the coast and deposited in the west. In May – September, ocean currents in the Java Sea flow to the west and vice versa from November to March ocean currents flow to the east. On July, which is included as the east monsoon which also influenced by the Javanese ocean currents, as stated in the research conducted by [11] also concluded that the flow pattern of Kendal coastal waters in July was influenced by tides and regional flow patterns in the Java sea which moves according to the monsoon. In Semarang Gulf Waters also experience the same flow pattern, which is moving from east to west which has been proven by a statement from [12]. The influence of current movement driven by wind direction makes the TSS distribution move towards the west and southwest sides of the study area and mostly collected on the estuary side of western sediment cells in accordance with the direction of the Java Sea influenced by the 2018 dry season monsoon which moves from east to west in the waters of the Java Sea.

4. Conclusion

The results of a simple linear regression test show that the Doxaran algorithm is the best algorithm and has the highest R value (correlation) which is equal to 0.956 and the coefficient of determination (R^2) of 0.915 (91.5%) with the TSS equation = $1.0248x - 10.503$. Based on the research results, in general, the red band reflectance value estimates better than green bands. These results also strengthen by previous studies that have been conducted, a case study conducted by Subiyanto [10] that located in West Flood Canal Semarang City, which uses a blue band (band2) and the red band (band 4) of Landsat 8, which lead to the conclusion that although different algorithms, the red band has a similar TSS value. Distribution of TSS concentrations in the range of TSS values $m > 75$ mg / l accumulated a lot in the middle and west of the study area, whereas for concentrations with TSS values < 75 mg / l a lot was collected in the east of the study location. Distribution of TSS is influenced by current movements driven by wind direction, and it moves towards the west and southwest sides of the study area and partially collects on the estuary side of the western sedimentary cell.

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