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COMPARISON OF TOTAL SUSPENDED SOLIDS (TSS) IN THE ESTUARY OF THE BENGAWAN SOLO GRESIK RIVER USING SATELLITE IMAGE DATA

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ABSTRACT

Comparison of Total Suspended Solids (TSS) in Muara Bengawan Solo Gresik River Using Satellite Image Data. The estuary of the Bengawan Solo River, which is in Ujung Pangkah District, has undergone many changes every year. This is influenced by several factors, one of which is the process of settling (sedimentation) from the transport of material carried by river water along the watershed (DAS). Based on this background, efforts are needed to monitor the distribution of Total Suspended Solid (TSS) in the Bengawan Solo Gresik river estuary. The aim of this study is to determine the distribution of Total Suspended Solid (TSS) over 5 years to find the right formula to model the impact of this change, which can be addressed in the future. The method developed below is remote sensing technology with Landsat 8 satellite image data extracting digital number values that are converted into reflectance values to then find the optimal mathematical model algorithm with parameters from Total Suspended Solid (TSS). From the research that has been done, the following results are obtained: the red band reflectance has the best relationship value with TSS In Situ with an R square value of 0.0450. and the appropriate algorithm model for estimating TSS concentrations is the Linear model with the equation Y = 1311.3x + 447.93.
Keywords: Total Suspended Solids (TSS), Landsat 8, Thematic Mapping

INTRODUCTION

Java Island has the largest and longest river, the Bengawan Solo River (Ismanto et al., 2022). This river drains water from a watershed (DAS) covering an area of ± 16,100 km2, starting from the Sewu mountains in the south west of Surakarta to the Java Sea north of Surabaya through a channel of ± 600 km. In 1880 to avoid sedimentation in Tanjung Perak Port, the estuary of the Bengawan Solo river was diverted from the Madura Strait to Ujung Pangkah (Solo, 2016)

Picture 1. Map of the research location
(Google Earth)

Sedimentation is the main cause of reduced productivity of agricultural land, and reduced capacity of channels or rivers due to the deposition of eroded material (Pulley et al., 2024). Over time, the flow of water concentrates into rather deep passages, and transports soil particles and deposits them to the lower regions which may be; rivers, reservoirs, irrigation canals or residential areas (Vincentius et al., 2017).

The distribution of TSS (Total Suspended Solid) material along the estuary of the Bengawan Solo river, Ujung Pangkah District, is one of the sedimentation rate parameters in the river estuary (Mustain et al., 2018). Changes in the coastline due to the sedimentation process around the mouth of the river, affect the survival of the estuary ecosystem and cause silting of the river channel, so that fishing boats find it difficult to enter the river (Elliott et al., 2019).

This study aims to determine the impact of sedimentation based on the value and distribution of Total Suspended Solid (TSS) Muara Bengawan Solo Gresik with remote sensing satellite data technology (Huda et al., 2021). The usefulness of this research is expected to provide information for the development of infrastructure near the sea, as well as being able to know the level of water turbidity and know the thematic map of the distribution of Total Suspended Solids (TSS).

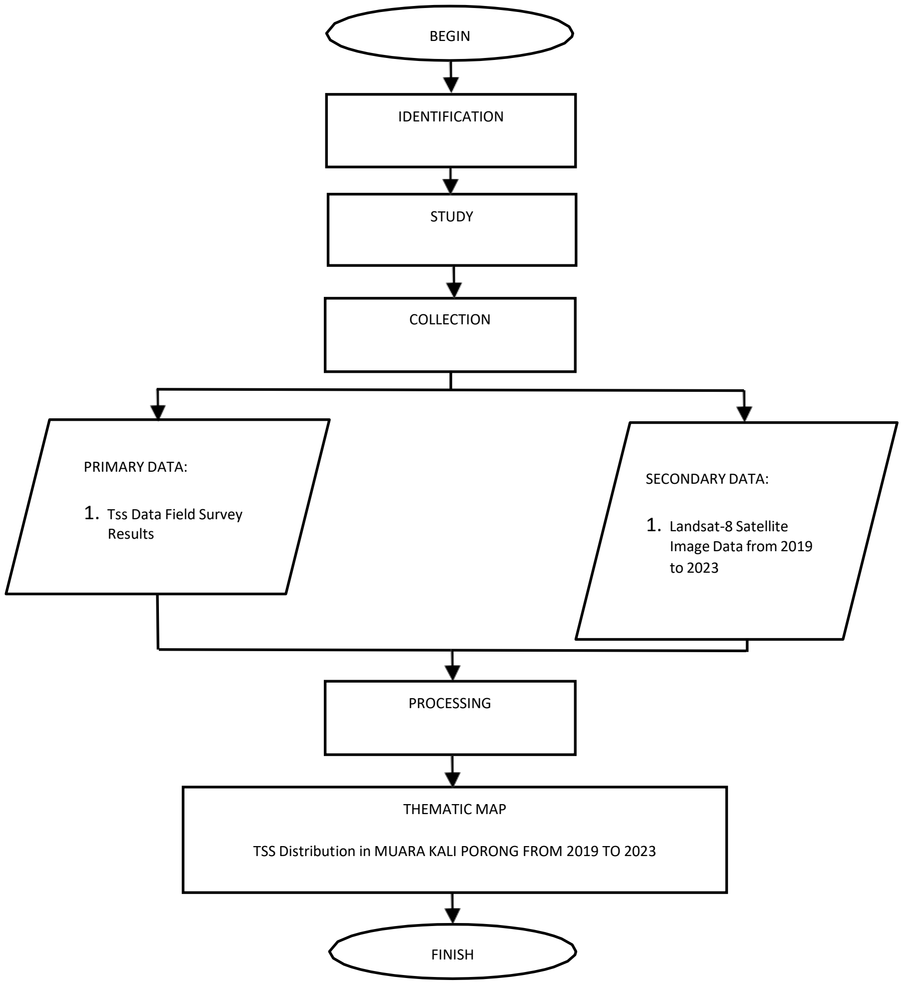
RESEARCH METHODS

The research location of this Final Project is the Bengawan Solo River Estuary, in Gresik Regency, East Java, precisely in Ujung Pangkah District.

Data

The data used in this study are as follows:
1. Landsat 8 Satellite Image in Muara Kali Porong Sidoarjo
2. Water sample data in Muara Kali Porong Sidoarjo.

Research Flow Chart



Picture 2

The data used is divided into two types, namely primary data and secondary data. Primary data were obtained through interviews, direct observations, and surveys in the field (Chatha et al., 2015). In this Final Project research, the primary data used is Total Suspended Solid (TSS) data taken directly in the field (Adjovu et al., 2023). While secondary data is data obtained through intermediaries (Yoon et al., 2018). In this Final Project study, the secondary data used was Landsat 8 satellite imagery (Sothe et al., 2017).

Image Data Processing Flow Diagram

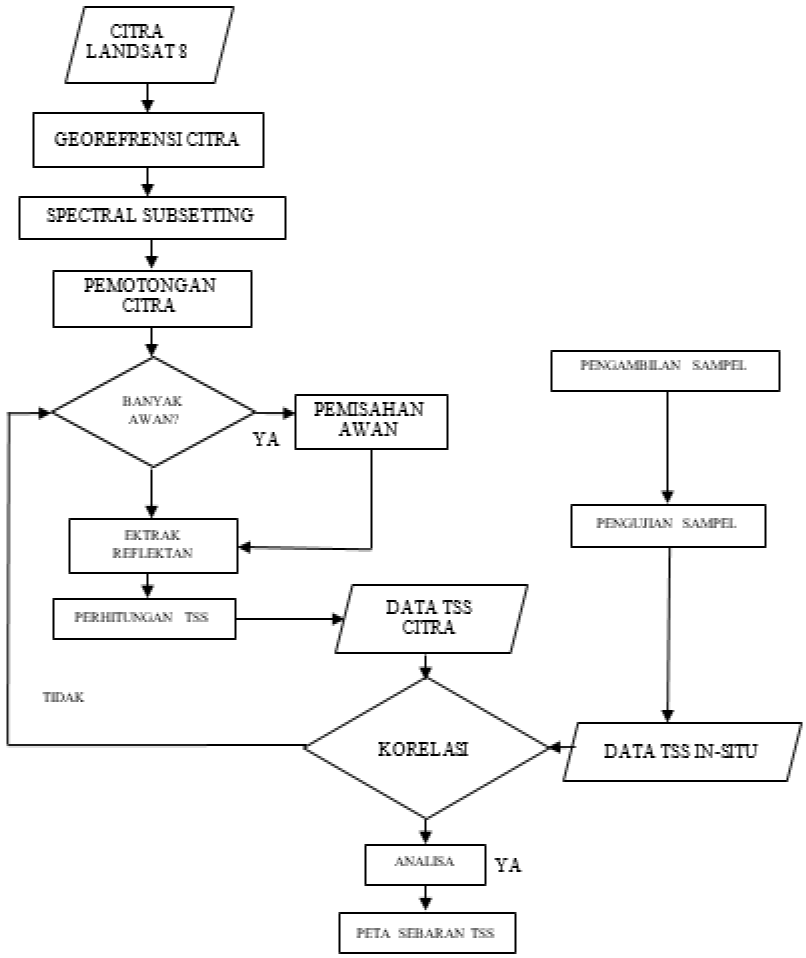


Figure 3. Digram flow data processing

RESULTS AND DISCUSSION

Data

This research activity was carried out along the estuary of the Bengawan Solo River to the coast of Ujung Pangkah District – Gresik Regency, the following are the locations used as research sites (Ali et al., 2018). Geographically, the sampling research location is located at 60 50' 46.35" N - 60 52' 38.74" LS and 1120 32' 49.06" BT - 1120 29' 28.58" BB.

Landsat 8 imagery data from 2019 to 2023

Landsat 8 satellite imagery data is taken from the https://earthexplorer.usgs.gov/ website with a period of January 18, 2019 to January 21, 2023. Landsat 8 satellite imagery data from 2019 to 2023 as listed in table 1 below:

Table 1. Landsat 8 imagery data from 2019 to 2023

No	Date	File Name
1	January 18, 2019	LC08_L1TP_118065_20190118_20200829_02_T1
2	January 21, 2020	LC08_L1TP_118065_20200121_20200823_02_T1
3	23 February 2021	LC08_L1TP_118065_20210123_20210305_02_T1
4	January 14, 2022	LC08_L1TP_118065_20220110_20220114_02_T1
5	January 21, 2023	LC09_L2SP_118065_20230121_20230123_02_T1

In Situ Data (Field)

In situ data was taken on January 21, 2023 at 08.00 WIB at the mouth of the Bengawan Solo Gresik river by taking water samples at a predetermined point. The field data captured was used to validate the Landsat 8 imagery data. Details of in situ data sampling can be seen in Table 2.

Table 2. Results of in situ (field) data collection

Point	COORDINATES		TSS *in situ* mg/l
	X	Y	
1	112°31'03.2''	-6°52'09.5''	646
2	112°31'06.5''	-6°52'09.6''	662
3	112°31'09.8''	-6°52'09.4''	654
4	112°31'12.8''	-6°52'09.3''	586
5	112°31'16.0''	-6°52'09.5''	494
6	112°31'18.7''	-6°52'09.8''	530
7	112°31'21.3''	-6°52'10.3''	730

Landsat 8 Satellite Image Data Processing

Landsat 8 imagery data is processed using a predetermined algorithm to calculate reflectance values (Abdelmalik, 2020). The selection of electromagnetic waves is carried out on Band 2 (blue), Band 3 (green), and Band 4 (red). The reflectance value is obtained by entering pixel data through the pin manager and selecting a filter, then selecting the desired band (Band 2, Band 3, Band 4, and Band 5). After that, the digital number that appears is multiplied by 0.00002 and subtracted by 0.1 to get the reflectance value. The reflectance values produced in 2023 are documented in Table 3.

Table 3. Reflectance value obtained in 2023

Point	2023 bands		
	Band 2	Band 3	Band 4
1	0,1478	0,1371	0,1478
2	0,1473	0,1365	0,1473
3	0,1510	0,1383	0,1510
4	0,1475	0,1369	0,1475
5	0,1363	0,1310	0,1363
6	0,1070	0,1153	0,1070
7	0,1311	0,1293	0,1311
8	0,1211	0,1253	0,1211
9	0,1236	0,1261	0,1237
10	0,1408	0,1348	0,1409
11	0,1193	0,1223	0,1193
12	0,1072	0,1174	0,1072
13	0,1404	0,1318	0,1405
14	0,1016	0,1103	0,1016
15	0,1292	0,1314	0,1293
16	0,1394	0,1346	0,1394
17	0,1140	0,1243	0,1140
18	0,1233	0,1350	0,1233
19	0,1412	0,1401	0,1412
20	0,1200	0,1261	0,1201

Comparison of Total Suspended Solids (TSS) for 2019-2023.

Comparison of in situ TSS and image TSS from 2019 to 2023 with selected algorithms is listed in the graph as follows:

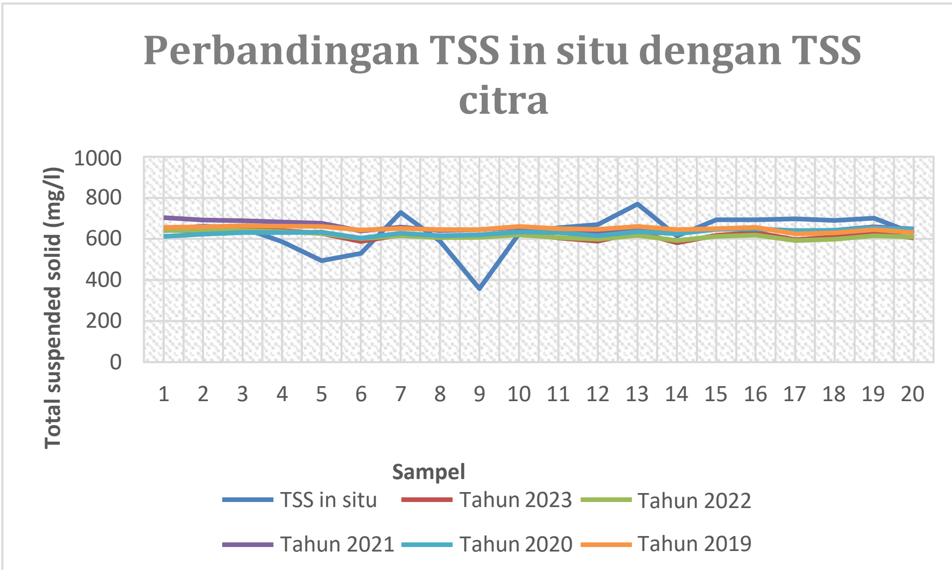


Figure 4. Comparison graph of TSS in situ with TSS imagery for 2019-2023

Anova TSS in situ and TSS Citra Test 2019-2023

The results of the ANOVA Test are summarized in table 4 below:

Table 4. ANOVA TSS in situ and TSS Citra test results for 2019-2023

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	46735,83	19	2459,78	1,649034	0,059913	1,69707
Columns	27008,91	5	5401,782	3,621349	0,004835	2,310225
Error	141706,7	95	1491,649			
Total	215451,4	119				

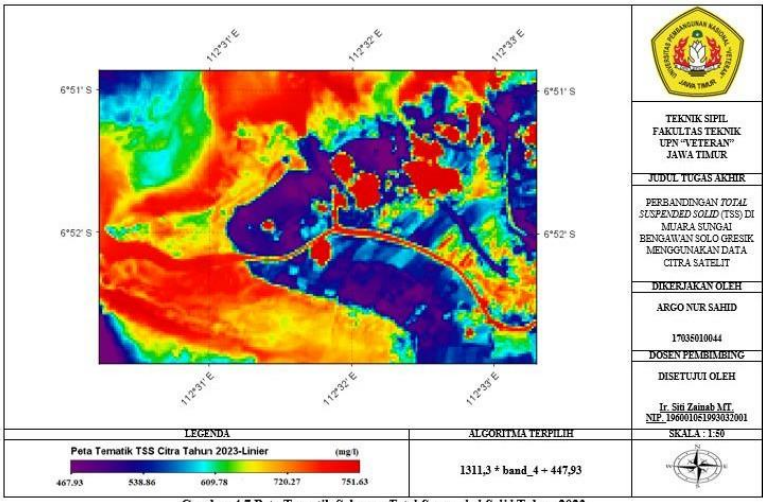
In row analysis because the P-value > α for α = 0.05 with a value of 0.0599 > 0.05, H0 is rejected, and H1 is accepted meaning that there is a significant difference between the image data from 2019 to 2023 with the in situ data in 2023 taken at each coordinate point.

In column analysis because the P-value □ α for α = 0.05 with a value of 0.0048 □ 0.05 then H0 is accepted, and H1 is rejected meaning that there is no significant difference at each coordinate point.:

Results of Total Suspended Solid (TSS) Distribution Mapping

From the results of calculations and analysis shows that data taken directly (in situ) and data calculated from Landsat 8 satellite images there are slight differences at some sample points (Pahlevan et al., 2017). Then the data is mapped by entering Linear and Logarithmic Regression

Persaman. So that a thematic map of the Distribution of Total Suspended Solids (TSS) from 2019 to 2023 will be shown in the following figure.



Gambar 4.7 Peta Tematik Sebaran *Total Suspended Solid* Tahun 2023

Figure 6. Thematic map of Total Suspended Solids distribution in 2023

The results of thematic map images 4.3 to 4.7 above can be concluded that the redder the color on the map, the higher the Total Suspended Solid (TSS) content and the bluer the lower the level. Based on the selected algorithm has a result that approximate, the linear regression equation. The distribution of Total Suspended Solids (TSS) from 2019 to 2023 is relatively stable and there is only a slight difference in value. In 2019 based on image data, the highest level was found at the 3rd point of 664.06 mg / l and the lowest level was found at the 17th point of 624.43 mg / l. In 2020 based on image data, the highest level was found at the 19th point of 655.04 mg / l and the lowest level was at the 6th point of 604.11 mg / l. In 2021, based on image data, the highest level was found at the 1st point of 703.82 mg/l and the lowest level was at the 14th point of 626.61 mg/l. In 2022, based on image data, the highest level was found at point 2 at 642.03 mg/l and the lowest level was at point 17 at 592.36 mg/l. In 2023 based on image data, the highest level is at the 3rd point of 645.94 mg / l and the lowest level is at the 14th point of 581.41 mg / l. Based on in situ data, the highest level is at the 9th point of 358 mg / l and the lowest level is at the 13th point of 770 mg / l.

CONCLUSION

Based on the analysis that has been done in Chapter IV, the following conclusions can be drawn: Red band reflectance has the best relationship value with TSS In Situ with an R square value of 0.045 with a linear regression equation. The corresponding algorithm model in estimating TSS concentration is a linear model with the equation y = 1311.3x + 447.93. Based on the anova test, Fcalculate = 3.621349 is greater than Ftabel = 2.310225, then H0 is rejected and H1 is accepted, meaning that the average TSS in situ with TSS images from 2019 to 2023 is different. The thematic map of Total Suspended Solid (TSS) in the Bengawan River Estuary Solo Gresik using Landsat 8 satellite images shown in chapter IV shows that in 2019 the highest TSS levels at the 3rd point were 664.06 mg / l and the lowest levels at the 17th point of 624.43 mg / l, in 2020 the highest TSS levels at the 19th point of 655.04 mg / l and the lowest levels at the 6th point of 604.11 mg / l, In 2021 the highest TSS level was at the 1st point of 703.82 mg/l and the lowest level at the 14th point of 626.61 mg/l, in 2022 the highest level at the 2nd point was 642.03 mg/l and the lowest level at the 17th point was 592.36 mg/l. In 2023, the highest level at the 3rd point is 645.94 mg / l and the lowest level at the 14th point is 581.41 mg / l, based on in situ data the highest level is at the 9th point of 358 mg / l and the lowest level is at the 13th point of 770 mg / l. The concentration of TSS distribution in the estuary of the Bengawan Solo Gresik river is included in the high category according to the Regulation of the State Minister of Environment No. 1 of 2010.

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