WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study of the Distribution of Suspended Solid Material Concentrations at the Banger Estuary, Pekalongan City, Central Java

Siti Zulaihah[1], Muhammad Zainuri[1], Azis Rifai[1*]

[1]Oceanography Department, Faculty of Fisheries and Marine Sciences, Diponegoro University, Jl. Prof Jacub Rais, Tembalang, Semarang, Indonesia
**Email azisrifai@lecturer.undip.ac.id*

A B S T R A C T

The Banger River in Pekalongan City, Central Java, apart from functioning as a canal to control floods, is also used as a dumping ground for industrial textile waste in the area around the river. Waste that is not managed properly can increase the organic material content in waters, one of which is in the form of suspended solid material which, if it exceeds the threshold limit, can harm aquatic living creatures. Excessive suspended solid material in waters can increase turbidity and reduce the penetration of sunlight into the air column, thereby affecting the photosynthesis process and inhibiting the respiration of marine biota. This research aims to examine the distribution of concentrations of suspended solids in the Banger Estuary, Pekalongan City. This research uses a quantitative method based on the results of the analysis of samples taken in situ, on June 25, 2023. A geospatial approach was carried out by comparing the results of Total Suspended Solids (TSS) distribution mapping based on field data with the TSS distribution on sentinel-2 satellite imagery based on algorithms. The results of this research indicate that the concentration of suspended solid material in the Banger Estuary, Pekalongan City is in the range of 18.2 mg/l - 48.2 mg/l., with a tendency for high concentrations to be near the coastline and concentrations decreasing towards open waters beach. This is thought to be related to the supply of nutrients from various human activities, from upstream to river mouths, as well as activities in coastal waters. The results of the concentration of suspended solids in the Banger Estuary and the Coastal Waters of Pekalongan City between the results of in situ data analysis and the results of the image analysis algorithm show that in situ data analysis has a wider range of concentration values with a fairly large level of significance. The distribution of suspended solid material concentrations in the Banger Estuary and Pekalongan City Coastal Waters tends to follow the coastline pattern, although there is a group of stations that form a convergent pattern in the estuary waters. It can be concluded that the oceanographic parameters of tides, currents, seasons, mixing of air masses, and water depth influence the concentration and distribution of suspended solid material in the Banger Estuary and the Coastal Waters of Pekalongan City.

Keywords: Suspended Solids Materials, Sentinel-2, Banger Estuary, Pekalongan City Coastal Waters

1. Introduction

River estuaries are water bodies that are susceptible to being influenced by environmental variations originating from nature or even caused by human actions (Indrayanti *et al*., 2022). Degradation of the estuary environment can result in ecological damage, as well as changes in social and economic conditions. This can happen if waste from human activities is thrown into the river body, it will affect the dynamics of the river waters (Zainuri *et al*., 2022, Wirasatriya *et al*., 2023). One of the rivers used as a waste disposal site is the Banger River which is located in Pekalongan City, Central Java. This waste can increase organic concentrations such as COD, BOD, Total Suspended Solids (TSS), and pH, which if it exceeds the threshold, the easiest symptom to detect is the death of aquatic biota (Budiyanto *et al*., 2018).

Total Suspended Solids (TSS) is a material that decomposes from organic waste as its source. Excessive TSS in waters can increase turbidity and reduce the penetration of sunlight into the water column. These conditions will ultimately affect the photosynthesis process and inhibit the respiration of marine biota (Wirasatriya *et al*., 2023). Based on research conducted by Zainuri *et al*., (2022) and Ridarto *et al*., (2023), residential areas along the Banger Estuary have a great influence on increasing TSS concentrations in the area. Apart from that, the sediment input factor from land which is influenced by rainfall is also the cause of the high concentration of TSS in the Banger Estuary area.

Sentinel-2 was the first satellite launched as part of the Europan Space Agency (ESA) Copernicus program in Europe in 2015. According to Liu *et al*., (2017), several studies have been carried out in retrieving water parameters using Sentinel-2 satellite image data. 2A includes taking TSS concentration values in turbid estuary waters, investigating the sensitivity of Sentinel-2A to optically active things in Italian lakes, demonstrating the superiority of Sentinel-2A compared to Landsat 8 OLI in taking TSS in black lakes, observing chlorophyll and organic matter dissolved, monitoring water quality in inland and coastal waters, and much more.

This research was conducted to determine and map the distribution of concentrations of suspended solid material at the mouth of the Banger River in June 2023. Field data collection pays close attention to the time at which the Sentinel-2 satellite passes through the study area so that the information

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000.
E-mail address: author@institute.xxx

obtained will be more accurate. It is also hoped that this research can become a reference in dealing with the waters of the Banger Estuary which are polluted by textile waste.

2. Material and Method

This research uses 2 data, primary and secondary data. The primary data is water samples taken in situ and analyzed in the laboratory to determine the TSS concentration. Meanwhile, the secondary data is Sentinel-2 Level 1C imagery with a recording date of 25 June 2023 obtained via the page https://scihub.copernicus.eu, Indonesian Rupabumi (RBI) maps, and Pekalongan waters bathymetry data obtained from the Geospatial Information Agency (BIG) via the page https://tanahair.indonesia.go.id/portal-web, wind data for Pekalongan waters obtained via the page https://cds.climate.copernicus.eu/, and tidal data for Pekalongan waters obtained from the Agency Geospatial Information (BIG) via the page http://ina-sealevelmonitoring.big.go.id/ipasut.

The method used in this research is quantitative to determine the concentration of suspended solid material, which produces numbers in data processing (Sugiyono, 2009). In this research, algorithmic calculations were used from the sentinel-2 image which will later produce numbers so that the TSS concentration value in June can be determined in the waters of the Banger Estuary, Pekalongan City.

Determining the sampling location in this study used a purposive sampling method with 30 station points which were considered to represent the entire research area. Determining the sampling time was carried out based on the conditions of the waters which coincided with taking pictures by the Sentinel-2 satellite image. This research was carried out on June 25 2023 at 06.00-12.00 WIB in Muara Sungai Banger, Pekalongan City with coordinates 6°50'10"S to 6°51'50"S and 109°40'50"E to 109°42' 30" E.

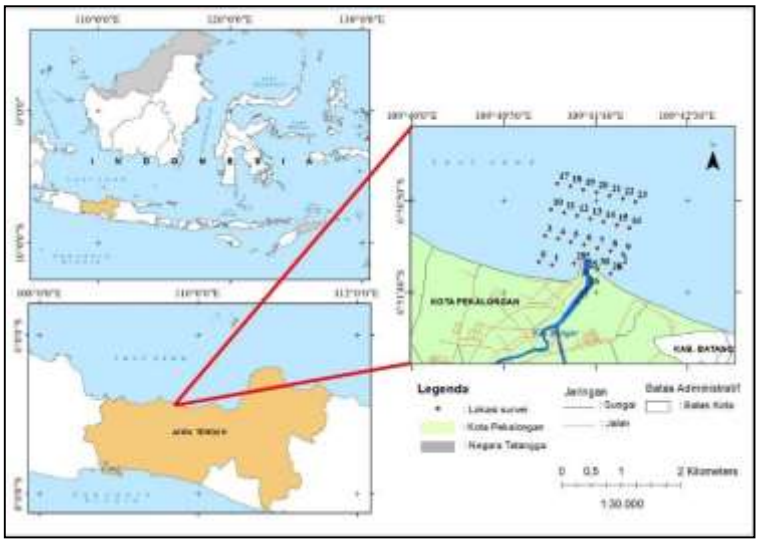

Figure 1. Sampling Area

Water samples from each station were taken using a 4.2-liter Nansen bottle and put into a 1-liter sample bottle. The sample bottle containing seawater is then stored in a coolbox so it is easy to carry.

TSS laboratory analysis is carried out using gravimetric methods that are accredited to SNI 6989.3:2019 (APHA 2540). Whatman filter paper with grade GF/F is heated in the oven for 1 hour at a temperature of approximately 60℃, then placed in a desiccator for 15 minutes to ensure that the filter paper is completely dry. The filter paper is then weighed using a digital scale. The water sample (1 liter) was stirred until homogeneous and filtered using a vacuum pump which had been coated with dry GF/F filter paper. The filter paper containing the precipitate was dried again in the oven at a temperature of approximately 105 ℃ for 1 hour. The filter paper containing the sediment was weighed again using a digital scale. Next, the TSS concentration is calculated using the TSS calculation formula.

Sentinel-2 level 1C image data is downloaded on the Copernicus website, https://scihub.copernicus.eu/. The image data that has been downloaded is then corrected for distortion due to atmospheric effects, using Sen2Cor software so that it becomes a Sentinel-2 level 2A image. This image data has been geometrically and radiometrically corrected and has Bottom of Atmosphere (BOA) reflectance values (Ridarto *et al*., 2023). Separation of land and sea (masking area) is carried out to differentiate between land and sea using the Normalized Difference Water Index (NDWI) formula. This is followed by an image-sharpening process using a formula derived from an empirical algorithm to transform spectral values into concentrations of suspended solid material (Milenia *et al*., 2021). In this research, the Budhiman (2004) algorithm (in Putri *et al*., 2023) is used, namely:

$$MPT\ (mg/L) = 8{,}1429 \times exp^{(23{,}704 \times Rrs(\lambda 4))}$$

Where TSS is the total suspended solids and $Rrs(\lambda 4)$ is the value of the red channel reflectance.

Data validation was carried out using the RMSE (Root Mean Square Error) and Bias methods. Root Mean Square Error (RMSE) is the magnitude of the error rate in prediction results, where the smaller (closer to 0) the RMSE value is, the more accurate the prediction results will be. RMSE and Bias values can be calculated using the following equation.

$$RMSE = \sqrt{\frac{\sum(Xm - Xe)^2}{n}}$$

$$Bias = \frac{\sum_{i=1}^{n} Xe - Xm}{n}$$

Where Xe is the value of field measurement results are considered correct, Xm is the value of data processed, and n is the amount of data.

The surface flow model in this research uses a hydrodynamics module which is the basic calculation of the entire MIKE 21 Flow Model FM software system program (Wiyadi *et al*., 2022). The data entered as model input is wind data, bathymetry data, and tidal data in June 2023. The results of the tidal current model simulation using MIKE 21 software are a map of the direction and speed of current movement on June 25 2023 at the Banger Estuary, Pekalongan City.

3. Results and Discussion

3.1 The Total Suspended Solids Concentrations in Banger Estuary

Based on in situ observations, the TSS concentration at the Banger Estuary shows a range between 15.2 – 49 mg/L, while the results of satellite image data processing show a narrower range of values, namely between 19.2 – 43.2 mg/L. The distribution map of TSS at the Banger Estuary from field data and the results of analysis of the concentration and distribution of suspended solid material using sentinel-2 level 2A image data processing based on the Budhiman (2004) algorithm is presented in **Figure 2**.

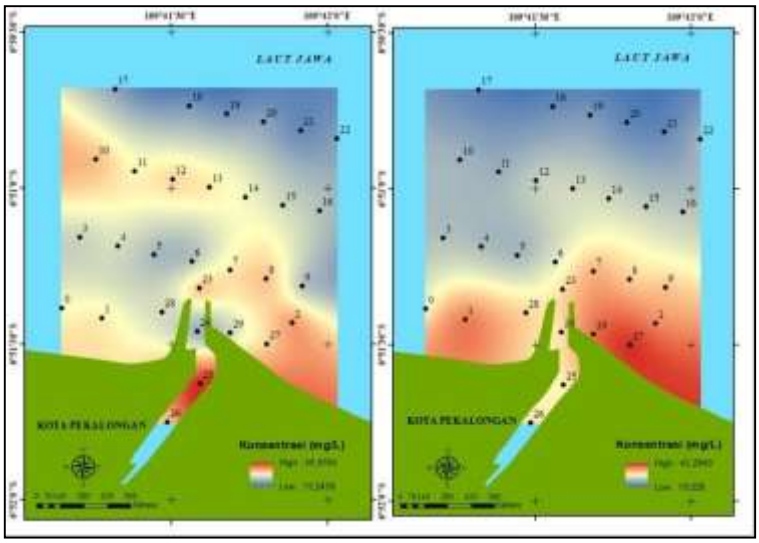

Figure 2. Map of Distribution of Suspended Solid Material at the Banger Estuary, Pekalongan City Field Data (left); Budhiman Algorithm Estimation (right)

3.2 The Total Suspended Solids Concentrations in Banger Estuary

The resulting surface current modeling is a vector current plot that shows the speed and direction of the current. The time interval from the model simulation was processed on June 25 2023 at 08.30 WIB. Based on the results of surface current modeling in Figure 3, the current speed around the Banger Estuary, Pekalongan ranges from 0.02 m/s to 0.16 m/s with the dominant current direction moving from East to West.

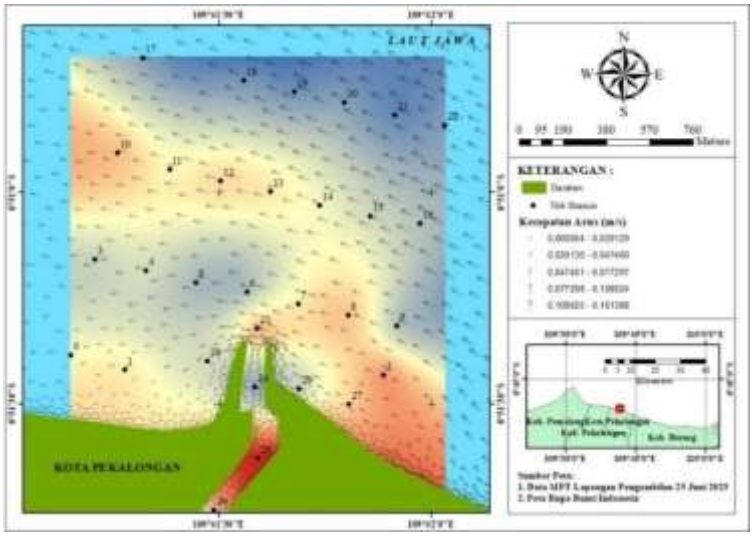

Figure 3. Map of Surface Currents and Distribution of Suspended Solid Material Concentrations at the Banger Estuary on June 25, 2023

3.3. The Total Suspended Solids Concentrations in Banger Estuary

A comparison of TSS concentrations from field data and satellite image data was carried out by looking at the resulting correlation coefficient (r). From the calculation results, the correlation coefficient (r) value is 0.5593. This shows that the correlation between the TSS concentration from image analysis using the Budhiman (2004) algorithm and the TSS concentration resulting from field data analysis is in the strong category (Siregar *et al*., 2021). Apart from that, an error validation test was also carried out by calculating the bias and RMSE values from the two data, namely field data and image data. Based on the calculations that have been carried out, the bias value is -0.60 and the RMSE is 5.96. A bias value of -0.60 indicates that the TSS estimate from satellite image data is below the TSS estimate from field data. However, the resulting RMSE is quite small with a value of 5.96. These results show that the error value that occurs is quite low. Representation of the results of the TSS comparison of field data and satellite image data can be seen in the following graph (**Figure 4**).

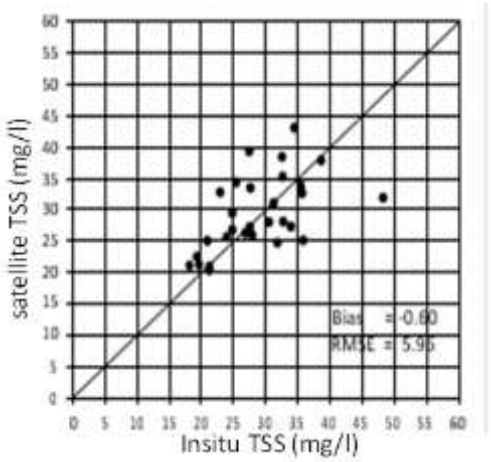

Figure 4. Graph of Comparison Results of Field TSS Data and Satellite Image TSS Data with the Budhiman Algorithm (2004) in Putri *et al*., (2023)

Based on the results of field data processing using gravimetric analysis, TSS concentrations in the Banger Estuary and the coastal waters of Pekalongan City show quite varied distribution patterns between stations close to the coast and stations located in the open sea. This condition is thought to be because TSS input around the waters of the Banger Estuary does not only come from the Banger Estuary but there is input from the Slamaran River Estuary which is located to the east of the Banger Estuary. This can happen because when water samples were taken surface currents were moving from East to West and carrying TSS from the mouth of the Slamaran River so that the concentration in the middle (stations 10 – 14) increased quite significantly (Figure 2). The distribution of the concentration of suspended solid material which is influenced by surface currents (Figure 3) shows a pattern in the same direction as the direction of the current. The direction of this current is influenced by the tides and winds that blow when water samples are taken. The

wind direction produced when taking water samples corresponds to the current season, namely the East season in June. This is to research by Tampubolon *et al*., (2021) which states that in June-July the direction of currents in the Pekalongan waters is still influenced by wind gusts from the Southeast (Eastern season) of Indonesia so the distribution pattern of material in the seawater column will be distributed according to the direction of the current influenced by the wind.

Map of surface currents and TSS concentration distribution (Figure 3), stations 3, 4, 5, 6, and 28 have relatively low concentrations. This occurs due to the presence of a retaining embankment or river banger polder so that the distribution of suspended solid material is diverted up and down by the current which causes the TSS concentration value at the station to be low. In addition, there is an exchange between inflow and outflow at station 24 which causes low TSS concentrations at that station. Overall, it can be seen that both the results of field sampling and the results of satellite imagery estimation show that the waters of river estuaries or areas close to the coast have higher concentrations of TSS compared to other areas. High concentrations of TSS in river mouth areas are generally caused by the input of organic materials from upstream of the river to the estuary. These organic materials come from textile industry waste and anthropogenic activities that occur around the Banger Estuary. This is following research by Ridarto *et al*., (2023), which states that the concentration of TSS in the Banger Estuary comes from anthropogenic factors that occur around the upstream of the river. Apart from that, several oceanographic parameters such as depth, topographic conditions, and land use along the Pekalongan coast also supply suspended solid material which influences its concentration in the waters.

Based on the TSS concentration results obtained from laboratory tests using the gravimetric method and from satellite image data using the Budhiman algorithm, show linear results. This is by the calculation of the correlation coefficient (r) which produces a value of 0.5593. This value is positive and greater than 0.5, which is based on research by Siregar *et al*., (2021), a correlation coefficient value greater than 0.5 can be said to have a strong correlation relationship. Apart from that, looking at the TSS comparison graph of field data and image data (Figure 4), it is known that the relationship between the two is quite linear. This means that estimating TSS concentrations at the Banger Estuary, Pekalongan City using the Budhiman algorithm can be said to be suitable for use in this area. The validation test by calculating the RMSE and bias values obtained results of 5.96 and -0.60 respectively. The RMSE results with a value of 5.96 indicate that there are still errors in the calculation results using the Budhiman algorithm to estimate the TSS content in the Banger Estuary. However, this value is low enough so that TSS concentration calculations using the Budhiman (2004) algorithm can be used in the Banger Estuary area and surrounding waters.

4. Summary

The concentration of suspended solid material in the Banger Estuary and the Coastal Waters of Pekalongan City is in the range of 18.2 – 48.2 mg/L, with quite varied TSS concentration distribution patterns. This is because TSS input not only comes from the mouth of the Banger River but also comes from the mouth of the Slamaran River which is to the east of the mouth of the Banger River which is carried by surface currents. The distribution of suspended solid material at the mouth of the Banger River and Pekalongan Beach waters also tends to follow the coastline pattern, although several stations form a convergent pattern in the estuary waters.

References

APHA. 2017. APHA No. 2540 D-2017 Standard Operating Procedure for Total Suspended Solids.

America Public Health Association, America. pp 7-8.

Budiyanto, S., Anies, H. Purnaweni, dan H. R. Sunoko. 2018. Environmental Analysis of The Impacts of Batik Waste Water Pollution on the Quality of Dug Well Water in The Batik Industrial Center of Jenggot Pekalongan City. E3S Web of Conferences, ICENIS 2017, 31. pp 1-7.

Damayanti, T. R., A. Ismanto, E. Indrayanti, M. Zainuri, dan L. Maslukah. 2022. Sebaran Konsentrasi Fosfat di Muara Sungai Sengkarang dengan Pendekatan Model Matematika 2 Dimensi. Indonesia Journal of Oceanography, 4(1): 12-22.

Indrayanti, E., L. Maslukah, M. Astariningrum, dan M. Zainuri. 2022. Impact of Nutrients and Suspended Particulate Matter on Phytoplankton Chlorophyll-a Biomass, in the Estuary of Kendal, Indonesia. Ecological Engineering & Environmental Technology, 23(4): 212–218.

Liu, H., Li, Q., Shi, T., Hu, S., dan Wu, G. 2017. Application of Sentinel 2 MSI Images to Retrieve Suspended Particulate Matter Concentrations in Poyang Lake. Remote Sensing, 9(7), pp. 761.

Maslukan, L., A. Wirasatriya, S. Widada, D. H. Ismunarti, M. Yusuf, U. Salma, dan M. Zainuri. 2022. Fractionation and Bioavailability of Phosphorus and Its Relation to Chlorophyll-A at the Coastal Area of Semarang City. Ecol Chem Eng S, 29(2): 183-197.

Milenia, A. P., A. Wirasatriya, L. Maslukah, M. Yusuf, dan M. Helmi. 2021. Distribusi Material Padatan Tersuspensi di Perairan Semarang dengan Penginderaan Jauh. Indonesia Journal of Oceanography, 3(3): 57-62.

Putri, T. N., Y. S. Putra, Risko, Muhardi, dan R. Adriat. 2023. Pola Sebaran Sedimen Tersuspensi Menggunakan Teknik Penginderaan Jauh di Sungai Sambas Kabupaten Sambas. Acta Aquatica: Aquatic Sciences Journal, 10(2): 172-175.

Ridarto, A. K. Y., M. Zainuri, M. Helmi, Kunarso, B. Rochaddi, L. Maslukah, H. Endrawati, G. Handoyo, dan M. Koch. 2023. Assessment of Total Suspended Solid Concentration Dynamics Based on Geospatial Models as an Impact of Anthropogenic in Pekalongan Waters, Indonesia. Buletin Oseanografi Marina, 12(1): 142-152.

Siregar, G. R. S., Muslim, Ali, B. Rochaddi, S. Widada, D. Muljawan, dan A. Afi. 2021. Analisis Laju Dosis Serap Material Norm di Sedimen Dasar Laut Banda, Sulawesi Tengah. Oseanika: Jurnal Riset dan Rekayasa Kelautan, 2(1): 38-52.

Sugiyono. 2009. Metode Penelitian Kuantitatif Kualitatif dan R&D. CV. Alfabeta : Manado. pp.7-9.

Tampubolon, O. F. R., A. Ismanto, A. A. D. Suryo, Muslim, dan E. Indrayanti. 2021. Simulasi Pola Sebaran Logam Berat Tembaga (Cu) di Perairan Kota Pekalongan. Indonesia Journal of Oceanography, 3(2): 1-15.

Wirasatriya, A., L. Maslukah, E. Indrayanti, M. Yusuf, A. P. Milenia, A. A. Adam, dan M. Helmi. 2023. Seasonal Variability of Total Suspended Sediment off The Banjir Kanal Barat River, Semarang, Indonesia Estimated from Sentinel-2 Images. Regional Studies in Marine Science, 57. pp.102735.

Wiyadi, H. T., Muslim, dan J. Marwoto. 2022. Pemodelan Hidrodinamika pada Musim Barat di Pantai Gosong Kalimantan Barat sebagai Calon Tapak PLTN Pertama di Indonesia pada Tahun 2025. Indonesian Journal of Oceanography, 4(2): 97-106.

Zainuri., M., M. Helmi, M. G. A. Novita, H. P. Kusumaningrum, dan M. Koch. 2022. Improved Performance of Geospasial Model to Access the Tidal Flood Impact on Land Use by Evaluating Sea Level Rise and Land Subsidence Parameters. Journal of Ecological Engineering, 23(2): 1- 11.