Indonesian Journal of Earth Sciences, Vol. 1, No. 2 (2021): 74-83

P-ISSN: 2798-1134 | E-ISSN: 2797-3549 | DOI: 10.52562/injoes.v1i2.237

Indonesian Journal of Earth Sciences

http://journal.moripublishing.com/index.php/injoes

Sedimentation Rate Analysis in Dock C PT. Petrokimia Gresik, Indonesia

Abiyani Choirul Huda [1]*, Rendatiyarso Laksono [2], Anggie V R Dewi [2], Rima G Harahap [1], Nurwati [1], Siti Rahayuningsih [1], Destyariani L Putri [1], Anggoronadhi Dianiswara [1], Muhammad K Wirawan [1]

[1] *Ocean Engineering Department, Institut Teknologi Kalimantan, Balikpapan, Indonesia*

[2] *Ocean Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*

**Correspondence: abiyani.choirul@lecturer.itk.ac.id*

Received: 10 August 2021; Accepted: 13 November 2021; Published: 27 December 2021

Abstract: Dock C is one of the supporting facilities at PT. Petrokimia Gresik which have function as a place to loading and unloading goods from ships to land and vice versa. Jetty is one of the coastal structures that able to reduce sedimentation. Another benefit of the jetty is that it can significantly increase the company's production capacity. In the treatment of sedimentation in port, it is necessary to analyze the current pattern and sedimentation rate early, because this is the first step to predict the amount of sedimentation contained in the port in a certain period of time. Several ways can be done to minimize the rate of sedimentation. One of those ways is modifying the layout of Dock C to reduce the frequency of dredging. This study compares the sedimentation volume at the existing condition jetty and two alternative jetty that occur due to currents and waves, while modeling is done using Mike 21. The results of the existing jetty modeling show the sedimentation volume for 12 months was 20,641.68 m³. Whereas the sedimentation volume from alternative jetty 1 and 2 produced for 12 months was 11.293.56 m³ and 7.426.2 m³. Modifications to the layout of the jetty provided were able to reduce the rate of sedimentation in Dock C, with the most optimal sedimentation volume for 12 months at 13.215.48 m³.

Keywords: Dock C, Current Pattern, Sedimentation Rate, Jetty Modification

INTRODUCTION

Sedimentation is a coastal dynamic process that has an impact on changes in the ecosystem and the shape of the coast, this is also related to coastal erosion. Sedimentation can result in silting of water areas, especially waters with the necessary capacity for the economy (Pratikto et al., 2021). In reducing and controlling sedimentation, it is necessary to review software that used to model the sediment prediction before the field survey. One of the water areas development that requires a review of sediment transport is PT. Petrokimia Gresik. PT Petrokimia Gresik is the most complete fertilizer producer in Indonesia that produces various kinds of fertilizers and chemicals for agro-industrial solutions. Occupying an area of more than 450 hectares, PT Petrokimia Gresik operates more than 21 factories consisting of fertilizer factories and factories that produce non-fertilizer products, with a production quantity of more than 6 million tons/year (PT. Petrokimia, 2018).

As an effort to increase the productivity of PT. Petrokimia Gresik in 2018 carried out the construction of Pier C with a loading and unloading capacity of 1.5 million tons/year to overcome the very high density of loading and unloading activities. To keep productivity activities running, it is necessary to carry out periodic maintenance of the wharf, one of which is related to sedimentation in the docking pond of Pier C PT. Petrokimia Gresik. Novianto (2009), in the previous research, explained that sedimentation at the pier can make it difficult for ships to dock and maneuver around the pier. To carry out maintenance of anchored ponds related to sedimentation of course requires accurate sedimentation rate data to carry out periodic dredging. An accurate description of sediment transport, caused by waves and tidal or wave-induces currents, is importance in predicting coastal morphological changes (Sravanthi et al., 2015). Figure 1 explain study location via Google Earth.

Figure 1. Study Location via Google Earth
(Source: *www.google.co.id/maps*)

The process of sediment grain transfer to the dock anchorage is influenced by the large sediment supply from the Ujung Pangkah area with a volume of 9.38 m^3/m^2 annually. This is part of a natural process, this can change if it is influenced by the shape of the beach or water structure which results in changes in particles becoming unbalanced, resulting in or erosion of the structure. The objectives to be achieved from this research are as follows: Knowing the current pattern through the model at Pier C PT. Petrokimia with MIKE 21 software, Knowing the sedimentation rate at Pier C PT. Petrokimia by modeling through MIKE 21 software and Knowing alternative dock layouts for sedimentation at Pier C PT. Petrokimia can be minimized.

METHOD

The location of the object of study in this research is the docking pool of Pier C PT. Petrokimia Gresik which is located in Gresik Regency, East Java. Pier C is located in the Madura Strait area which is geographically located at 7° 8'13.46"S and 112°39'0.71"E. Figure 2 explain study location via bathymetry and flow diagram explain in Figure 3.

Current data obtained from the Final Report on Depth Measurement and Investigation of Siltation Problems at the Petrokimia Gresik Port in 1989. The following Figure 4 is the location of the current data used as validation of the numerical modeling of the Mike 21 flow pattern.

To see the level of accuracy of the simulation model, it is necessary to look at a measure of the simulation error, namely the difference from the magnitude of the simulation results to the magnitude that actually occurred. This can be done by comparing the magnitude of the simulation results with the magnitudes of direct observations. The equation used to see the error rate from the simulation results with the observations is MAPE (Mean Absolute Percentage Error) with the formula proposed by equation (1) as follows:

$$MAPE = \frac{1}{n}\sum\left[\frac{|actual-forecast|}{actual}\right] \times 100\% \quad (1)$$

Where
Actual : In-situ Data

Forecast: Modeling Data

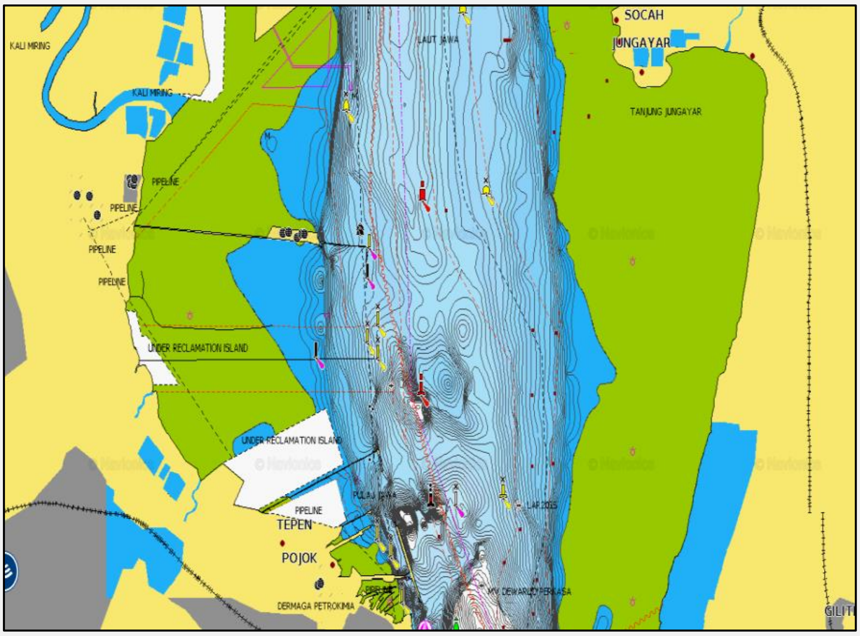

Figure 2. Study Location via Bathymetry Image
(Source: *navionic.com*)

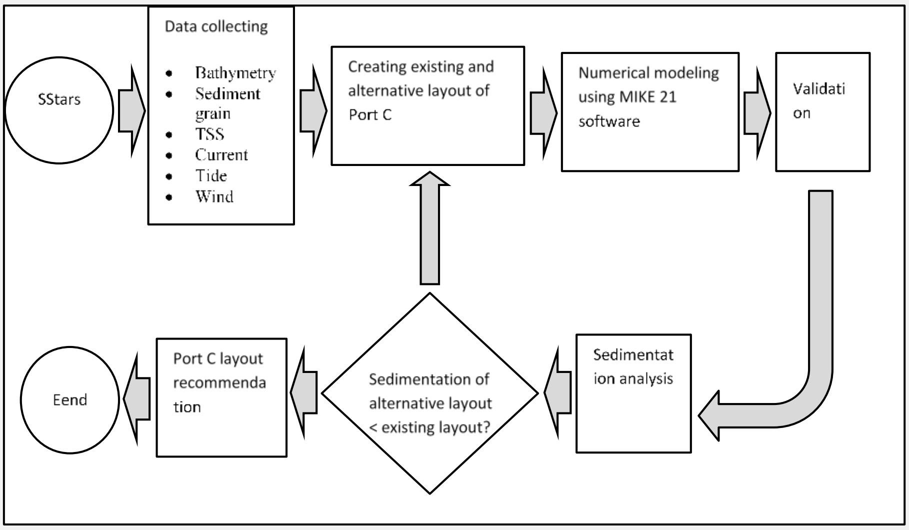

Figure 3. Flow Diagram

In this research, the tidal data used comes from the 2018 Indonesian Archipelago Tidal List issued by the Hydro-Oceanography Service (Dishidros) of the Indonesian Navy (Nontji, 1987). Tidal data used is tidal data which refers to the Tanjung Perak area of Surabaya and APBS (Alur Pelayaran Barat Surabaya) in August 2018 (for the east season) and November 2018 (for the west season). Figure 4 explain location of current data.

Figure 4. Location of Current Data

Sediment grain size data used in the input software in this research as shown in Table 1 was obtained from Putra et al. (2017).

Table 1. Grain Size Sediment

No.	Geographic		UTM		Diameter (mm)	
	S	E	X	Y	d50	d90
1	07 07 11.2	112 38 02.0	680442	9212691	0.002	0.02
2	07 07 18.6	112 38 05.0	680533	9212464	0.002	0.022
3	07 07 33.9	112 37 44.2	679893	9211996	0.001	0.03
4	07 07 19	112 37 44.5	679905	9212454	0.001	0.06
5	07 05 59.1	112 37 54.3	680214	9214907	0.003	0.1
6	07 06 52.3	112 38 10.6	680708	9213271	0.001	0.1
7	07 06 47.1	112 37 46.7	679975	9213434	0.001	0.08
8	07 06 31.4	112 37 39.6	679759	9213916	0.001	0.07
9	07 06 01.1	112 38 11.8	680750	9214843	0.001	0.1
10	07 05 56.6	112 37 32.3	679539	9214986	0.001	0.1
11	07 05 44.6	112 37 58.8	680353	9215352	0.003	0.1
12	07 05 44.0	112 38 09.1	680669	9215369	0.003	0.1
13	07 06 28.6	112 38 05.6	680557	9214000	0.001	0.1
14	07 06 42.9	112 38 07.8	680623	9213560	0.007	0.09

TSS data was obtained from Krishna et al. (2012). The location of the TSS data used is x = 704782, y = 9168932 with the amount of TSS in the field 31.9 mg/L.

RESULT AND DISCUSSION

Tides

Based on the data that has been obtained from DISHIDROS, a graph is made to find out the types of tides found in the area studied. Based on the tidal (Figure 5 and Figure 6), it can be seen that the water area has a semidiurnal tidal type. This tidal data will be used as input data for boundary conditions in the hydrodynamics module of the Mike 21 program to obtain a model of current and sedimentation patterns (Hidayat et al., 2017).

Wind Data

One of the factors that affect the current is the wind factor. In the Mike 21 program, wind data plays a role in wind forcing data input contained in the hydrodynamics module. In addition to influencing the pattern of current movement, the wind also affects the generation of waves, so that later this wind will also affect the movement pattern of sediment transport which is influenced by currents and waves (Ezzeldin et al., 2020). However, for data input, only wind data is used in August and November 2018. Input data This is in accordance with the time step and the time of the modeling simulation carried out. The following wind rose diagram shows that the dominant wind direction is from the northwest to the southeast. Figure 7 explain 2018 wind rose diagram, August 2018 wind rose diagram, and November 2018 wind rose diagram.

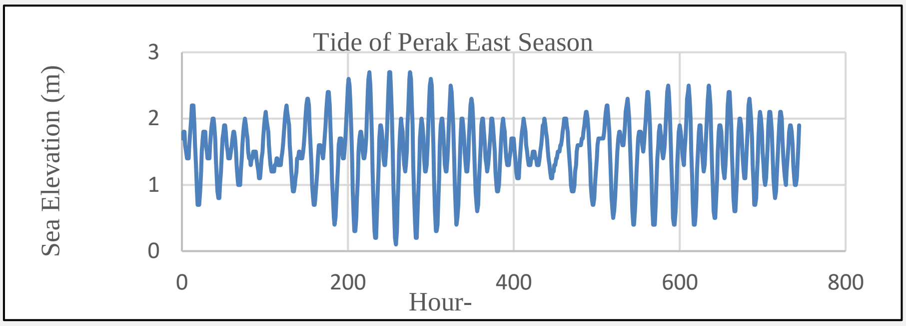

Figure 5. Tide of Perak East Season (August)

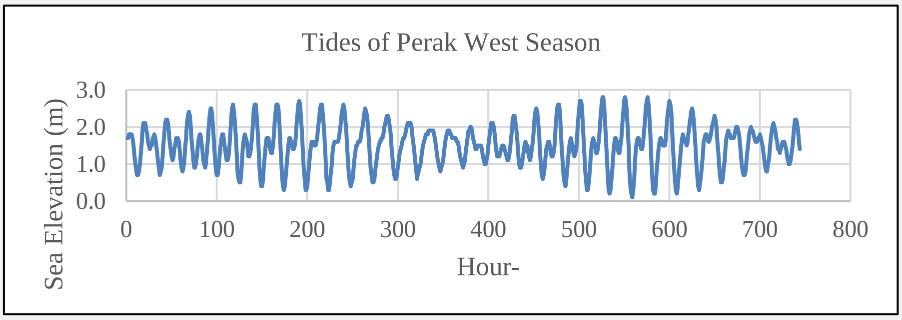

Figure 6. Tides of Perak West Season (November)

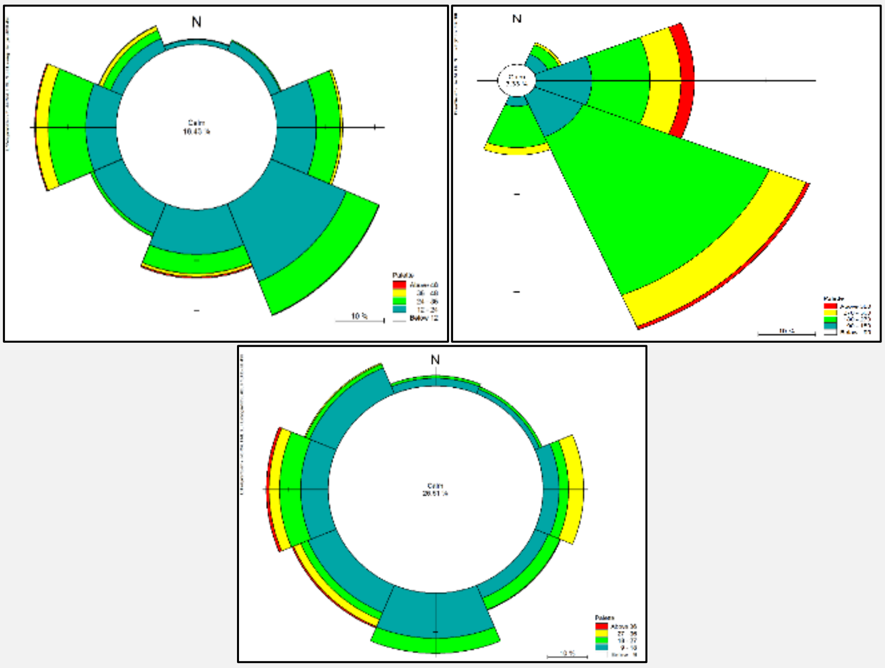

Figure 7. 2018 Wind Rose Diagram, August 2018 Wind Rose Diagram, and November 2018 Wind Rose Diagram

Modeling Validation

By using the error formula above, an error value of 34.93% is obtained. For a Figure 8 of the comparison of the average current velocity from secondary data and the modeling results, it can be seen as follows.

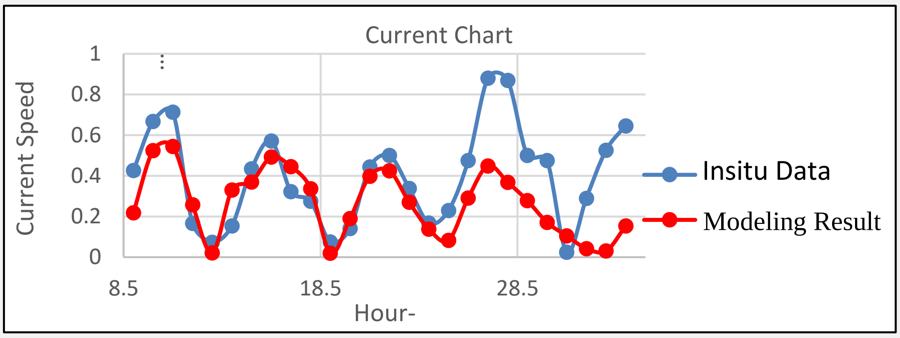

Figure 8. Current Speeds Comparison Chart

Modelling Simulation Result

The results of the hydrodynamic modeling simulation are in the form of tidal models, current velocity, and current movement patterns, maximum tides (Figure 9), and wave heights (Kohansal et al., 2021). From this current movement pattern, it is possible to know the pattern of sediment movement, so that it can be considered for planning alternative jetty design layouts (Mahmoodi et al., 2020). The location for the observation of the simulation results is carried out at 2 points, namely at the pier and the port entrance. The location coordinates are as follows and Figure 10 explain bed thickness change east season and west season.

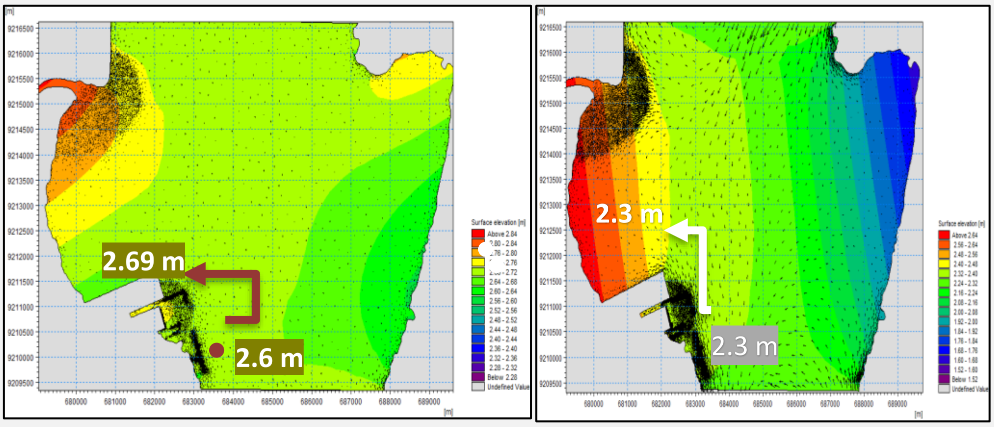

Figure 9. Maximum Tides East Season and West Season

Alternative Dock Model

For the design of Pier 1, modifications are given in the form of adding a jetty on the north side of Pier C. The addition of this jetty is made in an upright position with the aim of reducing sediment carried by the dominant current from northwest to southeast so that sediment does not enter the docking pool of Pier C (Katsiri et al., 2009).

In the additional jetty to the north, a straight jetty is added with a length of about 500 m and a width of 6 m from the shoreline. Alternative design 1 on Pier C. Figure 11 explain dock alternative 1.

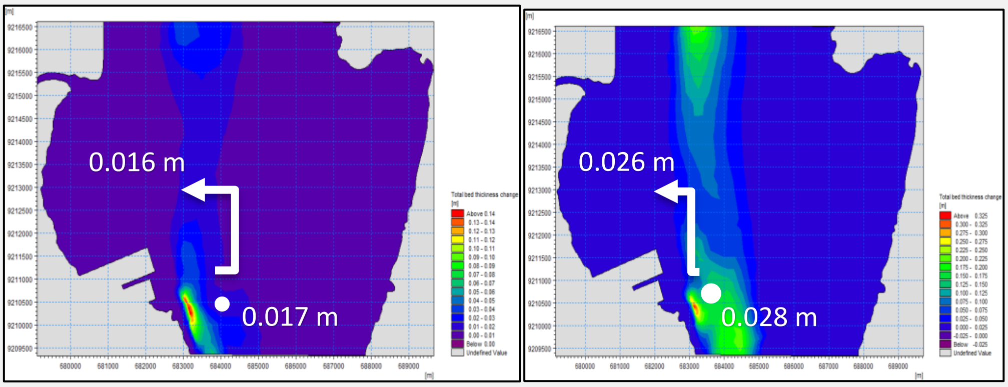

Figure 10. Bed Thickness Change East Season and West Season

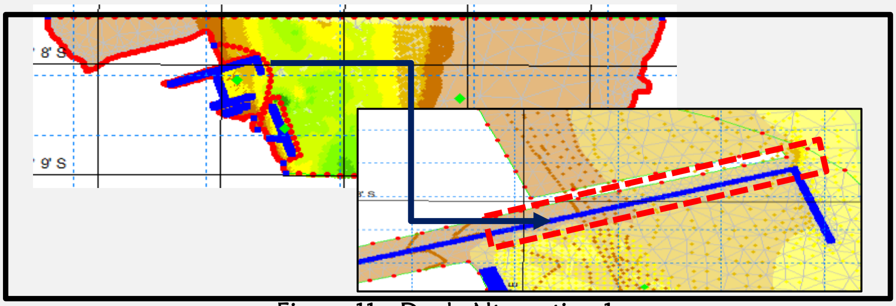

Figure 11. Dock Alternative 1

From the simulation results of mud transport modeling, it is known that there are differences in the bottom profile of the water (bed level) from before modeling and after modeling. This means that there is a change in the bathymetric contour during the 30 day simulation period. These changes can be seen as follows. Figure 12 explain bed thickness change east season and west season alternative dock.

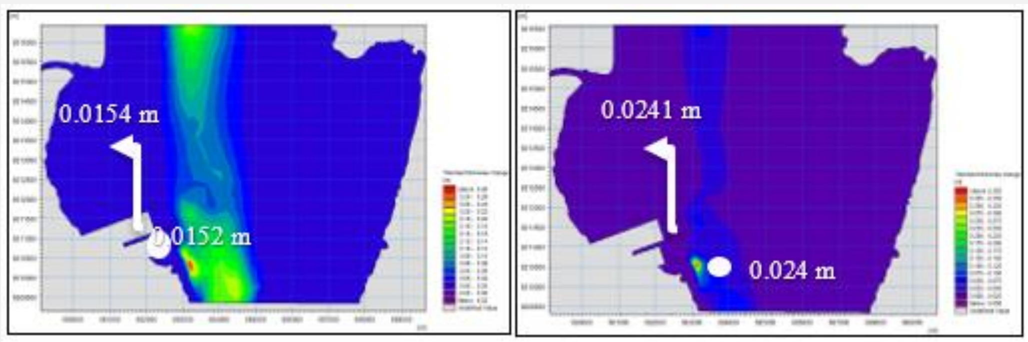

Figure 12. Bed Thickness Change East Season and West Season Alternative Dock

To find out the magnitude of the sedimentation volume rate, the sedimentation volume calculation is carried out using Surfer 16 software. The calculation of the volume of sediment accommodated in the anchored pond with an area of this aims to determine the estimated dredging time that must be done so that the ship can still operate.

In calculating the volume using Surfer 16, bed thickness change data from the results of Mike 21 mud transport modeling is used which is then modeled using the cut and fill volume integration method so that the sediment volume (net volume) can be known. Table 2 explain existing for 16 surfer report volume grid.

Table 2. Existing for 16 Surfer Report Volume Grid

Volume Report	West Season Volume (m^3)	East Season Volume (m^3)
Total Volumes by:		
Trapezoidal Rule	2276.84	1163.44
Simpson's Rule	2237.35	1164.78
Simpson's 3/8 Rule	2258.74	1164.93
Cut & Fill Volumes:		
Positive Volume [Cut]	2354.24	1172.61
Negative Volume [Fill]	77.41	9.16
Net Volume [Cut-Fill]	2276.83	1163.45

Based on Table 2, it can be seen that the sediment volume for 30 days in the east season is 1163.45 m^3, while in the west season it is 2276.83 m^3. From the calculation of sediment for 30 days in the east and west monsoons, then the average is searched and linearized to get the sediment volume value for 12 months, which can characterize sedimentation that occurs within one year.

The calculation of sediment linearization for 12 months below results in the accumulation of sedimentation volume that occurs in the existing anchorage pond in 1 month of 2276.83 m^3 in the west season, namely (October - April), and 1 month at 1163.45 m^3, in the east season (April - October), and the accumulation for 12 months between the east and west monsoons was 20641.68 m^3. Table 3 explain alternative 1 for 16 surfer report volume grid.

Table 3. Alternative 1 for 16 Surfer Report Volume Grid

Volume Report	West Season Volume (m^3)	East Season Volume (m^3)
Total Volumes by:		
Trapezoidal Rule	1271.77	610.52
Simpson's Rule	1270.23	610.57
Simpson's 3/8 Rule	1276.06	611.85
Cut & Fill Volumes:		
Positive Volume [Cut]	1360.11	624.66
Negative Volume [Fill]	88.346	14.15
Net Volume [Cut-Fill]	1271.75	610.51

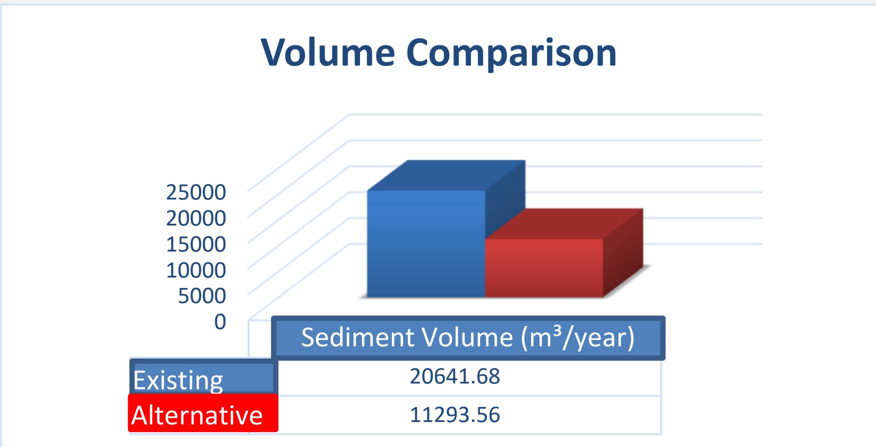

Figure 13. Sediment Volume Comparison

In this study, the alternative jetty chosen is the most optimal alternative jetty to reduce the sedimentation rate in the anchored pond area. The selection of the most optimal alternative jetty to reduce the sedimentation rate is based on the alternative jetty which has the minimum volume rate for 12 months and has the largest volume difference to the volume of the existing jetty (Wibowo, 2020). Based on the two graphs above, it can be seen that the sedimentation volume accumulated for 12 months in the second alternative jetty has the minimum volume and has the largest volume ratio difference to the sedimentation volume in the existing jetty.

CONCLUSION

The sedimentation rate in the Port C area is mainly caused by the effect of current pattern, tide, and wave. The dominant current direction from the simulation results is from the northwest to the southeast. This result led to the increase of sedimentation in the north area of the port. Hence, the sediment rate of 0.042 m at the main port and 0.045 m at the port entrance are obtained. The two modifications of the port layout are proposed to reduce the sedimentation. As a result, it is known that the sedimentation rate at the same location is decreased. The sediment volume of the alternative layout 1 and 2 over 12 months were 11293.56 m^3 and 7426.2 m^3, respectively. These results can reduce the sediment volume by about 45% and 64%, compared to 20641.68 m^3 of sediment volume in the existing layout of Port C. Between the alternative layout 1 and 2, the latter is the most optimal recommendation. Therefore, it can be concluded that the modification of the port layout is proven to reduce the rate of sedimentation in Port C. Based on this research, the following conclusions can be drawn: The dominant current direction from the simulation results is from the northwest to the southeast. The volume accumulation that occurred in the 12th month in the existing condition was 20641.68 m^3, in alternative 1 it was 11293.56 m^3, in alternative condition 2 was 7426.2 m^3.

ACKNOWLEDGEMNET

Thank you to the research team and reviewers of the InJoES who took the time to read this research paper.

REFERENCES

Ezzeldin, M., Rageh, O., & Saad, M. (2020). Assessment Impact of The Damietta Harbour (Egypt) and Its Deep Navigation Channel on Adjacent Shorelines. *Journal of Integrated Coastal Zone Management*, *20*(4), 265–281.

Hidayat, F., Juwono, P. T., Suharyanto, A., Pujiraharjo, A., Legono, D., Sisinggih, D., Neil, D., Fujita, M. & Sumi, T. (2017). Assessment of sedimentation in Wlingi and Lodoyo reservoirs: A secondary disaster following the 2014 eruption of Mt. Kelud, Indonesia. *Journal of Disaster Research, 12*(3), 617-630. https://doi.org/10.20965/jdr.2017.p0617

Katsiri, A., Pantazidou, M., Damikouka, I., Kontogiorgi, C., & Tringali, A. (2009). Disposal options for dredged marine sediments based on physicochemical and toxicological characterization. *Global NEST Journal*, *11*, 449–456.

Kohansal, K., Toor, S., Sharma, K., Chand, R., Rosendahl, L., & Pedersen, T. H. (2021). Hydrothermal liquefaction of pre-treated municipal solid waste (biopulp) with recirculation of concentrated aqueous phase. *Biomass and Bioenergy, 148*, 106032. https://doi.org/10.1016/j.biombioe.2021.106032

Krishna, H., Das, B., Attri, B. L., Kumar, A., & Ahmed, N. (2012). Interaction between different pre-and postharvest treatments on shelf life extension of 'Oregon Spur'apple. *Fruits, 67*(1), 31-40. https://doi.org/10.1051/fruits/2011064

Mahmoodi, A., Lashteh Neshaei, M. A., Mansouri, A., & Shafai Bejestan, M. (2020). Study of current-and wave-induced sediment transport in the Nowshahr Port entrance channel by using numerical modeling and field measurements. *Journal of Marine Science and Engineering*, *8*(4), 284. https://doi.org/10.3390/jmse8040284

Nontji, A. (1987). *Laut Nusantara*. Djambatan.

Novianto, I. M. (2009). *Sedimentation Analysis at Domestic Pier of Surabaya Container Terminal (TPS)*. Institut Teknologi Sepuluh Nopember.

Pratikto, W. A., Fitriadhy, A., Maulana, M. I., Huda, A. C., Putri, D. L., Simatupang, L. A., Wahyudi, N. R., Laksono, R., & Dewi, A. V. R. (2021). The Study of Coastline Changing and Total Suspended Solid Distribution Based on The Remote Sensing Data in Teluk Lamong Multipurpose Port Terminal. *IOP Conference Series: Earth and Environmental Science*, *698*(1). https://doi.org/10.1088/1755-1315/698/1/012046

PT. Petrokimia. (2018). *Company Profile*.

Putra, S. M. B., Suharyanto, A., & Pujiraharjo, A. (2017). Simulasi Numeris Perubahan Morfologi Dasar Laut Pada Desain Pelabuhan Di Kabupaten Gresik, Indonesia. *Jurnal Teknik Pengairan: Journal of Water Resources Engineering*, *8*(1), 130-138. http://dx.doi.org/10.21776/ub.jtp.2017.008.01.13

Sravanthi, N., Ramakrishnan, R., Rajawat, A. S., & Narayana, A. C. (2015). Application of Numerical Model in Suspended Sediment Transport Studies along the Central Kerala, West-coast of India. *Aquatic Procedia*, *4, 109-116*. https://doi.org/10.1016/j.aqpro.2015.02.016

Wibowo, M., Hendriyono, W., Rahman, R. A., Susatijo, G., Kongko, W., Istiyanto, D. C., Widagdo, A.B., Nugroho, S., Khoirunnisa, H., Wiguna, E., Aziz, H. & Santoso, B. (2020). Sediment Transport Modeling at Jelitik Estuary, Sungailiat-Bangka Regency for the Design of Sediment Control Structures. *Journal of Physics: Conference Series*, 1625(1), 012042. IOP Publishing. https://doi.org/10.1088/1742-6596/1625/1/012042

Copyright (c) 2021 by the authors. This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.