Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 146 (2020) 202-214 EISSN 2392-2192

The Effect on Mangrove Density with Sediment Transport Rate in Sikakap Coastal Area of Mentawai Island District, West Sumatera Province, Indonesia

Achmad Rizal* and **Zuzy Anna**

Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Indonesia

*E-mail address: achmad.rizal@unpad.ac.id

ABSTRACT

This study aims to determine what is the influence of the density of mangroves on the rate of coastal sediment transport and abrasion that occurred in the Sikakap Coastal area of Mentawai Island district. The research method used is the quadratic transect method and the sediment trap method. The type of mangrove vegetation that dominates in the Sikakap Coastal area of Mentawai Island district is *Avicennia marina*. Tree level mangrove density at Station I is 1,450 stands / ha and categorized as good, while the tree level mangrove density at Station II is 900 stands / ha and categorized as heavily damaged mangrove forests. The relationship between mangrove density and transport sediment rate in Sikakap Coastal, Mentawai Island district shows a negative correlation with the value -1, meaning that when mangrove density is high, the transport sediment rate will be low, and vice versa, when mangrove density is low, the transport sediment rate will be high.

***Keyword*:** mangrove density, quadratic transect method, sediment trap method, transport sediment rate, *Avicennia marina*

1. INTRODUCTION

Mangrove forest area in addition to physically functioning as a barrier to coastal abrasion, also has a biological function, namely mangroves provide food for humans, especially fish,

(Received 04 June 2020; Accepted 22 June 2020; Date of Publication 23 June 2020)

shrimp, shellfish, crabs, and a source of energy for life on the beach, like plankton, nekton, and algae. Ref. [3] states that there are 38 types of mangroves that grow in Indonesia, including the genera Rhizophora, Bruguiera, Avecennia, Sonneratia, Xylocarpus, Barringtonia, Lumnitzera, and Ceriops. Ecologically, the use of mangrove forests in coastal areas that are not managed properly will decrease the function of the mangrove forest itself with a negative impact on the potential of biota and forest function others as habitat [1,3].

Mangrove forests provide many valuable services, including wave- and tidal-energy dissipation, sediment accumulation, and substrate stabilization. But, their global extent is rapidly shrinking. Sedimentary research that is needed to inform restoration projects has so far been focused on characterizing flow patterns through the forests associated with single rivers, nearshore environments, or terminating tidal channels. However, flows within the most extensive mangrove forests tend to be driven through channels that connect the multiple estuaries or other channels with temporally lagged tides [1-3].

Mangrove forests, according to [4-8], are a set of plant species that grow along tropical to sub-tropical coastlines, having important functions in an environment that contains salt and landforms in the form of beaches with an aerobic soil reaction. The physical function of mangrove forests can function as a controller of coastal abrasion by mangrove ecosystems that occur through the mechanism of breaking the kinetic energy of sea water waves. Mangrove forests can also function to control sea water intrusion, in addition mangrove forests can accelerate the rate of sedimentation which eventually gives rise to arising land so that the land area is expanding.

Results of sedimentological analysis showed that the habitat of *Rhizophora* spp. and *Avicennia* spp. mud content reaches 61%, while the remainder is sand and gravel [2-9]. Sediment transport on the coast can occur due to waves, ocean currents or a combination of both. A beach will experience erosion or sedimentation being dependent upon the equilibrium of incoming and outgoing sediment on the beach.

The foundations of coastal ecosystems and communities are built with sediment that is captured by hydrodynamic processes within coastal zones and then deposited. Sediment-transport dynamics in coastal environments, such as tidal mudflats [3-6] and vegetated marshlands [2, 4-7] have been the focus of numerous research projects over the past several decades. Recently, more focus has been directed towards mangrove forests. In tropical and subtropical settings, these forests serve as buffers to coastal erosion and storm damage [2, 5, 6-8] and are considered important juvenile habitats, refuges, and feeding grounds for many fish species. Mangroves also sustain traditional human communities worldwide, especially in developing regions, such as the Indonesian coastal area [4-10].

The condition of mangrove forests in the Mentawai Island district has been getting worse from year to year. That was due to the change of function of the mangrove forest land into ponds, plantations, human settlements, as well as illegal logging. This triggers the occurrence of coastal erosion (abrasion) which is quite severe because it is estimated that within 30 years the coastline will retreat to 1 km [3]. Even today, the threat of a coastline retreat is increasingly visible and has a negative effect on coastal and oceanic ecosystems.

This study is intended to determine what is the influence of the density of mangroves on the rate of sediment transport and coastal abrasion that occurs in the Sikakap Coastal Coast region, Mentawai Island district (**Fig. 1**). This research activity expects from outputs in the form of information and data about the condition of mangrove forests and how they affect the rate of sediment transport in the Sikakap Coastal Coast region, concerning the mangrove density.

This can be the basis for Mangrove forest management in the Sikakap Coastal region, Mentawai Island district, West Sumatra Province.

Fig. 1. Map of Sikakap Coastal Area

2. MATERIAL AND METHOD

The material used is mangrove vegetation and sediment samples in Sikakap Coastal, Mentawai Island district, West Sumatra Province. This research was carried out using survey techniques and mangrove vegetation analysis with a combination of transect methods and quadrat methods, referred to as quadratic transect methods. Transects are placed perpendicular to the coastline to the land with a size of 10 × 10 m in length, depending on field conditions (the distance of the mangrove forest on the coast with the border of the mangrove forest with the land behind the mangrove forest) [5, 11].

According to [5, 11], the size of the stands used in the mangrove forest vegetation analysis activities are as follows:

A) Sample plot of 10 × 10 m for trees> 10 cm in diameter> 1.5 m high
B) Sample plot of 5 × 5 m of samplings with height above 1.5 m with diameter <10 cm with height <1.5 m
C) Sample plot of 2 × 2 m for seedlings.
Sedimentation rate is calculated by a sediment trap (**Figure 2**).

The sediment trap tube used is a PVC pipe with a diameter of 5 cm and a height of 11.5 cm. At the top of the PVC pipe, baffles are installed and the bottom is paid a cover. It should be decided, how to install a sediment trap, as a sediment trap tube tied to a steel pole, using a wire and then inserted at a height of 20 cm from the bottom of the water [5,11].

Fig. 2. Sediment Trap Tool

Pearson Correlation Analysis is used to analyze the relationship between the mangrove density and transport sediment to be assessed using IBM SPSS Statistics Version 17.0 for Windows or commonly called PASW (Predictive Analytics SoftWare). The value of the correlation coefficient ranges from −1 to 1. The value of the correlation coefficient −1 (minus one) leads to a perfect negative relationship (inverse), the value of the correlation coefficient 0 means there is no relationship at all, and the correlation coefficient value 1 means that there is a perfect positive relationship.

3. RESULTS AND DISCUSSION

3. 1. Mangrove type composition

There are 7 types of vegetation at Station I, namely *Avicennia marina, Avicennia alba, Bruguiera gymnorhiza, Bruguiera cylindrical, Rhizopora mucronata, Rhizopora stylossa, Rhizopora apiculata* (**Figure 3**). The highest composition of mangrove vegetation of tree level at the study site was *Avicennia marina* by 47%, and the lowest was *Bruguiera cylindrical* by 2%. *Avicennia marina* holds the highest composition because the characteristics of this research location match the characteristics of *Avicennia marina*.

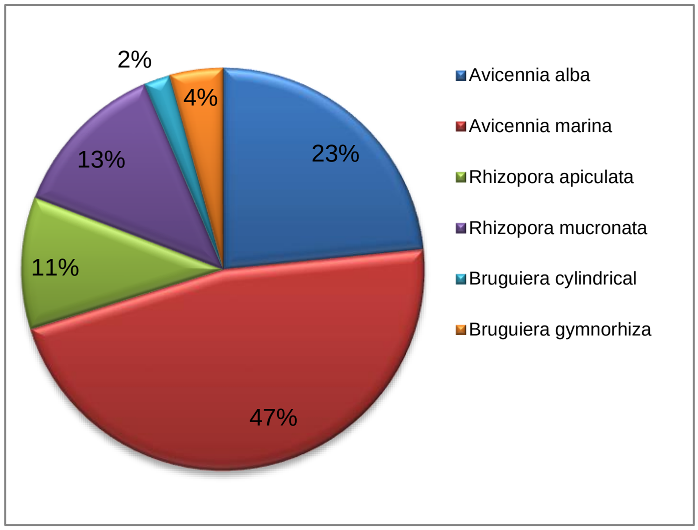

Fig. 3. Composition of tree-level mangrove vegetation.

The composition of mangrove vegetation for the highest sampling level is *Avicennia marina* by 40%, and the lowest is *Rhizopora stylossa* by 4% (**Figure 4**). *Avicennia marina* has the highest composition in addition to be paid to the compatibility of characteristics, also because this species grows to spread in large numbers at stations I and II.

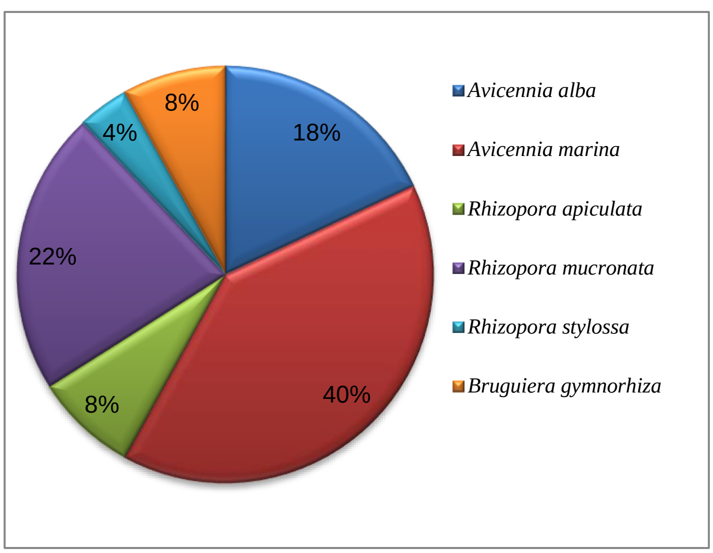

Fig. 4. Composition of mangrove vegetation at the stake level.

The highest composition of mangrove vegetation for seedlings is *Rhizopora mucronata* by 43%, and the lowest is *Bruguiera cylindrical* by 4% (**Figure 5**). *Rhizopora mucronata* dominates the seedling level because at Station II there is the result of planting that can be seen from the growth that spreads regularly.

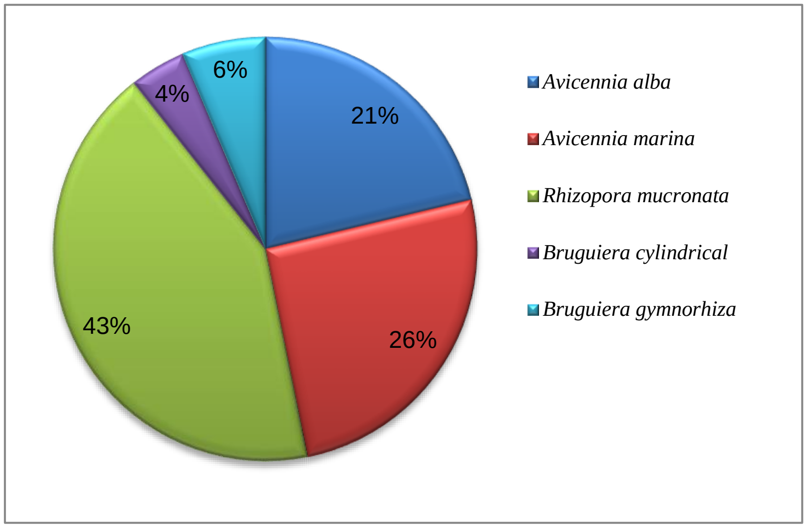

Fig. 5. Composition of seedling mangrove vegetation.

3. 2. Species density

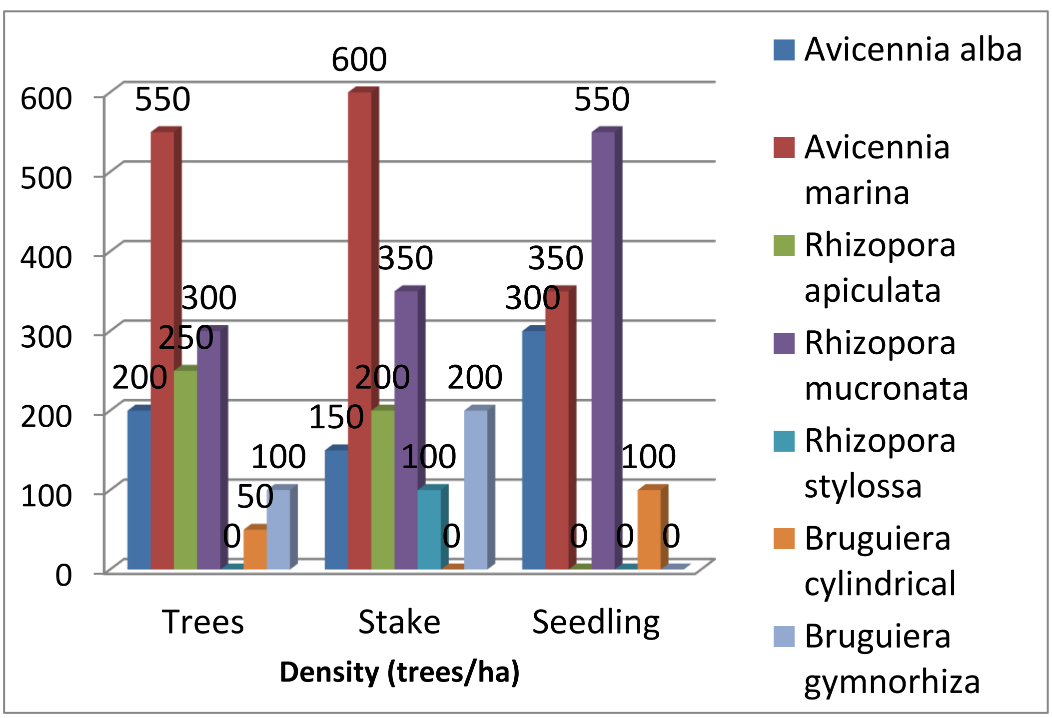

Fig. 6. Type density of Station I

Tree level is characterized by *Avicennia marina* with 550 stands / ha. The sampling level is dominated by *Avicennia marina* with 600 stands / ha. Seedlings are dominated by *Rhizopora mucronata* with 550 stands / ha (**Figure 6**). The number 0 in the Table means that no plants were found at the tree, sampling and seedling levels in the research transect. That is explained by the low regeneration ability (for seedling level) and is utilized by the community (tree level). Low regeneration ability to seedling level is caused by various things such as individuals covered by plastic waste and dead, thereby reducing the number of stands for seedling level. Meanwhile, for tree level stands, the small number of stands found was due to various factors, such as falling down by the wind and logging by residents.

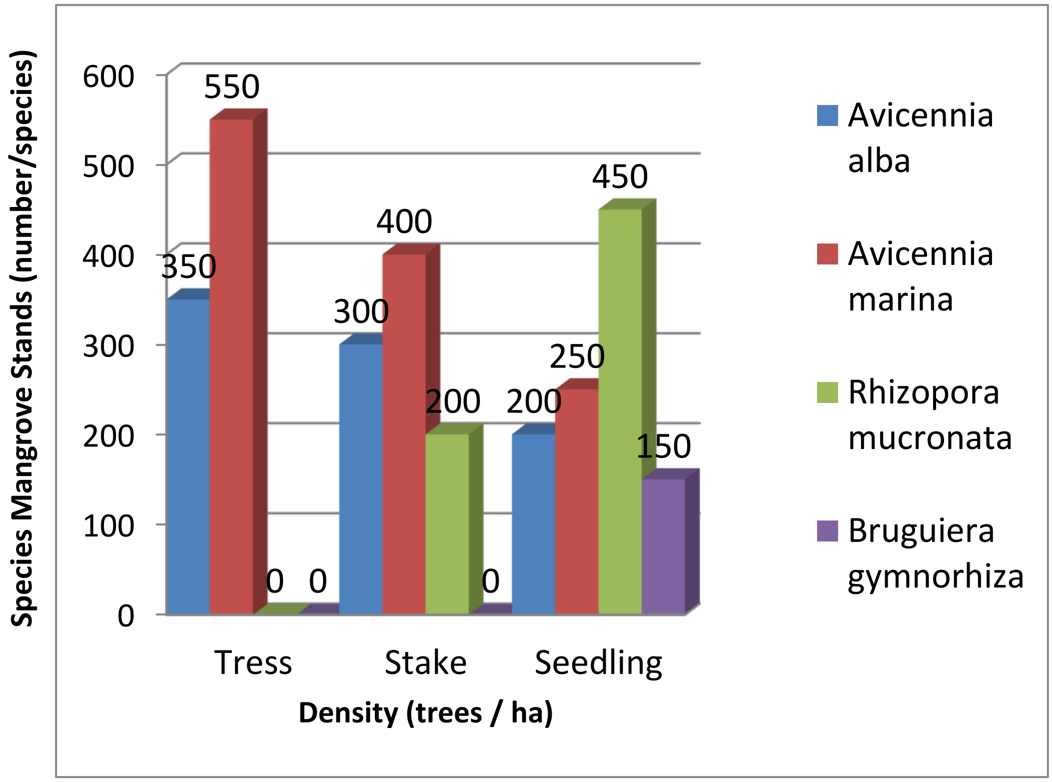

Fig. 7. Type density of Station II

Avicennia marina dominates at the tree level because this area of Station I is an area that is heavily influenced by tides. Density for tree level determines the level of mangrove forest damage, as contained in the Minister of Environment Decree No. 201 of 2004 with a good category > 1,500 species mangrove stands/ha, moderately damaged > 1,000 species mangrove stands/ha, and heavily damaged < 1,000 species mangrove stands/ha. Tree level density of 1,450 species mangrove stands/ha, station I was categorized as good.

There are 4 types of mangrove vegetation at Station II, namely *Avicennia marina*, *Avicennia alba*, *Bruguiera gymnorhiza*, *Rhizopora mucronata* (**Figure 7**). The tree level is dominated by *Avicennia marina* with a density of 550 stands / ha and there is also *Avicennia alba* with a density of 350 stands / ha, while at the state level is also dominated by *Avicennia marina* with a density of 400 stands / ha. The seedling level is dominated by *Rhizopora mucronata* with a density of 450 stands / ha. *Rhizopora mucronata* at the seedling level is found to grow very regularly and spread because it is the result of planting. The absence of *Bruguiera* *gymnorhiza* and *Rhizopora mucronata* species at the tree level is due to the type of mangroves planted at this location which has only reached saplings and seedlings.

Station II is a mangrove forest area which is included in the utilization zone by the local government, where the location is exercised by the surrounding community as a place to tour. In accordance with the Minister of Environment Decree No. 201 of 2004, with a total tree species density of 900 stands / ha, Station II was still categorized as heavily destroyed mangrove forests (<1000 stands/ha).

3. 3. Physical Characteristics - Chemistry

This study measured several physical-chemical parameters, namely temperature (air and water), current velocity, degree of acidity (pH), and salinity. Physical - chemical parameters at the study site can be seen in **Table 1** below.

Table 1. Physics - Chemistry Parameters at the study site.

Parameter	Station I			Station II		
Seawater Temperature (°C)	29	30	31	30	30	32
Seawater Current Speed (m/s)	0.216	0.225	0.240	0.142	0.164	0.193
pH	8.3	8.4	8.1	8.3	8.5	8.4
Salinity (ppt)	24	26	26	35	35	33

3. 4. Temperature

Temperature is part of the important parameters for the survival of marine life. Temperature can affect processes, such as photosynthesis and respiration. In addition, temperature can also serve as a limiting factor for certain biota. Water temperature in the study area ranged from 29 – 32 °C. The lowest water temperature is 29 °C obtained at Station I. The highest water temperature is found at Station II, which is 32 °C.

Of all types of mangrove vegetation found at each station in the study location, all are suitable and ideal at these temperatures in accordance with the Standard Quality in Minister of Environment Decree No. 51 of 2004 which states that the ideal sea water temperature for mangroves is 28 – 32 °C.

3. 5. Salinity

Water salinity is a major factor for growth, survival, and zoning of mangrove species [11-20]. Salinity at the study site shows a range of 24 - 35 ppt. The highest salinity value was found at station II which was 35 ppt, while the lowest salinity was found at the station I which was 24 ppt. (Salinity value at each study location.)

3. 6. Acidity (pH)

The pH value at the study site ranged from 8.1 - 8.5. The highest pH value was found at the station II with a value of 8.5. The lowest pH was found at station I, which was 8.1. The pH values at each study site can be seen in **Table 1**. The low pH values indicate the influence of river flows that tends to be alkaline. The results of the measurement of the degree of acidity showed a difference that was not so large, so that the pH of the water of the Sikakap Coastal Mentawai Island district was classified as homogeneous.

3. 7. Flow Speed

The measured current velocity is the velocity of tidal currents at the sea level caused by tides. Current speed needs to be measured using a current meter. The current meter is located in a depth of 0.5 - 1 meter and faces the direction of the current. Current speed values at each study location can be seen in Table 1.

Current velocity measurements at the study site were conducted in high tide, thus the current conditions at the study site came from the eastern Java sea (**Figure 8**). Current velocity ranges from 0.142 - 0.240 m/s. The lowest current speed at the station II is 0.142 m/s and the highest – at the station I, with a value of 0.240 m/s.

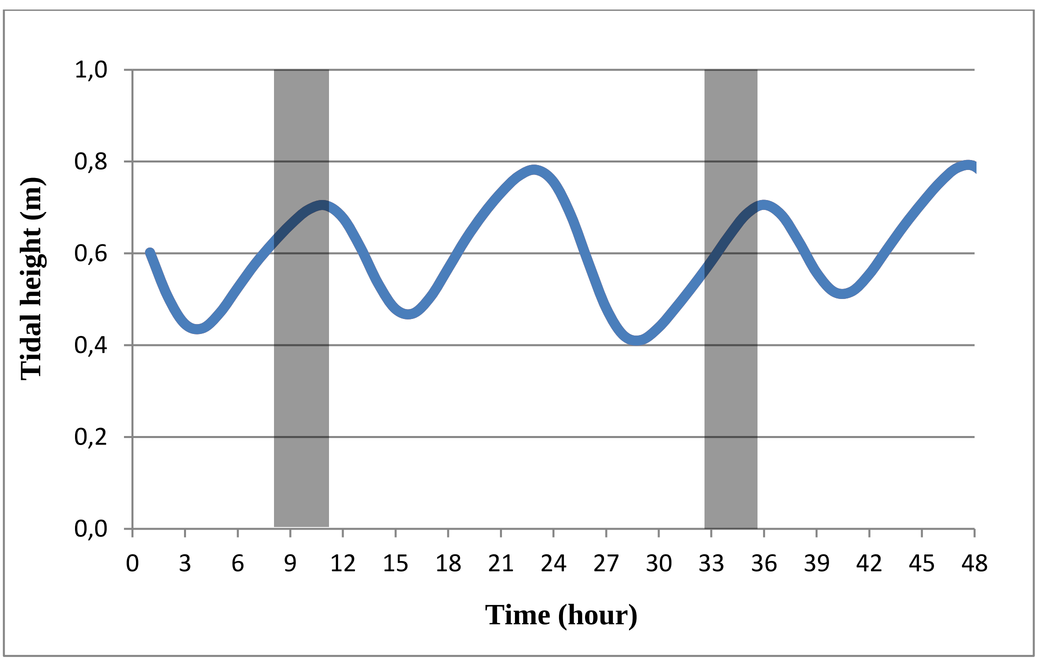

Fig. 8. Tidal height graph on March 21-22, 2017 in Sikakap Coastal of Mentawai Island district

3. 8. Substrate

Observation of the substrate type was carried out at the Soil Physics Laboratory, Department of Soil Science, Faculty of Agriculture, Padjadjaran University. Types of substrates at the study site are presented in **Table 2**.

Table 2. Types of substrates at the study site.

Location	**Sand (%)**	**Clay %**	**Silt (%)**	**Substrate Classification**
Station I	42.58	25.40	32.02	Dusty clay
Station II	55.51	20.65	23.84	Dusty sand

Substrate was analyzed based on 3 fractions, namely sand, clay, and dust. The sand texture content was greater when opposed to the value of the percentage of clay and dust. Sand substrate type dominates at the two stations located in Sikakap Coastal. The characteristics of the substrate is a factor that limits the growth and distribution of mangrove plants, as suggested by [12-19], that differences in physical and chemical characteristics of the soil will cause differences in Mangrove zoning. This is proven by the finding of many *Avicennia marina* and *Rhizopora mucronata* at the study site, as stated by [2, 6-11] that in Indonesia, muddy substrates are very good for stands of *Rhizopora mucronata* and *Avicennia marina*.

3. 9. Sediment Transport Rate

Sediment transport rates at the observation station ranged from 73.81 - 262.8 mg/cm^2 / day (**Table 3**). The highest sediment transport rate occurred at Station II, which was 262.8 mg/cm^2 / day. The results of the analysis showed that the high level of sedimentation at the study site was due to the low density of mangrove forests [3, 20-24]. The research location is open water (windward), dealing directly with the incoming waves. The sediment transport rate at Station I was the lowest compared to Station II, which was 73.81 mg/cm^2/ day.

Table 3. Sediment transport rates at each research station

Station	Sediment Transport Rate mg/cm^2/day		
	Sub Station 1	Sub Station 2	Sub Station 3
I	82.98	111.2	73.81
II	262.8	190.6	244.1

It is observed that the rate of transport sediment occurring at the study site is the opposite of the current speed. At station II, with the lowest current speed of 0.142 m/s has the highest value of the transport sediment rate of 262.8 mg/cm^2 / day. At Station II in Sikakap Coastal is an area that is protected by a pier and its beach topography is facing the mainland, with the lowest current velocity when it receives sediment input; it is likely that a greater precipitation will occur [3, 25-29]. On the other hand, at the station I, with the highest current speed of 0.240

m/s it has a low value of the transport sediment rate of 73.81 mg/cm^2 / day, the rate of transport sediment that occurs is lower than that of station II.

4. CONCLUSION

The relationship between the mangrove density and transport sediment rate in Sikakap Coastal, Mentawai Island district, shows a negative correlation with the value −1 (minus one), meaning that when the mangrove density is high, the transport sediment rate will be low, and vice versa, when the mangrove density is low, the transport sediment rate will be high.

Obviously, similar to our assumptions, the transport sediment in mangrove ecosystems located in the Sikakap Coastal area was affected by tidal hydrodynamic factors. Specifically, (1) a high tidal current velocity appeared to promote sedimentation during the flood and ebb tides and thus increased the abundances of the mangrove sediment; (2) the sediment at the seaward boundary was significantly lower than that at the landward boundary, and the growth rates were also determined by the tidal current velocity. Furthermore, the findings of this study highlight that the tidal current velocity and tidal range must be taken into account when the mechanism of sediment in the mangrove ecosystems is studied.

Acknowledgment

The authors wish to thank the Faculty of Fisheries and Marine Science, Universitas Padjadjaran, which supported the study through the Research Faculty program.

Reference

[1] Rogers, K.G., Goodbred, S., and Migration, H., 2014. The Sundarbans and Bengal Delta: The world's largest tidal mangrove and delta system, in: Kale, V.S. (Ed.), Landscapes and Landforms of India. Springer, New York. doi:10.1007/978-94-017-8628-7

[2] Sheridan, P. and Hays, C., 2003. Are mangroves nursery habitat for transient fishes and decapods? *Wetlands* 23, 449–458.

[3] Rizal A. and Lantun P.D. Using economic values to evaluate management options for fish biodiversity in the Sikakap Strait, Indonesia. *Biodiversitas Journal* Vol 18 (2) (2017) 586-592

[4] Souza-Filho, P.W.M., Cohen, M.C.L., Lara, R.J., Lessa, G.C., Koch, B., and Behling, H. Holocene coastal evolution and facies model of the Bragança macrotidal flat on the Amazon mangrove coast, northern Brazil. *J. Coast. Res.* (2006) 306–310.

[5] Souza-Filho, P.W.M., Lessa, G.C., Cohen, M.C.L., Costa, F.R., and Lara, R.J., 2009. The subsiding macrotidal barrier estuarine system of the Eastern Amazon Coast, Northern Brazil, in: Geology and Geomorphology of Holocene Coastal Barriers of Brazil. Lecture Notes in Earth Sciences. Springer, Berlin, Heidelberg, pp. 347–375. doi:10.1007/978-3-540-44771-9_11

[6] Spalding, M.D., Blasco, E., and Field, C.D., 1997. World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okiwana, Japan. doi:10.1017/S0266467498300528

[7] Speer, P.E., Aubrey, D.G., and Friedrichs, C.T., 1991. Nonlinear hydrodynamics of shallow tidal inlet/bay systems, in: Parker, B.B. (Ed.), Tidal Hydrodynamics. John Wiley & Sons, Inc., pp. 321–339.

[8] Rizal A. and Nurruhwati I. New Methodological Approaches for Change in Traditional Sectors: The Case of the West Java Fisheries Socio Economic System. *World News of Natural Sciences* 22 (2019) 41-51.

[9] Rizal A. Reformulation of Regional Development Strategy To Strengthen Marine Sector in West Java, Indonesia. *World Scientific News,* 107 (2018) 207-215.

[10] Rizal A. Science and policy in the coastal zone management. *World News of Natural Sciences* 21 (2018) 1-8

[11] Thampanya, U., Vermaat, J.E., Sinsakul, S., and Panapitukkul, N. Coastal erosion and mangrove progradation of Southern Thailand. *Estuar. Coast. Shelf Sci*. 68 (2006) 75–85. doi:10.1016/j.ecss.2006.01.011

[12] Thomson, R.E. and Emery, W.J., 2014. Data analysis methods in physical oceanography, 3rd ed. Elsevier B.V. doi:https://doi.org/10.1016/C2010-0-66362-0

[13] Thorne, C., Annandale, G., Jensen, J., and Jensen, E., 2011. Review of Sediment Transport, Morphology, and Nutrient Balance, Report to the Mekong River Commission Secretariat prepared as part of the Xayaburi MRCS Prior Consultation Project Review Report.

[14] Uncles, R.J., Bale, A.J., Brinsley, M.D., Frickers, P.E., Harris, C., Lewis, R.E., Pope, N.D., Staff, F.J., Stephens, J.A., Turley, C.M., and Widdows, J. Intertidal mudflat properties, currents and sediment erosion in the partially mixed Tamar Estuary, UK. *Ocean Dyn*. 53 (2003) 239–251.

[15] Van Maanen, B., Coco, G., and Bryan, K.R. Modelling the effects of tidal range and initial bathymetry on the morphological evolution of tidal embayments. *Geomorphology* 191 (2013) 23–34.

[16] Walsh, J.P. and Nittrouer, C.A. Mangrove-bank sedimentation in a mesotidal environment with large sediment supply, Gulf of Papua. *Mar. Geol*. 208 (2004) 225–248. doi:10.1016/j.margeo.2004.04.010

[17] Rizal A., Izza M.A., Heti H., and Lantun P. Distribution and Condition of Coral Reefs in the Waters of Biawak Island, Indramayu Regency, West Java, Indonesia. *World Scientific News,* 144 (2020) 141-157.

[18] Rizal A., Andriani Y., and Kusumartono F.X.H., A Strategic Environmental Assessment for Southern Coastal of West Java Province, Indonesia. *World Scientific News*, 137 (2019) 188-209.

[19] Rizal A., Nora A., Pringgo Kdyp, Rega P., and Aulia A. Molecular diversity of the bacterial community associated with Acropora digitifera (Dana, 1846) corals on

Rancabuaya coastline, Garut District, Indonesia. *World Scientific News*, 144 (2020) 384-396.

[20] Warner, J.C., Schoellhamer, D., and Schladow, G. Tidal truncation and barotropic convergence in a channel network tidally driven from opposing entrances. *Estuar. Coast. Shelf Sci.* 56 (2003) 629–639.

[21] Wattayakorn, G., Wolanski, E., and Kjerfve, B. Mixing, trapping and outwelling in the Klong Ngao mangrove swamp, Thailand. *Estuar. Coast. Shelf Sci*. 31 (1990) 667–688. doi:10.1016/0272-7714(90)90019-N

[22] Wolanski, E., Jones, M., and Bunt, J.S. Hydrodynamics of a tidal creek-mangrove swamp system. *Aust. J . Mar. Freshw. Res* 31 (1980) 431–50.

[23] Rizal A., Nurruhwati I., and Khan A.M.A. Economic Contribution of Southern West Java Province Marine Fisheries. *World Scientific News*, 119 (2019) 204-217

[24] Wolanski, E., Mazda, Y., and Ridd, P., 1992. Mangrove Hydrodynamics, in: *Tropical Mangrove Ecosystems*. pp. 43–62. doi:10.1029/CE041p0043

[25] Woodroffe, C.D., 1985. Studies of a mangrove basin, Tuff Crater, New Zealand: II. Comparison of volumetric and velocity-area methods of estimating tidal flux. *Estuar. Coast. Shelf Sci*. 20, 431–445. doi:10.1016/0272-7714(85)90087-3

[26] Preston, B.L., Yuen, E.J., and Westaway, R.M.. Putting vulnerability to climate change on the map: A review of approaches, benefits, and risks. *Sustainability Science*, 6(2) (2001) 177–202.

[27] S. Wolfeand and D.B. Brooks.Water scarcity: an alternative view and its implications for policy and capacity building. *Natural Resources Forum* (27) (2003) 99–107.

[28] Rahmstorf, S. A new view of sea level rise. *Nature Reports: Climate Change*, 4 (2010) 44–45

[29] Machado, A.A.d.S., Lau, C.W., Kloas, W., Bergmann, J., Bachelier, J.B., Faltin, E., Becker, R., Görlich, A.S., and Rillig, M.C. Microplastics Can Change Soil Properties and Affect Plant Performance. *Environ. Sci. Technol*. 53 (10) (2019) 6044-6052.