International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 11, November 2017, pp. 1–9, Article ID: IJCIET_08_11_001
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=11
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

STUDY OF LONGSHORE CURRENT IN THE MOUTH OF TUNTANG RIVER IN MORODEMAK VILLAGE, DEMAK REGENCY, INDONESIA AND ITS POSSIBLE EFFECT ON FORMING THE COASTAL MORPHOLOGY

Anindya Wirasatriya, Baskoro Rochaddi, Ani Nur Faizah, Muhammad Zainuri, Muslim, Heryoso Setiyono, Hariadi, Jarot Marwoto

Department of Oceanography, Faculty of Fisheries and Marine Science,
Diponegoro University, Semarang, Indonesia

Anindya Wirasatriya and Muhammad Zainuri

Center for Coastal Rehabilitation and Disaster Mitigation Studies,
Diponegoro University, Jl. Prof. H. Soedharto, SH, Tembalang Semarang. 50275

ABSTRACT

The coastal morphology in Morodemak Village is unique since the erosion and sedimentation areas exist only in narrow area separated by the Tuntang River. Combining field measurement and the simulation based on the 10 years wind data, we investigated the characteristics of longshore current which may influence the coastal morphology of Morodemak Village. The distribution of bottom sediment in the Morodemak Village was mainly influenced by the ocean dynamics and it was not by the river input since there was no difference of sediment type between near and away from the river mouth. The characteristic of wind in Morodemak Village was influenced by the south east Asia monsoon system which blew north westerly during rainy season (December, January, February) and south easterly during dry season (Jun, July, August). Longshore current in Morodemak Village only flew south west wardly, occurred during dry and transition season. In the rainy season, longshore current was not generated since the wave breaker angle to the coastline was 0°. The river flow in the mouth of Tuntang River inhibited the speed of south west ward longshore current so that the speed of longshore current in the western side of river mouth was weaker than in the eastern side. The stronger (weaker) longshore current may scrap the coastal line (cause the suspended sediments easily to settle), enhanced the erosion (sedimentation) along the western coast of Morodemak Village.

Key words: Longshore Current, Sedimentation, Erosion, Morodemak Village

Cite this Article: Anindya Wirasatriya, Baskoro Rochaddi, Ani Nur Faizah, Muhammad Zainuri, Muslim, Heryoso Setiyono, Hariadi, Jarot Marwoto, Study of Longshore Current in the Mouth of Tuntang River in Morodemak Village, Demak Regency, Indonesia and Its Possible Effect on Forming the Coastal Morphology. *International Journal of Civil Engineering and Technology,* 8(11), 2017, pp. 1–9.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=11

1. INTRODUCTION

Demak Regency is a part of Central Java Province, Indonesia located in 6º43'26" - 7º09'43" S and 110027'58" - 110048'47" E. Areal size of Demak is ± 1.149,07 km², consists of ± 897,43 km²of land and ± 252,34 km²of ocean [1]. The common sediment type along coastal line of Demak is alluvial soil which is susceptible for erosion [2]. For example, based on the data from the Environmental Impact Management Agency (Bapedal) of Central Java Province in 2008, Sayung sub district which has an area of 78.80 km^2 and consists of 20 villages experienced severe abrasions in recent years and has become a national issue [1]. Morover, reference [3] reported that four villages in Sayung sub district, located along the coastal area experienced the severe coastal erosion. They are Surodadi, Timbulsloko, Bedono, and Sriwulan villages. Erosion in Timbulsloko village is the worst which caused the vanishing of two hamlets in this village, i.e., Tambaksari hamlet in 1997 and Rejosari in 2004. The eroded coastal area increased from 145.5 ha in 2002, to 758.3 ha in 2005. Satellite imagery analysis shows that between 1999 to 2006 shoreline changes due to coastal erosion was 771.4 ha. The erosion was driven by the propagation of waves, struck the coastline without obstacle generating longshore currents, scrapping the coastline. The study of oceanographic parameters in these areas have been well documented in [4-7].

To mitigate the impact of coastal erosion, some engineered coastal structures were applied in these areas. One of the successful effort is the application of semi permeable dam called hybrid engineering. Hybrid engineering is a friendly environment method, combines technical and ecosystem based solutions and accommodates economic and livelihood development needs [8]. Mimicking the concept of mangroves roots in trapping sediments, semipermeable dams which is composed from bamboo piles and brushwood have successfully stimulated sedimentation in comparable muddy environments [9] and then triggered the seedling of mangroves [3].

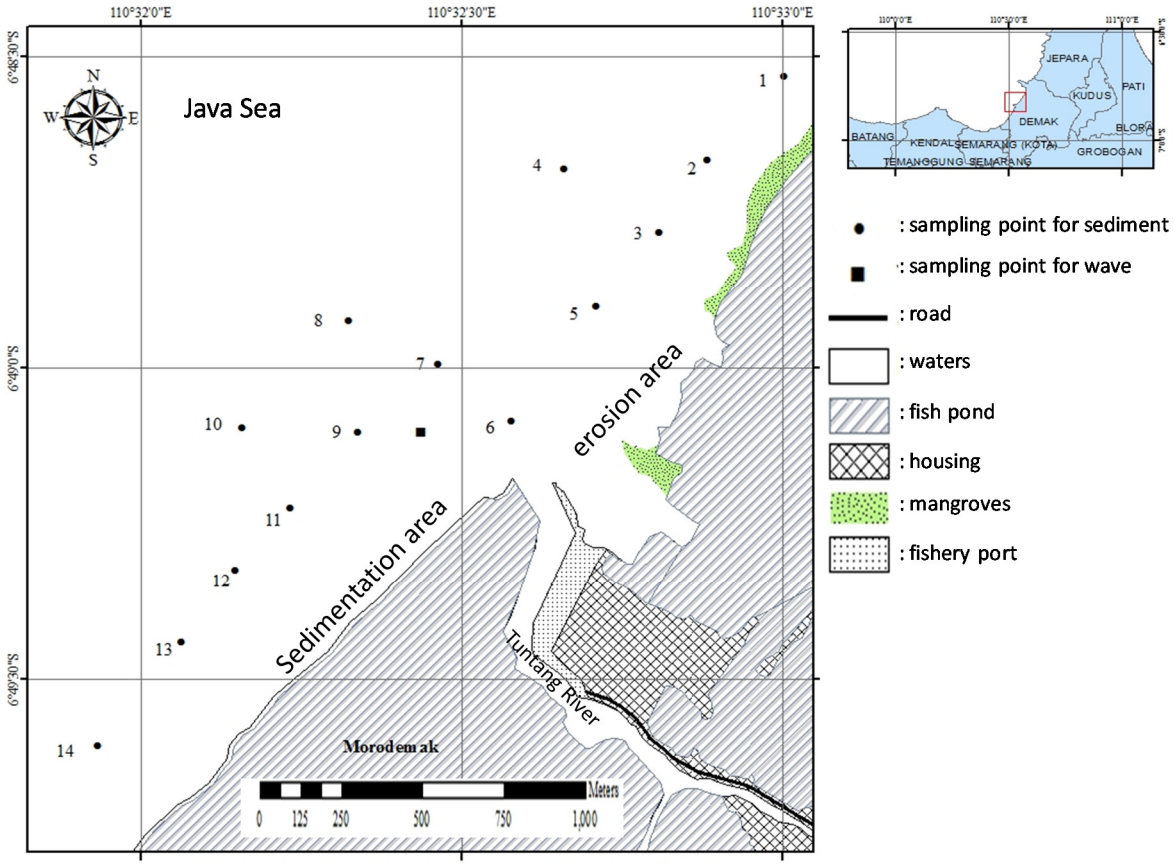

Figure 1 The land cover of the study area

Morodemak is a village in Bonang Sub District, Demak, located in the eastern side of Sayung Sub District. Morodemak village has dense human activity due to the existence of fishery port. The fishery port is connected to the sea through Tuntang River. The land cover map of Morodemak Village is shown in Fig. 1. Different with Timbulsloko Village, the coastline change in Morodemak is more complex. Not only erosion, Morodemak Vilage also suffer from high sedimentation which obstruct the fisherman boats entering the Fish Port. The sedimentation interfere the fisherman activities and cause the decrease of fisherman welfare. The dredging has been done several times to decrease the sediment accumulation in the mouth of Tuntang River. Nevertheless, this effort is less effective since the sedimentation rate is still high. This example indicates that the mitigation effort without scientific studies may lead to the unsuccessfully result.

In the present study, we conduct the scientific analysis to investigate the role of longshore current in the process of the erosion and sedimentation occurs in the mouth of Tuntang River, Morodemak Village. The morphodynamic in the mouth of Tuntang River is very interesting since the sedimentation and erosion occurs only in the narrow area (less than 2 km in width). The area of sedimentation and erosion is only separated by Tuntang River i.e., sedimentation (erosion) in the west (east) side of Tuntang River (Fig. 1). Thus, the present study may give better understanding to explain the causes of morphodynamic process in the coastal area of Morodemak Village which can be used as a scientific base for further mitigation effort.

2. DATA AND METHOD

The base map used in the present study is taken from the Agency of Geospatial Information (http://tanahair.indonesia.go.id/portal/landingpage). We also used Digital Global Image date

15 August 2016 for the coastal area of Morodemak Village taken from Google earth Pro. To investigate the morphodynamic process in the mouth of Tuntang River, we conducted the field measurements and simulation. The field measurements consists of 2 observations, i.e., sediment sampling and wave measurements. Sediment sampling was conducted in 14 points spread along the study area by using sediment grab. The sampling point positions are shown in Fig. 1. Sediment samples were then granulometrically analyzed following the Wenthworth Scale to classify the sediment based on the grain size [10]. The wave measurement was conducted by using wave staff observation for 3 days (21-23 December 2016) to obtain the wave height (H) and period (T). The significant wave height (Hs) and significant wave period (Ts) was calculated from H and T. The position of wave staff was outside the breaker wave area shown in Fig. 1.

The longshore current analysis was basically generated from simulation. We used 10 years wind data (2007-2016) from www.ogimet.com to make wave simulation based on Sverdrup-Munk-Bretscheneider (SMB) method [11].This wave simulation was verified by the wave measurement stated in the previous paragraph. Using the bathymetric map provided by Hidrography and Oceanography Agency of Indonesian Navy, we calculated the wave breaker height (H_b), breaker wave depth (d_b) breaker wave length (l_b), breaker wave velocity (C_b) and breaker wave angle (α_b) by using [4] formula. Longshore current occurs if the wave breaker angle to the coastal line is > 5°. In the coastal line, the speed of longshore current is negligible, then increases toward the sea and is maximum in the middle point of the surfzone. The average speed of longshore current and the rate of transported sediment were calculated following [4], i.e.,

$$V = 1.17(g \times H_b)^{1/2} sin\alpha_b cos\alpha_b \quad (1)$$

$$Q_s = KP_1 \quad (2)$$

$$P_1 = \frac{\rho g}{8} H_b^2 C_b sin\alpha_b cos\alpha_b \quad (3)$$

Where V and g are the speed of longshore current (m/s) and gravity acceleration (9.8 m/s^2), respectively. Q_s, P_1, ρ, and K are the rate of sediment transport (m^3/day), wave breaker energy flux (Nm/d/m), sea water density (kg/m^3), and constant, respectively.

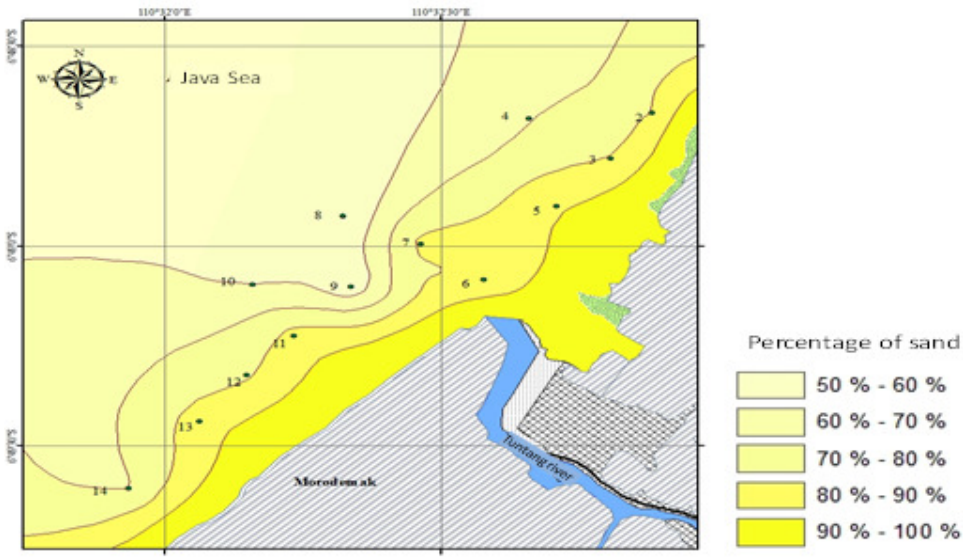

Figure 2 The distribution of bottom sediment

3. RESULTS AND DISCUSSIONS

3.1. Distribution of bottom sediment

Based on the granulometric analysis, bottom sediment in the coastal area of Morodemak Village was silty sand. Figure 2 shows the distribution of bottom sediment in Morodemak Village. The closer to the coastal line, the bigger grain size of sediment, indicated by the higher percentage of sand. The bigger size of sediment has more weight so that this type of sediment could settle along the coastline where the longshore current was generated. The smaller size of sediment settle away from the coastline in the more calm waters. This finding indicates that the distribution of bottom sediment in the Morodemak Village was mainly influenced by the ocean dynamics. The sediment input from the Tuntang River may be negligible since in the areas along the coastline, there was no difference of sediment type between near and away from the river mouth.

3.2. Wind Analysis

The wind characteristics of wind in the coastal area of Morodemak Village is summarized in the wind rose shown in Fig. 3. During rainy season (December, January, February), the dominant wind blew from north west direction with the speed about 4-9 m/s. Transition I season (March, April, May) was dominated by the low wind speed i.e., 2-4 m/s with the dominant direction was from north and south east. In dry season (Jun, July, August) the wind blew mostly from the south east direction. The characteristics of wind in transition II season (September, October, November) was similar with transition I season. The wind characteristics in this area was influenced by the south east Asia monsoon system which generated by the pressure different between Asia and Australia which has been reported by many researchers e.g., [12-14].

To obtain the influence of wind to the wave generation, we calculated the length effective fetch by using topographic map. We found that the effective fetch at north west direction is 139.559 km while at north direction is 50.747 km. Then, fetch value is used in SMB method to simulate the wave characteristics in the seas of Morodemak Village.

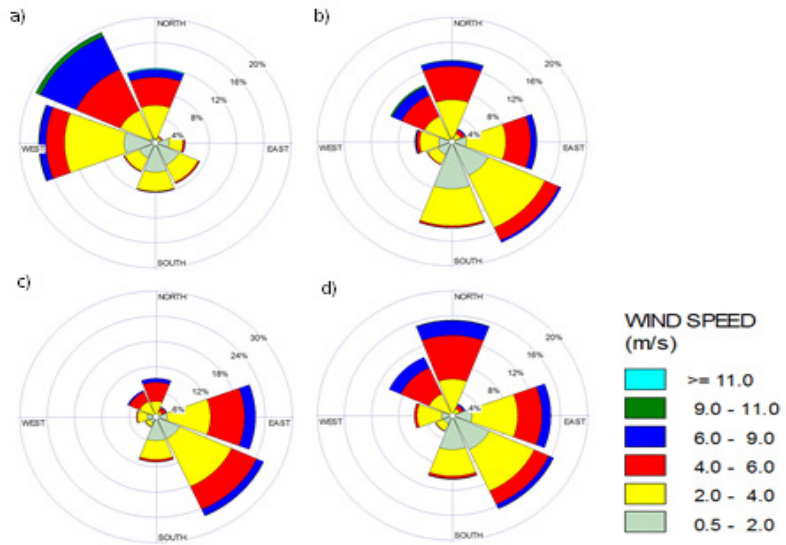

Figure 3 Wind rose in the study area during a) rainy season (December, January, February), b) transition I (March, April, May), c) dry season (Jun, July, August) and d) Transition II (September, October, November)

3.3. Wave Simulation and Longshore Current Analysis

The simulated wave height and period in Morodemak Village is shown in Table 1. The significant wave heights for rainy, transition I, dry and transition II season were 0.21 m, 0.20 m, 0.18 m, and 0.16 m, respectively. While their significant wave periods were 1.61 s, 1.58 s, 1.48 s, and 1.27 m, respectively. From this data we can conclude that the rainy season had the highest wave and the longest period among seasons. This simulation has been validated against in situ measurements which exhibited the low Bias Percentage i.e., 10.56% and 29.87% for significant wave height and period, respectively. Thus, the simulated wave is reliable and can be used further for calculating the characteristics of breaker wave, longshore current speed and sediment transport rate.

Table 1 The simulated wave height and period in the study area

No	Season	H_s (m)	T_s (s)
1	Rainy	0,214	1,609
2	Transition I	0,203	1,581
3	Dry	0,183	1,483
4	Transition II	0,160	1,273

The characteristics of wave breaker (H_b, d_b, and α_b), longshore current speed (V) and the rate of sediment transport (Q_s) are shown in Table 2. To give more validation, it also shows that the characteristics of wave breaker taken from field measurement was similar with it taken from simulation. The wave angle in the rainy season was 0°, which led to the absence of longshore current in this season. During dry season and both transition season the wave angle was more than 5°. Thus, the present study revealed that the longshore current only can be generated during the dry and transition season with the direction of south west wardly. The speed of longshore current was maximum at transition I season and minimum at dry season which led to the rate of sediment transport of 98.84 m^3/day, 71.91 m^3/day, and 36.89 m^3/day for transition I, II and dry season, respectively.

Table 2 The characteristics of wave breaker, longshore current and the rate of sediment transport in the study area.

No	Season	H_b (m)	d_b (m)	α_b (°)	V (m/s)	Q_s (m^3/day)
1	Field measurement (rainy season)	0,2016	0,2527	0	0	0
2	Rainy Season	0,2244	0,2749	0	0	0
3	Transition I	0,2064	0,2497	28,57°	0,6989	98,843
4	Dry Season	0,1890	0,2287	18,8°	0,4857	36,892
5	Transition II	0,1556	0,1945	29,85°	0,6237	71,909

The effect of longshore current which only moves south west wardly on the coastal morphology in the Morodemak Village is summarized in Fig. 4. During the dry and transition season, the wave breaker came from the north forming the angle more than 5° relative to the coastline. The longshore current was generated, flowing south west wardly along the coastline. In the mouth of Tuntang River, this current crossed the river flow moved north east wardly leading to the speed inhabitation of longshore current in the west side of the river mouth. Thus, the calm water in the west side of river mouth was favorable for the suspended

sediment to settle. We can see from Fig. 4 that in the west side of river mouth was shallow indicated as the sedimentation area.

In contrast, the east side of river mouth was seen as the erosion area denoted by the existence of the cavity along the coastline and deeper waters. The occurrence of strong longshore current may scrape the coastline and bring the sediment to settle in the west side of the river mouth. However, further investigation is still needed to determine whether the total amount of sedimentation in the eastern side is equal with the total amount of the erosion in the western side. Detail bottom topographic survey and the analysis of sediment transport per cell should be performed for the next study.

The existence of jetty may also contribute to this erosion process. The rigid canal of jetty may flows the river water mass north east wardly, crashing the longshore current, creating turbulence that also scraping the coastline in the east side of the river mouth. However, this possibility need to be analyzed further by using numerical model.

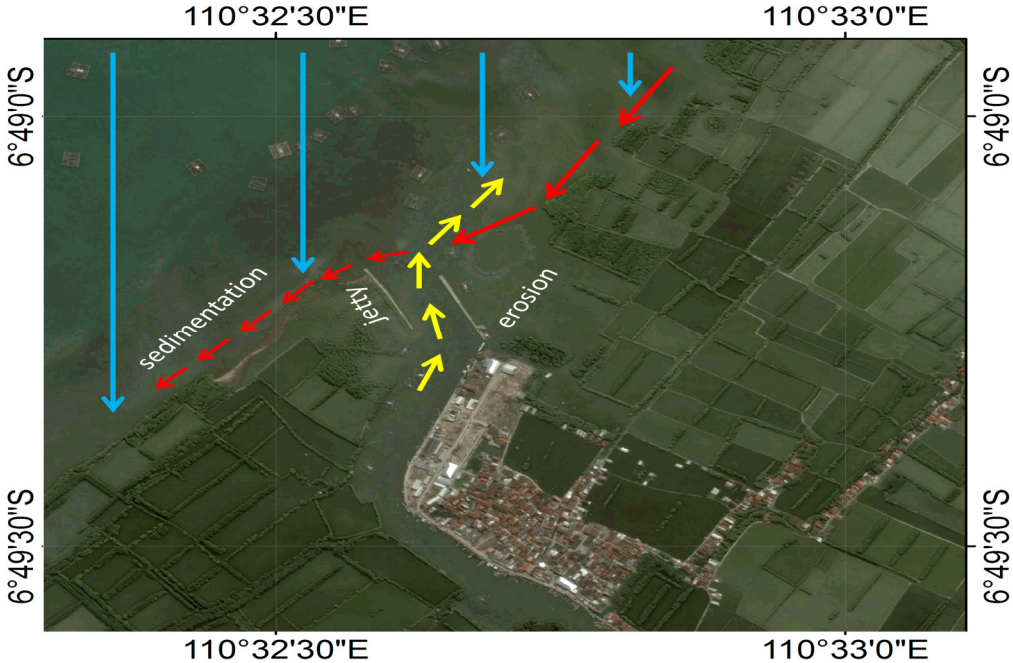

Figure 4 The scenario of longshore current in the study area and its possible effect on the sedimentation and erosion in the study area. Blue, red and yellow arrows denote the direction of wave breaker, longshore current and river flow.

CONCLUSIONS

Study of Longshore current in the mouth of Tuntang River in Morodemak Village, Demak Regency, Indonesia is concluded as follows:

- The coastal morphology in Morodemak Village is unique since the erosion and sedimentation areas exist only in narrow area separated by the Tuntang River.
- The distribution of bottom sediment in the Morodemak Village was mainly influenced by the ocean dynamics and it was not by the river input since there was no difference of sediment type between near and away from the river mouth.
- The characteristic of wind in Morodemak Village was influenced by the south east Asia monsoon system which blew north westerly during rainy season (December, January, February) and south easterly during dry season (Jun, July, August).

- Longshore current in Morodemak Village only flew south west wardly, occurred during dry and transition season. In the rainy season, longshore current was not generated since the wave breaker angle to the coastline is 0°.
- The river flow in the mouth of Tuntang River inhibited the speed of south west ward longshore current so that the speed of longshore current in the western side of river mouth was weaker than in the eastern side.
- The stronger (weaker) longshore current may scrap the coastal line (cause the suspended sediments easily to settle), enhanced the erosion (sedimentation) along the western coast of Morodemak Village.

ACKNOWLEDGEMENTS

We would thank to Oceanography Department Diponegoro University, LPPM Diponegoro University, WCU Program Diponegoro University, Center for Coastal Rehabilitation and Disaster Mitigation Studies (CoRem) Diponegoro University, Center of Excellence Science and Technology (PUI) Diponegoro University and Ministry of Research Technology and Higher Education (Ristek Dikti) Republic of Indonesia for funding our research.

REFERENCES

[1] M.A. Marfai, The hazards of coastal erosion in Central Java, Indonesia: An overview, Malaysia Journal of Society and Space, 7(3), 2011, 1- 9.

[2] Badan Pusat Statistik, Kecamatan Dalam Angka. Demak 2012.

[3] Suripin, D.N Sugianto, and M. Helmi, Mangrove restoration with environment friendly permeable breakwater, Asian Jr. of Microbiol. Biotech. Env. Sc., 19(1), 2017, 102-107.

[4] P. Hawati, D.N. Sugianto, S. Anggoro, A. Wirasatriya, S. Widada, Waves Induce Sediment Transport at Coastal Region of Timbulsloko Demak, IOP Conf. Series: Earth and Environmental Science 55, 2017, 012048, 1-8, doi:10.1088/1755-1315/55/1/012048

[5] A. Ismanto, M. Zainuri, S. Hutabarat, D. N. Sugianto,S. Widada, A. Wirasatriya, Sediment Transport Model In Sayung District, Demak, IOP Conf. Series: Earth and Environmental Science 55, 2017, 012007, 1-6, doi:10.1088/1755-1315/55/1/012007.

[6] D. N. Sugianto, S. Widada, A. Wirasatriya, A. Ismanto, A. Darari and Suripin, Modelling of suspended sediment transport in coastal Demak Indonesia by using currents analyzing, ARPN Journal of Engineering and Applied Sciences, 12 (16), 2017, 4666-4678.

[7] D.N. Sugianto, B. Rochaddi, S.Y. Wulandari, P. Subardjo, A.A.D. Suryoputro, W. Atmodjo, A. Satriadi, C.A. Suryono, and N. Soenardjo, Current characteristics in demak waters based on acoustic measurement, International Journal of Civil Engineering and Technology 8(9), 2017, 749-760.

[8] Sugianto,D.2015.Introduksi Konsep Building with Nature, Kasus Eksisting, dan Pentingnya Kaitan antara Sains, Kebijakan dan Praktek. Workshop dan Launching Building With Nature. March 4, 2015. Semarang.

[9] C. Saengsupavanich, Erosion Protection option of a muddy coastline in Thailand: Stakeholders shared Responsibilities, Ocean &Coastal Management, 83,2013, 81-90

[10] C.K Wentworth, A Scale of Grade and Class Terms for Clastic Sediments, J. of Geology, 30(5), 1922, 377.

[11] *C. L. Bretschneider,* Generation of waves by wind state of the art, Proc. International Summer Course, Lunteren, The Netherlands, 1964, 1-106.

[12] H.K.B. Tjasyono , R. Gernowo, B.H.S. Woro, and J. Ina, The Character of Rainfall in the Indonesian Monsoon, Proc. Symposium on Equatorial Monsoon System, Yogyakarta: BMKG, 2008.

[13] Y.Y. Loo, L. Billa and A. Singh, Effect of Climate Change on Seasonal Monsoon in Asia and it's Impact on the Variability of Monsoon Rainfall in Southeast Asia. *Geoscience Frontiers, 6*, 2015, 817-823.

[14] F. Tangang, L. Juneng, E. Salimun, K.M. Sei, L.L. Le, and H. Muhammad, Climate Change and Variability over Malaysia: Gaps in Science and Research Information. *Sains Malaysiana*, 2012, 1355 - 1366.

[15] H.L. Tiwari, Ankit Balvanshi and Deepak Chouhan, Simulation of Rainfall Runoff of Shipra River Basin. International Journal of Civil Engineering and Technology, 7(6), 2016, pp.364–370.

[16] Kokila Ramesh and R.N. Iyengar, Forecasting Indian Monsoon Rainfall Including Within Year Seasonal Variability. International Journal of Civil Engineering and Technology, 8(2), 2017, pp. 390–399.