TSS distribution of Banda Aceh waters

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Abstract. Coastal areas have conditions resulting from the sea-land interaction and then affect the ecological conditions in the area. One of the inputs that is carried from the land to the sea through river flow is suspended sediment. Suspended sediment studies have been carried out in the waters north of Banda Aceh City. Sampling has been carried out on the sea surface layer within 24 sampling points. The highest TSS value was recorded at 14 mg/l with an average of 7.42 mg/l. This value is still in accordance with the quality standards set by the Indonesian Ministry of Environment.

1. Introduction
Coastal areas have unique conditions resulting from interactions between land and waters that affect coastal morphology, hydrography and ecology of the area [1,2]. These interactions also make coastal areas sensitive and vulnerable to environmental changes [3], and are exacerbated by the fact that the human population continues to increase [4]. Analysis of water quality is an important factor that needs to be considered in the development of fisheries and marine activities such as fish catchment areas, sea transportation channels and the tourism sector [5,6].

Suspended solid is a number of particles that float in the water column that consists of biotic and abiotic components [7]. Total suspended solids (TSS) concentration is recognized as one of the most important water quality elements carried by urban runoff [8]. River flow becomes the main entry point for suspended solids in the estuary area and then ends up in coastal waters Banda Aceh has at least three main rivers, namely Alue Naga, Krueng Aceh, and Ulee Lheue, of which Krueng Aceh is the largest river of the three. The mixing of river and sea water masses that occur in the estuary during tides affects the distribution path and movement of the suspended material [9]. Related to the transport energy due to tide, the displacement of the suspended material is greater at high tide than during low tide [10].

Suspended sediments generally consist of a combination of inorganic materials, namely silt and clay. The distribution of suspended sediment in waters can be distributed vertically and horizontally, where the horizontal accumulation of suspended sediment is highly visible by surface currents and waves generated by wind [11–13]. Furthermore, the concentration of suspended solids that are carried by river flows towards the sea is also influenced by the intensity and duration of rainfall [14].

The study of the suspended solid distribution in the Banda Aceh marine area is important to do, given the vital role of these waters as a transportation, ecological and tourism area for the city of Banda Aceh. Proper Area Management can provide support to water areas so that it can provide long-term benefits.

2. The Methods
Field data collection was carried out on September 10-11 2019 in the waters of Banda Aceh City, which is precisely located north of Banda Aceh City. The nearest station distance from the beach is 200 meters and the farthest is 3 km. Sampling was carried out using Van Dorn bottles to collect surface water (approximately two meters depth below sea level) at 24 observation points (Figure 1). The use of a water sampler, such as that of Van Dorn, to collect water samples has a number of advantages such as low cost and simple use, but also has the disadvantage of being time consuming [15]. The data collection location is adjusted so that it is far from the dock and the ship traffic lane to reduce external factors that affect the results of data collection. Water samples obtained from 24 stations were then tested at the Baristand Laboratory of Banda Aceh City. Determination of quality standards and water quality is carried out based on the Decree of the Minister of Environment of the Republic of Indonesia Number 51 (2004), concerning sea water quality standards for marine biota.

Since the tidal process affects the circulation and mass transfer of water [16], the TSS value obtained also compensated for the tide data. Tide data were obtained using a method developed by IOS (Institute of Ocean Science) with tidal variation values depending on the value of the harmonic constituents [17]. The values of Highest Water Spring (HWS), Lowest Water Spring (LWS) and tidal range are calculated using the Least Square method which is a development of the tidal harmonic analysis method [18]. Harmonic constituent analysis used tidal data for 30 days [19], where data were taken from September 1 to September 30 2020 (Figure 2).

Wind data are obtained from the BMKG station with a duration of 1 month from September 1, 2019 to September 30, 2019. Wind characteristics used are surface wind data and maximum wind speed for 24 hours. For easy reading and analysis of winds, wind speed and direction data are displayed as wind roses (figure 3).
3. Result and discussion

Wind conditions affect water currents and waves, and can also have an impact on water mass transfer and TSS distribution. The maximum daily wind speed during September 2019 ranges from 3 to 8 m/s and is dominant towards the northwest. The dominant wind speed ranges from 5-6 m/s and moves towards the southwest of Banda Aceh waters. Dominant wind speed and direction can affect the movement of the suspension material concentration, generally found to be of high value in coastal and river areas. So that the wind moves the particles toward open water through oceanographic dynamics such as tides, waves and changes in the morphology of coastal areas.

The Total Suspended Solid (TSS) value obtained from 24 stations in the northern waters of Banda Aceh ranges from 4-14 mg/l and produces an average value of 7.42 mg/l for these waters (Figure 4). The highest TSS concentrations were at Station 6 and 7, while the lowest TSS value was found at five stations. The horizontal distribution pattern of TSS values in the northern waters of Banda Aceh was obtained using the kriging method.

Based on the tidal analysis, the HWS value was 0.73 cm and the LWS value was -0.69 cm with a tidal range of 142 cm. The highest average water level (MHWS) was 0.62 cm and the lowest average
water level was -0.56 cm. The tides in Banda Aceh waters are of a semi-diurnal tide type, in which there are two tides in one day and two ebbs of the same height [20].

**Figure 4.** TSS measurement results and threshold of Banda Aceh waters

**Figure 5.** TSS distribution along Banda Aceh water
Measurements made at observation stations 1 to 13 are carried out during low tide conditions, while data collection at observation stations 14 to 24 is carried out during high tide. The average value of TSS at observation stations 1 to 13 is 9.23 mg/l and at observation stations 14-24 is 5.27 mg/l. The TSS value is influenced by the contribution of the suspended material around the sampling. Since the average TSS value at low tide is greater than at high tide, this indicates a combined flow of TSS material concentrations from coastal areas and river estuaries. The contribution of the suspension at low tide is more influenced by the flow of the river estuary which is then carried away by large longshore currents, so that the location is not suitable for cultivation. The TSS value indicates that Banda Aceh's waters are still in quite good condition and the input of suspended solids from the river has not yet caused a high level of turbidity in these waters. In addition, TSS conditions allowed by the quality standard of the Ministry of Environment (2004) for marine waters is 80 mg./l.

In general, Figure 5 shows the information that stations near land have a higher TSS concentration than stations farther from land. The sea level is higher at high tide, so that the estuary will be dominated by sea water. Meanwhile, at low tide, the sea level will be lower than river water, so that the dominance of river water carrying suspended solids occurs in the estuary area and affects the existing estuary environment. The main source of TSS distribution is from land, which can be in the form of scouring of sediments by waves or longshore currents which are eventually suspended and transported to other areas [13,14,21], and it can also be caused by a stirred sediment resuspension event resulting in turbulence and a mixing process [22], which causes TSS concentration levels in Banda Aceh waters to be higher at stations near the mainland.

Stations 6 and 7, which are the stations with the highest TSS value (14 mg/l), are located around the mouth of the Krueng Aceh River. Meanwhile, station 10 which is near the Alue Naga area is a runoff area of the Lamnyong river. As the largest river in Banda Aceh, Krueng Aceh has a greater water mass transport than the other two rivers. Furthermore, the amount of water flow from the river that empties into the sea also allows more suspended particles to enter the ocean waters carried by the river flow.

4. Conclusion

Locations that are close enough to the river estuary have the highest TSS values, it is also related to the tides that have formed in the area, especially those in front of the Krueng Aceh estuary. The water conditions in Banda Aceh are in good condition, referring to the KLH quality standards in 2004.

5. References

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