Distribution of suspended sediment based on tidal activity at Kuala Pidie, Sigli City

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Abstract. Erosion and river flow affect the increase of suspended sediment loads. Sedimentation is the common problem found around the estuary. The purpose of this study is to determine the effect of tides during the new moon, full moon, ¼ half moon, and ¾ half moon to the concentration of suspended sediment around the waters of Kuala Pidie Sigli City. The station is determined using purposive sampling technique at 5 station and direct sampling technique is done by using 330 ml sample bottle. Sampling was taken during high tide for each condition of the lunar cycle, then analyzed in the laboratory. The results showed that the highest concentration was 7535 mg / L at station 1 when the low tide condition of the lunar month ¾, and the smallest was 100 mg / L at station 1 when the low tide condition of the new moon. The concentration of suspended sediments is affected by erosion and tidal currents. During full moon conditions, the concentration of suspended sediments at station 5 (downstream) is greater than station 1 (upstream).

1. Introduction
Kuala Pidie waters are located in Pidie sub-district, Sigli city, Aceh Province. These waters have a variety of activities like shipping and landing route for small fishing vessels. Kuala Pidie waters have locations that are directly related to the Baro River and the Tukah river. This causes Kuala Pidie waters to receive suspended solid waste from direct organic and inorganic wastes from industrial and residential products. In addition, the location of river estuaries is strongly influenced by high fishing activities, the amount of suspended solid material discharges, as well as hydro-oceanographic activities such as currents and tides that are also potentially in the process of silting of Kuala Pidie waters [1].

Tides are an important parameter in the process of transporting sediments at Kuala Pidie, besides the influence of river currents and discharges can stir the sediment and affect the concentration of suspended sediments in the river mouth. In narrow and semi-enclosed waters such as those in river mouths, tides are one of the main drivers of water mass circulation. At high tide, the volume of water in the river mouth increases with seawater. The addition of seawater volume will result in suspended sediment concentrations in changing waters. At low tide, the water will decrease, causing the suspended sediment concentration to change again. The concentration and position of suspension sediments are very depend on variations in tidal height and river discharge [2].
The concentration of suspended sediments will be related to the level of sedimentation in the river mouth that potentially cause siltation, which causes the flow of the river to the sea to be hampered and disruption to the shipping line of fishing vessels. The highest tide is able to carry suspended solid particles far upstream so that it can affect the total suspended solids (TSS) concentration in the area and this process affects the increase of turbidity in an area [3]. Therefore, a study is required to determine the tidal concentration and distribution of suspended sediments at Kuala Pidie, Sigli City.

2. Material and Methods

2.1 Time and location

This research was conducted in Kuala Pidie waters, Pidie sub-district, Sigli city in May and June 2018. Meanwhile, suspended sediment analysis was carried out at the Teaching and Education Faculty Chemistry Laboratory, Syiah Kuala University. Map of the research location is presented in Figure 1.

2.2 Tools research

The tools used in this study are GPS, sample bottles, digital cameras, 150 μm Whatman filter paper, digital scales, stationery, the measuring cup, and the oven.

2.3 Research procedure

2.3.1 Sampling. Sampling was carried out in the field at 5 stations. Those 5 stations consist of different locations, namely 2 stations located in industrial areas and residential areas, 1 station located on the lower reaches of the Tukah River and 2 other stations at the end of the estuary that is directly related to the sea, sources can be seen in (Figure 1). Sampling was carried out during highs and lows for new moon conditions, full moon, ¼ half moon, and ¾ half moon. Sediment samples were taken on the surface of the water using a 330 ml sample bottle that had been provided. The sample is taken to the laboratory to be carried out the screening process, before being filtered, the volume of each sample is first measured using a measuring cup.

2.3.2 Sample analysis. Before analyzing the distribution of suspended sediments at Kuala Pidie, Sigli City, the samples are first placed in containers that have been labeled according to the station name, then
after the sediment sample is placed in the sample container, the sediment is filtered using a filter paper filter. Filtering was carried out using the method [4] as follows:
1. Heat filter paper (Whatman with 150 µm pore size) at 105ºC for 15 minutes, then weigh the filter paper using a digital scale.
2. Shake the sample in the sample bottle until it is homogeneous, the volume of water is measured using a measuring cup of 200 ml. Then put it into a filter device that has been coated with filter paper. Waiting until the water sample runs out and the precipitate forms on filter paper.
3. Dry the filter paper in the oven at 105ºC for 15 minutes, then weigh the filter paper containing the sediment using a digital scale.
4. Calculated suspended sediment levels.
5. From the results obtained is the value of suspended sediment concentration.

2.4 Data analysis
The calculation used in this study is to find suspended sediment concentrations from the whole of each point by using the following equation:

\[ C = \frac{a-b}{V} \text{ gram/liter} \]  

Where C = suspended sediment content (g / L); a = dry weight of sediment containing filter paper (g); b = the weight of the empty filter paper (g); V = volume of water (ml)

3. Results and Discussion
The results showed that during New Moon phases, Full moon and ¼ half moon, the concentration of suspended sediments is normal with an average value of 887 mg / L, this situation is due to no rainfall occurrence within these periods. During averaged tide, the concentration of suspended sediments reach the highest at station 5 (in the downstream) because the sediment coming from the sea moves towards estuary. Meanwhile at station 1 (in the upstream), the concentration of suspended sediments is less because the current is weakening, causing a portion of the sediment to settle (Table 1 and Table 2)

Concentration of suspended sediments shows abnormal conditions during Phase ¾ Half Moon. The suspended sediment is characterized by turbid, muddy and dirty waters (Table 2). The turbid water conditions are caused by rainfall occurrence in the upstream. The rainfall affect on the erosion process that occurred in the upstream of the Baro River near Station 1, thus high concentration of suspended sediments at station 1 (7535 mg / l) and station 2 (6910 mg / l) were affected by the Baro River. During phase ¾ Half Moon, the concentration of suspended sediments at station 3 (downstream of the Tukah River) are carried by the current towards station 4 (6160 mg / l) and station 5 (5505 mg / l).

Based on the analysis of concentration of suspended sediments, the sediments entering the Kuala Pidie waters originated from sediment inputs transported by the Baro and Tukah River flows and due to the effects of tidal currents. Sediment concentrations from the sea are also transported towards the mouth of the river when condition is high. This makes sediment to accumulate in Kuala Pidie causing silting and disruption of the life of aquatic ecosystems.
| No. | Moon Phase   | Station | Sample volume (ml) | Filter paper weight (g) | Sediment + filter paper weight (g) | Net weight (g) | Sediment concentration (g/ml) | Sediment concentration (mg/L) |
|-----|--------------|---------|--------------------|-------------------------|-------------------------------------|----------------|-------------------------------|-------------------------------|
| 1   | New Moon     | 1       | 200                | 1.420                   | 1.442                               | 0.022          | 0.00011                       | 110                           |
|     |              | 2       | 200                | 1.420                   | 1.451                               | 0.031          | 0.000155                      | 155                           |
|     |              | 3       | 200                | 1.420                   | 1.485                               | 0.065          | 0.000325                      | 325                           |
|     |              | 4       | 200                | 1.420                   | 1.557                               | 0.137          | 0.000685                      | 685                           |
|     |              | 5       | 200                | 1.420                   | 1.562                               | 0.142          | 0.00071                       | 710                           |
| 2   | Full Moon    | 1       | 200                | 1.420                   | 1.456                               | 0.036          | 0.00018                       | 180                           |
|     |              | 2       | 200                | 1.420                   | 1.486                               | 0.066          | 0.00033                       | 330                           |
|     |              | 3       | 200                | 1.420                   | 1.493                               | 0.073          | 0.000365                      | 365                           |
|     |              | 4       | 200                | 1.420                   | 1.566                               | 0.146          | 0.00073                       | 730                           |
|     |              | 5       | 200                | 1.420                   | 1.576                               | 0.156          | 0.00078                       | 780                           |
| 3   | Quarter      | 1       | 200                | 1.420                   | 1.454                               | 0.034          | 0.00017                       | 170                           |
|     | Third        | 2       | 200                | 1.420                   | 1.475                               | 0.055          | 0.000275                      | 275                           |
|     |              | 3       | 200                | 1.420                   | 1.545                               | 0.125          | 0.000625                      | 625                           |
|     |              | 4       | 200                | 1.420                   | 1.537                               | 0.117          | 0.000585                      | 585                           |
|     |              | 5       | 200                | 1.420                   | 1.541                               | 0.121          | 0.000625                      | 605                           |
| 4   | Quarter      | 1       | 200                | 1.420                   | 1.477                               | 0.057          | 0.000285                      | 285                           |
|     | Third        | 2       | 200                | 1.420                   | 1.492                               | 0.072          | 0.00036                       | 360                           |
|     |              | 3       | 200                | 1.420                   | 1.568                               | 0.148          | 0.00074                       | 740                           |
|     |              | 4       | 200                | 1.420                   | 1.506                               | 0.086          | 0.00043                       | 430                           |
|     |              | 5       | 200                | 1.420                   | 1.554                               | 0.134          | 0.00067                       | 670                           |

| No. | Moon Phase   | Station | Sample volume (ml) | Filter paper weight (g) | Sediment + filter paper weight (g) | Net weight (g) | Sediment concentration (g/ml) | Sediment concentration (mg/L) |
|-----|--------------|---------|--------------------|-------------------------|-------------------------------------|----------------|-------------------------------|-------------------------------|
| 1   | New Moon     | 1       | 200                | 1.420                   | 1.440                               | 0.020          | 0.00010                       | 100                           |
|     |              | 2       | 200                | 1.420                   | 1.449                               | 0.029          | 0.00015                       | 145                           |
|     |              | 3       | 200                | 1.420                   | 1.550                               | 0.130          | 0.00065                       | 650                           |
|     |              | 4       | 200                | 1.420                   | 1.489                               | 0.069          | 0.00035                       | 345                           |
|     |              | 5       | 200                | 1.420                   | 1.480                               | 0.060          | 0.00030                       | 300                           |
| 2   | Full Moon    | 1       | 200                | 1.420                   | 1.495                               | 0.075          | 0.00038                       | 375                           |
|     |              | 2       | 200                | 1.420                   | 1.475                               | 0.055          | 0.00028                       | 275                           |
|     |              | 3       | 200                | 1.420                   | 1.487                               | 0.067          | 0.00034                       | 335                           |
|     |              | 4       | 200                | 1.420                   | 1.498                               | 0.078          | 0.00039                       | 390                           |
|     |              | 5       | 200                | 1.420                   | 1.488                               | 0.068          | 0.00034                       | 340                           |
| 3   | Half Moon    | 1       | 200                | 1.420                   | 1.444                               | 0.024          | 0.00012                       | 120                           |
|     |              | 2       | 200                | 1.420                   | 1.453                               | 0.033          | 0.00017                       | 165                           |
|     |              | 3       | 200                | 1.420                   | 1.552                               | 0.132          | 0.00066                       | 660                           |
|     |              | 4       | 200                | 1.420                   | 1.480                               | 0.060          | 0.00030                       | 300                           |
|     |              | 5       | 200                | 1.420                   | 1.462                               | 0.042          | 0.00021                       | 210                           |
| 4   | Half Moon    | 1       | 200                | 1.420                   | 2.927                               | 1.507          | 0.00754                       | 7535                          |
|     |              | 2       | 200                | 1.420                   | 2.802                               | 1.382          | 0.00691                       | 6910                          |
|     |              | 3       | 200                | 1.420                   | 1.482                               | 0.062          | 0.00031                       | 310                           |
|     |              | 4       | 200                | 1.420                   | 2.652                               | 1.232          | 0.00616                       | 6160                          |
4. Conclusion
It can be concluded that the highest concentration is 7535 mg / L at station 1 during low tide ¾ half moon. The smallest is 100 mg / L at station 1 when the new moon and the concentration of suspended sediments is affected by erosion and tidal currents. When high tide is happened at full moon, TSS concentration at station 5 (downstream) is greater than concentration at station 1 (upstream).

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