The spatial distribution of suspended sediment analysis along Krueng Cut River, Banda Aceh

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Abstract. The spatial distribution of suspended sediment research at an estuarial area was carried out in Krueng Cut River. The study employed a purposive sampling method at seven stations, and the data were analyzed by using the spatial distribution analysis of suspended sediment. The samples were taken at three places in each station during high tide and low tide conditions. The purpose of the research is to understand how the concentration of suspended sediment is distributed throughout Krueng Cut estuarial area during high tide and low tide conditions. The results informed that during high tide condition, the concentration of suspended sediment was mostly circulated downstream near the mouth of the river. In contrast, during low tide condition, the suspended sediment concentration was distributed predominantly in the upstream of the study area.

Keywords: estuarial area, Krueng Cut, suspended sediments, spatial distribution

1. Introduction

The Krueng Cut estuarial area is located at Alue Naga sub-district, Banda Aceh. This estuarial area has multifunctional activities that are frequently used by the fisherman community for their livelihood. Such activities have changed the existence of this estuarial area spatially and temporally. Beside the communal activities, the hydro-oceanographic parameters such as current, tide, and wave in this region have also influenced the environmental conditions [1], [2] so that the surrounding area can be positively or negatively impacted [5], [15]. Some of those impacts are the addition of land area as well as the occurrence of soil erosion along the river bank because of sedimentation and erosion [3], [11].

The occurrence of sedimentation in this area is due to the accumulation of upstream eroded, weathered rock materials carried away by the water and settled in the location where the materials cannot be transported anymore by the flow of the water [4], which is called sediment transport. The factors affecting sediment transport on this occasion are the properties of sedimentary materials such as grain size, cohesiveness, and grain distribution [8], [9], [12], [13], as well as hydrodynamics such as wave and current [7], [10], [14]. The combination of these properties resulted in water turbidity that affects the distribution of suspended sediment load spatially even though the dynamics of current and wave are relatively small [3], [6].

Krueng Cut River has a high level of turbidity because of the number of sedimentary particles hovering the surface area of this canal. At some points, the turbidity of this river is higher than usual. However, to assess it requires a specific study, both qualitatively and quantitatively. Therefore, the
amount of suspended sediment and their distribution pattern can be determined by analyzing the profile and the spatial distribution of suspended sediments.

2. Research Method

The research was conducted in Krueng Cut estuarial area located at 5°35’16.42”N and 95°21’01.79”W. The data were collected from February to April 2017 at seven stations by using the purposive random sampling (Figure 1). For the suspended sediment analysis, the field samples were examined in Marine Chemistry Laboratory of Marine and Fisheries Faculty of Syiah Kuala University.

![Figure 1. Map of sampling site of Krueng Cut River (the estuarial area).](image)

Each of the seven stations was divided into three points of sampling located in the west, central, and east part of it. Samples were taken during low tide and high tide conditions, subsequently brought to the laboratory for a screening at their perspective volumes. The sediment analysis was performed in the laboratory using a filter paper sized 125 mm Ø. The profile analysis was applied by employing the sediment weight based on the suspended sediment examination result, while the spatial analysis was conducted by obtaining the spatial space interpolation. The suspended sediment concentration was calculated using the following formula:

\[
\text{Concentration (g/ml)} = \frac{\text{Sediment weight (g)}}{\text{Sample volume (ml)}}
\]  

(1)

3. Results and Discussion

The results of suspended sediment concentration analysis for high tide and low tide conditions are listed in Table 1 and Table 2, respectively, showing that some samples could not be obtained due to the prevailing circumstances—the water was either too shallow or dangerous for the sampling. The sediment profile result can be seen in Figure 2, indicating a significant difference between the suspended sediment concentrations during the high tide and those during low tide condition.
### Table 1. Suspended sediment concentrations during high tide condition.

| Station | Point | Sample (ml) | Sediment + filter (g) | Sediment weight (g) | Sediment concentration (g/ml) | Average (g/mL) | Sediment concentration (g/L) |
|---------|-------|-------------|-----------------------|---------------------|-------------------------------|----------------|-----------------------------|
| 1       | 1     | 200         | 0.16                  | 0.05                | 0.00025                       | 0.25           |                             |
| 2       | 2     | 200         | 0.16                  | 0.05                | 0.00025                       | 0.25           |                             |
| 3       | 3     | 200         | 0.16                  | 0.05                | 0.00025                       | 0.25           |                             |
| 2       | 1     | 200         | 0.17                  | 0.06                | 0.0003                        | 0.3            |                             |
| 2       | 2     | 200         | 0.16                  | 0.05                | 0.00025                       | 0.25           |                             |
| 3       | 3     | 200         | 0.16                  | 0.05                | 0.00025                       | 0.25           |                             |
| 3       | 1     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 3       | 2     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 3       | 3     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 4       | 1     | 100         | 0.12                  | 0.01                | 0.0001                        | 0.1            |                             |
| 2       | 2     | 100         | 0.17                  | 0.06                | 0.0006                        | 0.6            |                             |
| 3       | 3     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 5       | 1     | 100         | 0.12                  | 0.01                | 0.0001                        | 0.1            |                             |
| 2       | 2     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 3       | 3     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 6       | 2     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 3       | 3     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 7       | 1     | 100         | 0.16                  | 0.05                | 0.0005                        | 0.5            |                             |
| 2       | 2     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 3       | 3     | 100         | 0.18                  | 0.07                | 0.0007                        | 0.7            |                             |

### Table 2. Suspended sediment concentrations during low tide condition.

| Station | Point | Sample (ml) | Sediment + filter (g) | Sediment weight (g) | Sediment concentration (g/ml) | Average (g/mL) | Sediment concentration (g/L) |
|---------|-------|-------------|-----------------------|---------------------|-------------------------------|----------------|-----------------------------|
| 1       | 1     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 2       | 2     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 3       | 3     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 2       | 1     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 2       | 2     | 100         | 0.14                  | 0.03                | 0.0003                        | 0.3            |                             |
| 3       | 3     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 3       | 1     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 3       | 2     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 3       | 3     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 4       | 1     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 4       | 2     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 4       | 3     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 5       | 1     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 5       | 2     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 5       | 3     | N/A         | N/A                   | N/A                 | N/A                           | N/A            | N/A                         |
| 6       | 1     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 2       | 2     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 3       | 3     | 100         | 0.13                  | 0.02                | 0.0002                        | 0.2            |                             |
| 7       | 1     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
| 2       | 2     | 100         | 0.14                  | 0.03                | 0.0003                        | 0.3            |                             |
| 3       | 3     | 100         | 0.15                  | 0.04                | 0.0004                        | 0.4            |                             |
The results of suspended sediment distribution during high tide and low tide conditions are illustrated in Figure 3A and 3B. The distribution depicts the dominant influence of water dynamics in the estuarial area. During the high tide condition, suspended sediment distribution was strongly dominated by the dynamics of the sea. On the contrary, during low tide condition, the flow of the river outnumbered the sea dynamics so that the river influence on the suspended sediment was dominating.

The results of data analysis showed that the spatial distribution of suspended sediment concentrations was ranging from 1 to 6 mg/L during high tide season and 0.5 to 4 mg/L for the low
tide condition. These differences occur due to the increasing and decreasing water volume in the estuarial area [15]. The concentration of suspended sediment in the estuary area increases during high tide condition because of the dominant influence of hydro-oceanographic dynamics at the river mouth compared to the river dynamics (Figure 3A) [16]. The profile analysis also showed that the concentration of suspended sediment during low tide condition increases in the upstream area due to the predominate river flow during this season. The results indicated that the circulation region (in the middle of the study area) tended to settle the sediments.

In a shallow area where suspended sediments flow from the upstream toward the sea, the influence of sea currents and waves is more dominant than that of the river flow and river discharge [8], [10]. The mixing between current dynamics and sediments in shallow water increases the suspended sediment concentration so that it is higher during high tide condition compared to the low tide season. The sediment distribution stated that high water discharge led to the higher suspended sediment concentration near the coastline area. It is because the coast region is shallow so that the interaction between the currents and the sediments can transport the sediment upwards, augmenting the water turbidity [6].

The results also showed that the significant suspended sediment concentrations were encountered in the river mouth (Figure 3A). It is on account of the higher interaction between ocean current sand bed sediments compared to the upstream area where the river flow starts to weaken, and the current interaction with bed sediments decreases as the depth of water increases [7]. On the other hand, during low tide condition, the dominant suspended sediment concentrations occurred in both upstream and estuary areas due to the interaction of currents and bed sediments, especially in the upstream region where bed sediments were facilitated to transport upward.

4. Conclusion
The spatial distribution analysis of suspended sediments in Krueng Cut estuarial area has two major differences between the high and low tide conditions. During the high tide season, the concentration of suspended sediments was heavily distributed downstream near the river mouth due to the mixing between riverbed sediments and hydro-oceanographic dynamics which then resurfaced the sediments. On the other hand, during low tide condition, the concentration of suspended sediments was circulated mostly in the upstream of the study area.

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