STATISTICAL PARAMETERS ANALYSIS OF SEDIMENT GRAIN SIZE FROM RAYA RIVER BENGKAYANG REGENCY, WEST BORNEO

ANALISIS PARAMETER STATISTIK UKURAN BUTIR SEDIMEN DARI SUNGAI RAYA KABUPATEN BENGKAYANG, KALIMANTAN BARAT

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ABSTRACT : The study of the statistical analysis parameters of grain size in the waters of Sungai Raya was carried out in order to understand the characteristic of the sediment in the river and coastal areas. The grain size analysis was conducted by sieving method, afterwards, the statistical parameters including the average grain size, sorting, skewness, and kurtosis, were also analyzed. Sediment samples were acquired from six stations with each station consisting of three sampling points representing river west bank, river midstream, river east bank, and the coastal area consisting of five stations. The results of the sediment analyses showed that the average grain size in the river ranges from 1.23 to 2.77 mm, and on the beach area is between 1,52 - 2,59 mm, classified as fine sand, medium sand, very fine sand, and coarse sand with predominant fine sand in all stations. The results of the statistical parameter analysis of the grain size of the bottom sediment in the waters of Sungai Raya exhibit the average diameter value ranging from 1.23 to 2.77 mm, classified as fine sand to medium sand. This value indicates that the type of sediment in this location is dominated by silt with grain sizes ranging from < 0.05 - 0.002 mm. The sorting value ranges from 0.14 to 1.59 mm, categorized into moderately sorted, moderately well-sorted, very well sorted, and poorly sorted classes. The average value of skewness is 2.17 with the classification of the bed load being very fine. The kurtosis value ranges from 0.72 to 1.67 indicating the classification in these waters is platycuric, mesokurtic, leptokurtic, and very leptokurtic. These findings concluded that in the study area there is a variation in the angularity of the sediment grains due to the different hydrodynamic processes.

Keywords: Sediment, grain size, statistical parameters, Raya River waters

ABSTRAK: *Kajian tentang analisis parameter statistik ukuran butir di perairan Sungai Raya dilakukan untuk memahami karakteristik sedimen di bagian sungai dan daerah perairan pantai. Analisis ukuran butir dilakukan dengan metode pengayakan, kemudian dilakukan pula analisis parameter statistik yaitu rata-rata ukuran butir, sortasi, skewness dan kurtosis. Sampel sedimen di sungai diperoleh dari enam stasiun dengan masing-masing stasiun terdiri dari tiga titik pengambilan sampel dan bagian pantai terdiri dari lima stasiun. Hasil analisis parameter statisik ukuran butir sedimen dasar di bagian sungai diperoleh nilai diameter rata-rata berkisar antara 1.23 - 2.77 mm dan area pantai 1.52 - 2.59 mm dengan klasifikasi pasir halus hingga pasir sedang. Nilai tersebut menunjukkan bahwa jenis sedimen di lokasi ini didominasi oleh lanau dengan ukuran butir berkisar antara <0.05 - 0.002 mm. Nilai sortasi seluruh sampel sedimen diperoleh nilai berkisar antara 0.14 - 1.17 mm dengan empat jenis klasifikasi yaitu terpilah sedang, terpilah cukup baik, terpilah sangat baik, dan terpilah buruk. Untuk nilai skewness nilai rata-rata sebesar 2.17 mm dengan klasifikasi sedimen dasar condong sangat halus dan nilai kurtosis diperoleh berkisar antara 0.72 - 1.67 mm yang menunjukkan klasifikasi di perairan ini adalah tumpul, cukup tumpul, runcing dan sangat*

runcing. Hasil ini menunjukan bahwa di lokasi ini terjadi variasi keruncingan butiran sedimen yang disebabkan adanya proses hidrodinamika.
Kata kunci: Sedimen, ukuran butir, parameter statistik, perairan Sungai Raya

INTRODUCTION

Rivers are very dynamic waters due to their flows which transport sediment to the estuary. Sediment and nutrient run-off cause siltation in the waters, thus decreasing the transport capacity of the rivers, leading to the flood hazard (Soemarwoto, 1978). The process of sediment deposition can be estimated through the distribution of sediment grain size (Nugroho and Basit, 2014; Purnawan et al., 2015). Grain size is the most basic aspect of sedimentary particles that affects sedimentation, transport, and deposition processes (Blott and Pye*,* 2001; Gemilang et al., 2018). One of the methods used to explore sediment transport pathways is by using the granulometric method. Grain size observation is determined by grain size analysis (methods: sieve, pipette, particle size analyzer by laser or settling, etc.). From the analysis, we could evaluate the average grain size, sorting, skewness and kurtosis. These values are used to interpret the distribution, transport, and deposition mechanisms of sediment in waters (Korwa et al*.,* 2013; Nugroho and Basit, 2014).

The grain size distribution in rivers is influenced by several hydrological factors, one of which is current velocity, particularly for suspended sediment (Purnawan et al., 2012). Slow current speeds are only able to transport sediments with smaller particle sizes and stronger current speeds will be able to carry coarser sediment particle sizes. Finer sediments are usually found further from river mouths and shores, while coarser sediments are generally found in coastal areas (Mukminin, 2008; Tanto et al*.,* 2017). The large potential for sedimentation is influenced by the reduced current velocity and wide river conditions (Lestari et al., 2017; Brookes, 1994; Li et al., 2007). Coarse sediments such as gravel and sand will settle faster in high turbulent areas as opposed to fine grain sediments such as mud (Darlan, 1996; Nugroho and Basit, 2014).

This research was conducted in the waters of Raya River Bengkayang Regency, West Kalimantan. The problem is that there is siltation in the downstream part of the river so it interferes with access to and from fishing boats. Moreover, considering this area is designated for Nuclear Power Plant (PLTN) by the government, it is imperative to understand the characteristics of the bottom sediments to provide initial information. Therefore, this study was conducted to determine the grain size of the sediments based on statistical parameters in the waters of the Raya River, in order to understand the characteristics of the sediment in the river and in the coastal area.

MATERIALS AND METHODS

Time and Study Area

This study was conducted in March 2021 in Raya River, Bengkayang Regency, West Kalimantan (Figure 1). Field activities involved hydrologic parameter measurements including river current velocity, water depth and sediment sampling. Sediment sampling was carried out by using an Ekman Grab sampler. We collected 3 samples from each station of sta. 1-6 in the river area, and only one sample was taken from stations 7 – 11 in the coastal area, thus in total there are 23 samples for this grain size analysis.

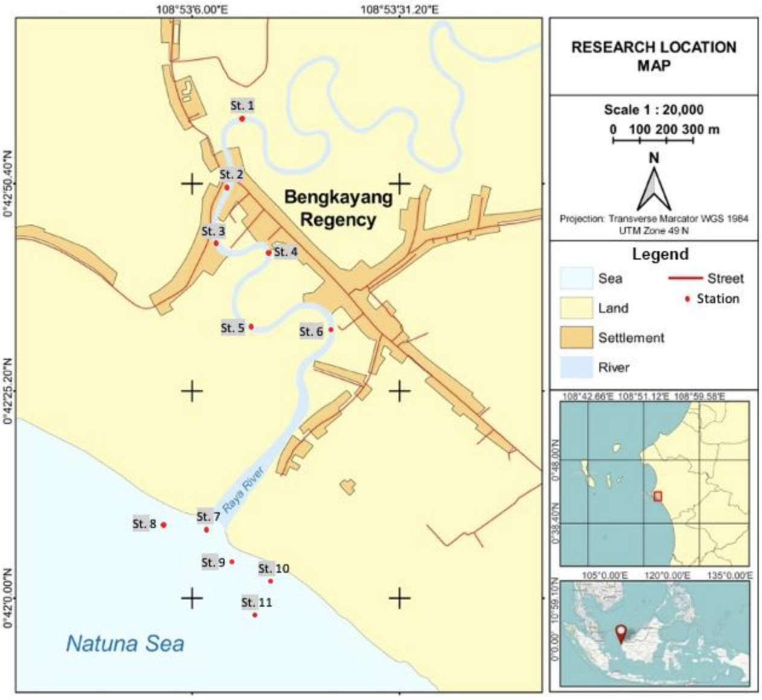

Figure 1. Location of sediment sampling along Raya river and coastal areas

Data analysis

Statistical parameters analysis of sediment grain size is generally characterized by four parameters, namely mean, sorting, skewness, and kurtosis. The grain size indicates the amount of energy derived from the flow of water or wind acting in the area (Folk and Ward, 1957; Friedman, 1967; Purnawan et al. 2015). Separation of grain size is carried out by sieve method using the following sieve sizes: 0.85; 0.425; 0.25; 0.18; 0.125; and 0.075 mm. Determination of the sediment type is based on the classification of Shepard Triangle Diagram (Dyer, 1986). Statistical parameters analysis of sediment in the form of mean size, sorting, skewness and kurtosis using Wentworth classification (1922).

The sediment grain size is presented in phi (φ) scale that is defined by (Folk and Ward, 1957) as:

$$\varphi = -\,log_2\,d \qquad (1)$$

Where φ and d are grain size and grain diameter (mm), respectively.

The average grain size is the average grain size value and can be calculated using the equation:

$$M_z = \frac{\varphi_{16}+\varphi_{50}+\varphi_{84}}{3} \qquad (2)$$

Determination of sorting will be better using a mathematical approach by finding the value of the standard deviation determined by the equation:

$$\sigma_i = \frac{\emptyset_{84}-\emptyset_{16}}{4} + \frac{\emptyset_{95}-\emptyset_{5}}{6,6} \qquad (3)$$

Determination of skewness is based on the standard deviation value. If in a grain size distribution there is an excess of coarse particles, then the shrinkage is negative and vice versa and if the grain size distribution is excessive, the fine particle size distribution is positive, which can be calculated using the equation (Folk, 1974):

$$SK_t = \frac{\emptyset_{84}+\emptyset_{16}-2\emptyset_{50}}{2(\emptyset_{84}-\emptyset_{16})} + \frac{\emptyset_{95}+\emptyset_{5}+2\emptyset_{50}}{2(\emptyset_{95}-\emptyset_{5})} \qquad (4)$$

Kurtosis is calculated by the equation of Folk and Ward (1957):

$$K_G = \frac{(\emptyset_{95}-\emptyset_{5})}{2,44(\emptyset_{75}-\emptyset_{25})} \qquad (5)$$

RESULTS

The statistical parameters of particle size that are commonly used are mean grain size, sorting (OT), skewness (SKI), and kurtosis (KG). This research was conducted in 2 study areas, each representing a part of the river and coastal waters. The results of the overall sediment grain size classification are presented in Table 1.

Based on the calculation of statistical parameters of the bottom sediment grain size in the river area, the average diameter value ranges from 1.23 to 2.77 mm, and in the coastal area it ranges from 1.52 to 2.59 mm, classified as fine sand to medium sand. The sorting value of all basic sediment samples at each station ranges from 0.14 - 1.59 mm, as a result, the research area is divided into 4 classification, are moderately sorted, moderately well sorted, very well sorted, and poorly sorted. The higher sorting value in the river was found at Stations 3, 4, and 6 with an average value of 1.04 mm, 1.17 mm, and 1.15 mm. In the coastal area, the sediment is relatively categorized into a poorly sorted group. The average value indicates that the classification is poorly disaggregated.

According to Ingmanson and Wallace (1989), the poorly sorted classification is due to the particle size that accumulated randomly. Many fishing boats are anchored at Stations 3, 4, and 5 may modify and block the current flows, lead to the occurrence of unstable currents. In addition, the morphology of the river bottom topography also affects the classification of the sorting value. Rifardi (2012) stated that poor sorting is influenced by current velocity that is inhomogenous most of the time, so the

Table 1. Grain Size Parameter and Classification

ST	Mean size (mm)	Classification	OT	Classification	SKI	Classification	KG	Classification
1a	2,46	fine sand	0,89	moderately sorted	1,59	very fine skewed	1,67	very leptokurtic
1b	2,86	fine sand	0,64	moderately well sorted	2,71	very fine skewed	0,92	mesokurtic
1c	2,98	fine sand	0,71	moderately sorted	1,89	very fine skewed	1,34	leptokurtic
2a	2,77	fine sand	0,14	very well sorted	2,56	very fine skewed	0,86	platycuric
2b	1,83	medium sand	1,59	poorly sorted	0,63	very fine skewed	0,9	mesokurtic
2c	3,28	very fine sand	0,35	very well sorted	2,39	very fine skewed	1,01	mesokurtic
3a	3,12	very fine sand	0,57	moderately well sorted	2,84	very fine skewed	1,49	leptokurtic
3b	2,22	fine sand	1,37	poorly sorted	0,77	very fine skewed	0,72	platycuric
3c	2,57	fine sand	1,18	poorly sorted	1,02	very fine skewed	0,97	mesokurtic
4a	2,4	fine sand	1,26	poorly sorted	0,96	very fine skewed	0,74	platycuric
4b	1,39	medium sand	1,37	poorly sorted	0,7	very fine skewed	0,85	platycuric
4c	1,33	medium sand	0,86	moderately sorted	1,18	very fine skewed	1,08	mesokurtic
5a	2,62	fine sand	0,98	moderately sorted	1,37	very fine skewed	0,96	mesokurtic
5b	0,97	coarse sand	0,99	moderately sorted	0,67	very fine skewed	1,33	leptokurtic
5c	0,09	coarse sand	0,99	moderately sorted	0,37	very fine skewed	1,29	leptokurtic
6a	2,01	fine sand	1,29	poorly sorted	0,76	very fine skewed	0,94	mesokurtic
6b	2,87	fine sand	0,8	moderately sorted	1,55	very fine skewed	1,47	leptokurtic
6c	2,2	fine sand	1,35	poorly sorted	2,09	very fine skewed	1,08	mesokurtic
7	2,59	fine sand	1,02	poorly sorted	1,22	very fine skewed	1,14	leptokurtic
8	2,70	fine sand	0,77	moderately sorted	2,04	very fine skewed	0,95	mesokurtic
9	2,38	fine sand	1,14	poorly sorted	0,94	very fine skewed	1,35	leptokurtic
10	2,55	fine sand	1,19	poorly sorted	0,94	very fine skewed	1,64	very leptokurtic
11	1,52	medium sand	1,10	poorly sorted	0,85	very fine skewed	0,95	mesokurtic

accumulated sediment grains would be relatively various. The shape of the riverbeds at each station is as shown in Figure 2.

The value of skewness in the river area is diverse, ranging from 0.30 to 2.84 mm (2.17 mm on average). Based on the average value of the skewness, the sediments are defined to be very fine. In the coastal area, the skewness value is 0.95 – 1.64 with the same classification, which is very smooth. While the kurtosis values ranged from 0.72 to 1.67 mm, can be categorized as platycuric, mesokurtic, leptokurtic and very leptokurtic.

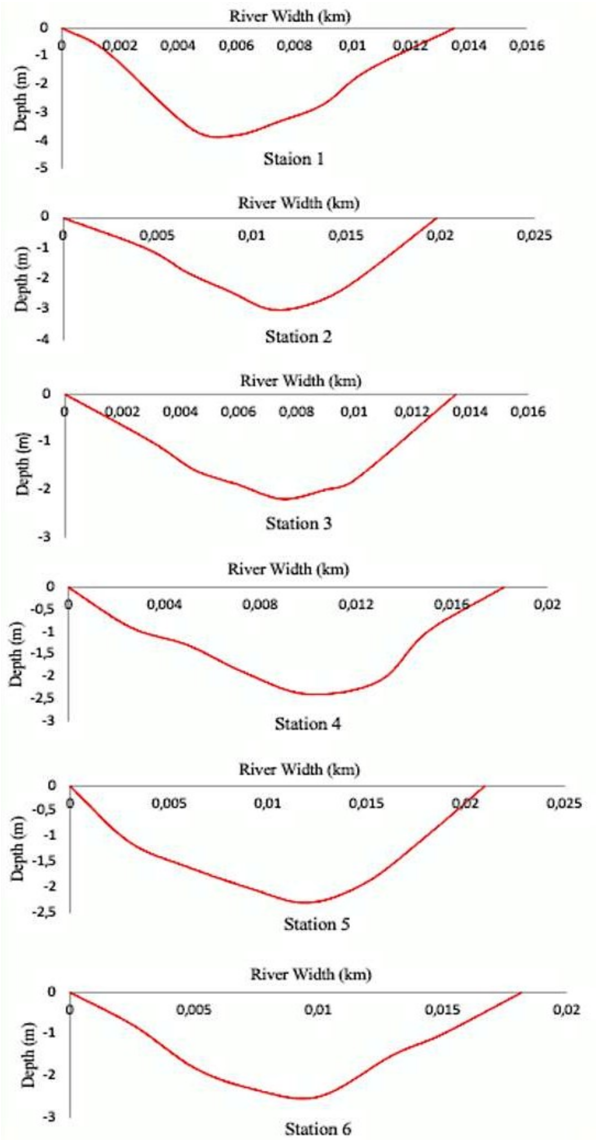

Figure 2. Cross-section of the river shapes in the water of Raya River Bengkayang Regency West Borneo

DISCUSSION

Sediment Characteristics

Based on the results of statistical parameter analysis in the river and coastal sections, the classification of both areas indicates relatively similar findings. The coherent result can be observed from the correlation between the kurtosis and skewness value of both areas (Figure 3). The average kurtosis and skewness values in the river are 1.09 and 1.4, respectively. Meanwhile, on the coast, the average kurtosis and skewness values are 1.20 and 1.21. These results indicate that the values of kurtosis and skewness in both areas are within similar group, which is very fine skew and leptokurtic. Aritonang et al. (2014) argued that positive value of skewness generally indicate fine-sized substrate (silt to mud). Surbakti (2010) also mentioned that the skewness in the estuary is in the average range of symmetrical, smooth, to very fine. According to Purnawan et al (2015), the very high kurtosis value is produced by the distribution pattern, which is dominated by medium and fine sand fractions. Boggs (2009) also explained, the peak's high degree is parallel with the observed sorting conditions, where all stations are quite well sorted.

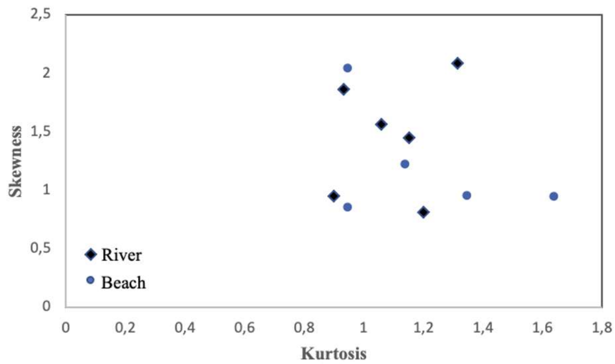

Figure 3. The scatter of graphic kurtosis Vs skewness in the river and beach area display a close correlation between both areas

The grain size values obtained ranged from <0.05 mm – 0.002 mm, indicating that the overall sediment type was dominated by silt. Sediment grain size in general is strongly influenced by the current speed in the waters (Thruman in Arifin, 2008). Fine grain sizes dominate slow currents and strong currents are dominated by coarser ones. According to Djurdjani (1998) in Sukuryadi (2015), the weak/slow current is defined for current speed <0.4 m/s. The average of current speed measurement in the river of our study is 0.33 m/s, while in the coastal most part is 0.37 m/s in average, considered as a weak current, resulting in relatively fine grain size of sediment as we have discussed above.

CONCLUSION

Based on statistical parameter analysis of sediment grain size, the average diameter of sediment in the river area ranged from 1.23 to 2.77 mm, and within the beach area, the grain size value was 1.52 to 2.59 mm, that can be classified into fine sand, medium sand, very fine sand, and coarse sand. However, the average value of the grain size is 2.22, which indicates that fine sand is dominant. Sorting values in the river and coastal waters ranged from 0.14 - 1.59 and 0.77 - 1.19, respectively, defined as moderately sorted, moderately well-sorted, very well sorted, and poorly sorted. Overall, the average of sorting value is 0.96, signifies moderately sorted. This classification indicates that the sorting process is not good indicated by the more diverse distribution of sediment grain sizes. The skewness of both in the river and in the coast can be categorized as very fine skewed, confirmed from relatively low skewness value, which are is between 0.37 to 2.56 mm, and between 0.85 to 2.04 mm respectively. These results indicate that the density or grain size of the sediment is more distributed to the finer grain size. The value of kurtosis in rivers ranges from 0.89 to 1.31 mm, classified as platycuric, mesokurtic, leptokurtic, and very leptokurtic. While in coastal areas it ranges from 0.95 to 1.64, classified as leptokurtic and very leptokurtic.

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