



# Granulometry Analysis and Its Effect on the Concentration of Iron Metal (Fe) in the Sediment of Sungai Pampang Kiri, Desa Budaya Pampang, North Samarinda, Samarinda City, East Borneo

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**Abstract.** Pampang Kiri River in Pampang Culture Village, North Samarinda, Samarinda City, East Borneo is one of the catchment rivers of Benanga Dam, Lempake. This study aims to determine the distribution of sediment texture and Fe concentration in samples and the influence of Fe concentration from upstream to downstream rivers. The research methods used are the mathematical approach granulometry method and XRF method to determine the concentration of Fe metal. Based on the results of granulometric analysis in the upstream and downstream parts of the river, the size and sorting of grains with an average size of sand with moderately – poorly sorted grains. The skewness and kurtosis values in the river in the upstream part are more active than the downstream part of the river. The distribution of Fe content in the upstream section is lower than in the downstream section of the river. This indicates that further down the river, the process of sedimentation, deposition, and current conditions as a medium of transportation are quieter than in the upper reaches of the river. It is necessary to use a more diverse mesh and the use of graphical and mathematical methods as data validation in the study.

**Keywords:** River, Granulometric Analysis, Iron Concentration, Skewness, Kurtosis

## 1 Introduction

Sediments are fragments of material that generally consist of physical and chemical descriptions of rocks. River morphology is the size and shape of the river as a result of the reaction to changes in the hydraulic conditions of the flow. A meander-shaped river is a river that has turns that regularly form a sine function in the plane of the plain [1]. According to Miall, various kinds of river morphology are related to the transport of bedload and suspended load and the cross-section of river geometry that shows the ratio of width, river depth and curves [2].

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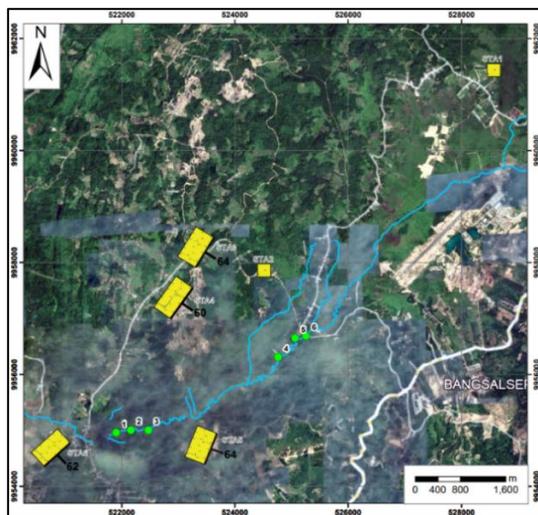
Texture is the appearance of sediments related to the physical condition and arrangement of sediment grains. Sediment texture describes the relationship between grains/minerals consisting of fragments, minerals, and base mass [3]. The grain size of sediment particles is one of the factors that control the process of sediment deposition in rivers. The most common classification for grain size is the Udden-Wentworth scale which was modified in Blair & McPherson [4]. Sorting is the uniformity of grain size of the rock fragments [3], which is a common method for determining the grain size of sediments from the river.

Heavy metals are one of the common environmental pollutants and are often found in the aquatic environment. Heavy metals that enter the waters will undergo precipitation, dilution and dispersion and then accumulate in organisms in the waters. Iron (Fe) heavy metal is one of the essential metals whose existence in certain amounts is needed by living things, but with concentrations exceeding the normal threshold, it will cause toxic or toxic effects [5].

Therefore, this research aims to determine the distribution of sediment texture and Fe concentration in samples and the influence of Fe concentration from upstream to downstream rivers.

## 2 Materials and Methods

Administratively, the research area is located on the river in Pampang Culture Village, North Samrinda District, Samarinda City, East Kalimantan Province. The research site has 6 sampling points. The study area is located 21 km from the Faculty of Engineering, Mulawarman University.



**Fig. 1.** Location Map of the Sampling Points

Based on field sampling, 6 sampling locations were obtained. The sample is divided into 2 parts. Sample 1, sample 2 and sample 3 are samples located in the downstream part of the river. While sample 4, sample 5, and sample 6 are samples located in the upper reaches of the river.

## 2.1 Research Methods

For this research, there are 2 (two) methods used. The first one is the granulometric method. Granulometric is one of the methods to analyze clastic sediments in the form of rocks or deposits that prioritize the distribution of clastic sediment grains. Granulometric testing is carried out by sieving to separate certain grains in soil samples of a certain size. The mesh size used depends on the type of sample and the purpose of the study [6]. Data presentation can be in two forms, namely statistical data and graphical data. Statistical data displays mean, median, mode, and deviation. Statistical analysis is used to describe the frequency distribution of grain size which produces mean, sorting, skewness, and kurtosis values following Friedman's (1961) arithmetic equation in [7]. The following equation of granulometric calculation [8]:

$$Mm = (\text{upper limit} + \text{lower limit})/2 \quad (1)$$

$$\bar{X}_a = \frac{\sum f \cdot m_m}{100} \quad (2)$$

$$\sigma_a = \sqrt{\frac{\sum f (m_m - \bar{X}_a)^2}{100}} \quad (3)$$

$$SK_a = \frac{\sum f (m_m - \bar{X}_a)^3}{100 \cdot \sigma_a^3} \quad (4)$$

$$K_a = \frac{\sum f (m_m - \bar{X}_a)^4}{100 \cdot \sigma_a^4} \quad (5)$$

Where  $\bar{X}_a$  is the mean value,  $\sigma_a$  is the standard deviation (sorting coefficient),  $SK_a$  is the skewness value,  $K_a$  is the Kurtosis value,  $f$  is the frequency of weight in each fraction (gr), and  $m_m$  is the center value of each fraction (median).

The mean value is the average grain size value. Mean has units in the form of phi ( $\phi$ ) (equation 2). Median is the middle value of a curve. The median is the central number of a group in a measure of data centering (equation 1). Standard deviation is a number that measures the dispersion of a group of data with respect to the mean value of the data (equation 3). Skewness characterizes which way the grain size of a population is dominant, it may be symmetrical, skewed towards coarse-grained sediments or skewed towards fine-grained (equation 4). Kurtosis is a statistical value that indicates the degree of skewness of a graph, that is the spread of the sample distribution, all these properties are used to describe the frequency distribution (equation 5) [9].

The classification of granulometry uses the classification according to Folk and Ward which consists of sorting, skewness, and kurtosis classification [8]. The standard

deviation classification can be grouped into categories as in Table 1. As for the skewness classification can be grouped into categories as in Table 2, and the kurtosis classification can be grouped into five categories as in Table 3.

**Table 1.** Sorting Classification [8]

<i>Sorting Coefficient</i>	<i>Characterization</i>
>4	<i>Extremely poor sorted</i>
2 – 4	<i>Very poor sorted</i>
1 – 2	<i>Poorly sorted</i>
0.71 – 1	<i>Moderately sorted</i>
0.50 – 0.71	<i>Moderately well sorted</i>
0.35 – 0.50	<i>Well sorted</i>
<0.35	<i>Very well sorted</i>

**Table 2.** Classification of skewness [8]

<i>Value</i>	<i>Description in terms of</i>	
	<i>ϕ-units</i>	<i>Relative particle size</i>
-0.3 to -1	<i>Very negatively skewed</i>	<i>Very skewed towards the fine side</i>
-0.1 to -0.3	<i>Negatively skewed</i>	<i>Skewed towards the fine side</i>
-0.3 to 0.1	<i>Nearly symmetrical</i>	<i>Nearly symmetrical</i>
0.1 to 0.3	<i>Positively skewed</i>	<i>Skewed towards the coarse side</i>
0.3 to 1	<i>Very positively skewed</i>	<i>Very skewed towards the coarse side</i>

**Table 3.** Classification of kurtosis [8]

<i>Value</i>	<i>Classification</i>	<i>Explanation</i>
<0.67	<i>Very platykurtic</i>	<i>Very flat frequency distribution</i>
0.67 – 0.90	<i>Platykurtic</i>	<i>Flat distribution</i>
0.90 – 1.11	<i>Mesokurtic</i>	<i>Non especially peaked, normal distribution</i>
1.11 – 1.50	<i>Leptokurtic</i>	<i>Highly peaked distribution</i>
1.50 – 3	<i>Very leptokurtic</i>	<i>Very highly peaked distribution</i>
>3	<i>Extremely Leptokurtic</i>	<i>Extremely highly peaked distribution</i>

The results of determining the grain size is done by using mesh 50, 80, 100, 200 and panning on the loose material of the Pampang Culture Village River.

The other method used is XRF (X-Ray Fluorescence) method, which is one of the methods used to analyze the content of metal mineral elements and their percentage in a material. The use of the XRF method has a detection limit of up to ppm (part per million). XRF is a non-destructive analysis used for identification and determination of the concentration of elements present in solid materials. The advantages of the XRF method are that it is fast, easy, does not damage the sample, and is relatively cheaper. This method is usually chosen for field applications and material control depending on its use [10].

### 2.2 Research Flow Chart

The research flow chart starts from the preparation stage which includes literature study, preparation of tools and materials. Then enter the data collection and data processing stage. Then at the final stage is the completion stage which includes the data analysis stage and discussion of the research results which are then made conclusions.

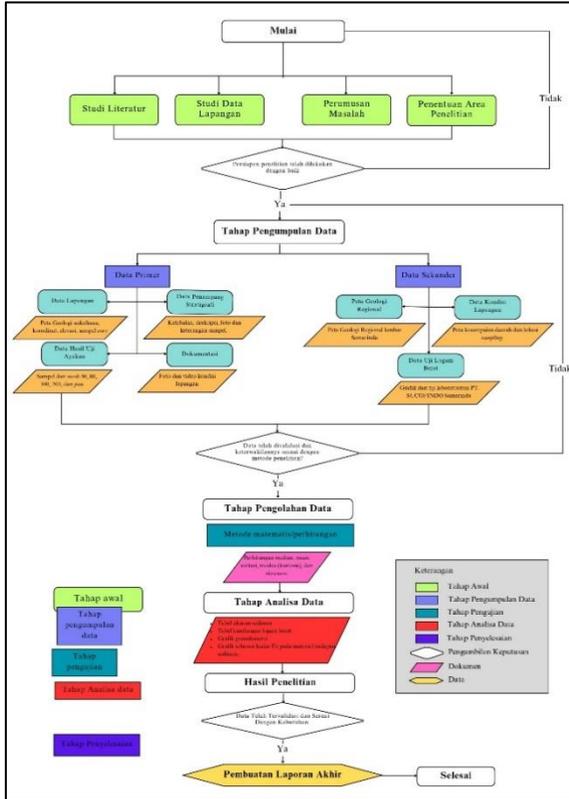


Fig. 2. Research Flow Chart

### 3 Results and Discussions

Variations in iron (Fe) concentrations depend on the characteristics of the aquatic environment, which is influenced by several factors. One of the factors that affect the concentration of iron (Fe) in sediments is the sedimentation process. Based on the results of granulometric calculations, the mean value, standard deviation (sorting), skewness, and kurtosis are obtained and their relationship with the distribution of iron (Fe) levels in the Left Pampang River which is depicted in graphical form.

### 3.1 Granulometric and XRF Test Results

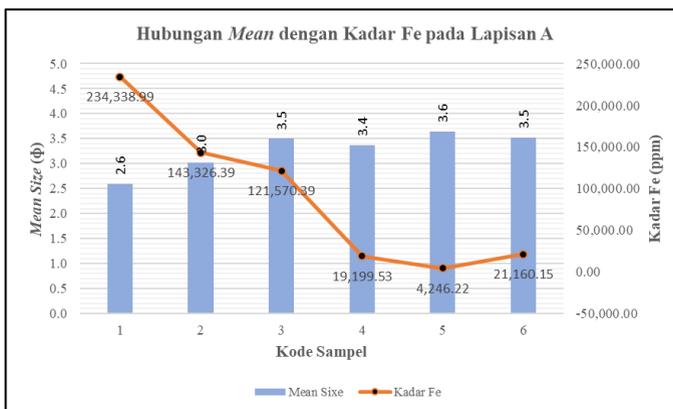
From all 6 sampling locations in Pampang Culture Village River, there are 18 samples of the sediment taken from those plots and tested by the PT SUCOFINDO Samarinda City Branch. The results from the tests can be seen in Table 4.

**Table 4.** Granulometry and XRF Test Results

Numb. Of Sample	Mean ( $\phi$ )	Standard Deviation (Sortation)	Skewness	Kurtosis	Fe Concentration (ppm)
1A	2.60	0.43	2.85	5.18	234,338.99
1B	3.56	1.24	0.66	2.96	108,879.39
1C	3.56	0.79	0.76	4.01	200,979.79
2A	3.02	0.78	1.45	5.25	143,326.39
2B	3.36	0.86	0.06	1.16	82,590.89
2C	3.69	1.33	0.05	1.26	113,955.79
3A	3.50	1.06	0.54	3.66	121,570.39
3B	3.66	1.50	0.24	1.55	85,129.09
3C	3.13	1.05	0.95	2.74	186,838.39
4A	3.37	1.38	0.42	1.22	19,199.53
4B	3.22	1.12	0.66	1.84	15,660.85
4C	2.95	1.14	1.06	2.34	10,018.09
5A	3.64	1.54	0.21	0.71	4,246.22
5B	4.10	1.37	-0.32	1.09	8,392.21
5C	3.79	1.56	-0.11	0.96	18,577.87
6A	3.52	1.54	0.22	1.01	21,160.15
6B	2.51	0.38	4.26	6.64	10,639.75
6C	2.46	1.26	0.80	1.45	7,101.07

### 3.2 Relationship between Mean Size and Fe Content

The variation of the mean value in each sample is influenced by differences in current strength and sediment supply at different levels that affect the sediment material deposited. In addition to the influence of currents and depositional processes, variations in grain size values are due to differences in layers that are not correlated with each other.



**Fig. 3.** Diagram of the relationship between *mean size* and Fe content on layer A

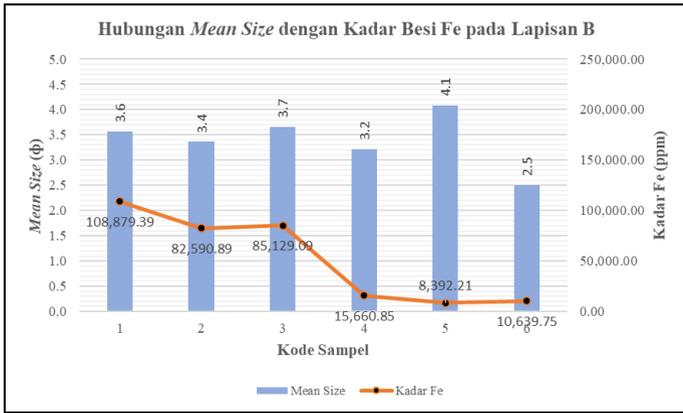


Fig. 4. Diagram of the relationship between mean size and Fe content on layer B

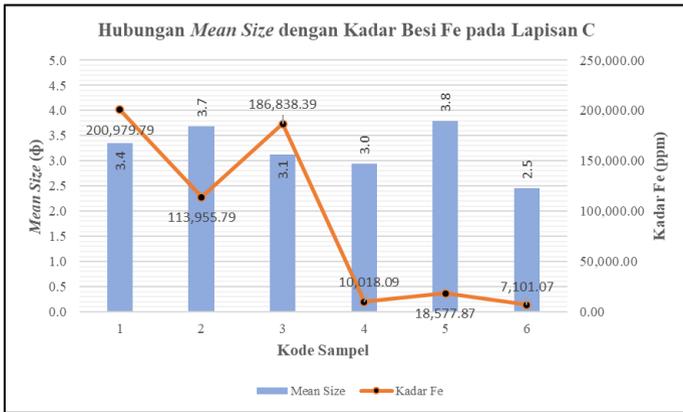


Fig. 5. Diagram of the relationship between mean size and Fe content on layer C

Based on the distribution of sediment particles and Fe levels in layers A, B, and C, it illustrates that changes in sediment grain size and Fe levels are not correlated due to varying depositional processes. The sampling position and anthropogenic activities of the river also affect the distribution of sediment levels and distribution so that there are anomalies in various places. The insignificant changes in sediment particles are also not in line with the significant changes in Fe levels in the upstream to downstream parts of the river.

This depends on the material transported, the source of the Fe, the degree of corrosiveness, elevation and the amount of soluble Fe carried by the water current.

### 3.3 Relationship between Sorting and Fe Content

Standard Deviation is a value that describes the distribution of grain uniformity in the sample or referred to as the sorting of sediment particles. The particles become sorted on the basis of density (specific gravity), due to the energy of the transport medium. The particles become sorted on the basis of density (specific gravity), due to the energy of the transport medium. The result of this sorting is related to density.

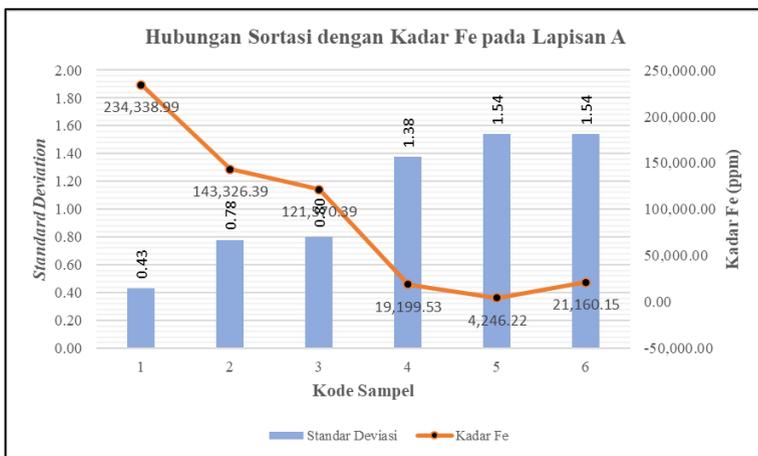


Fig. 6. Diagram of the relationship between sorting and Fe content on layer A

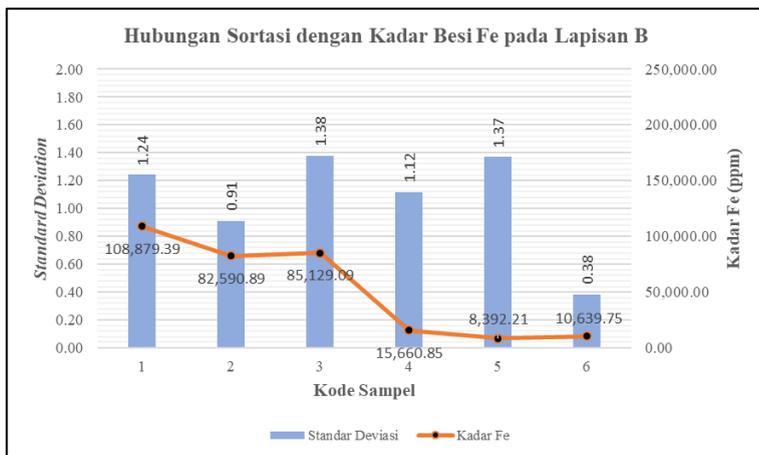


Fig. 7. Diagram of the relationship between sorting and Fe content on layer B

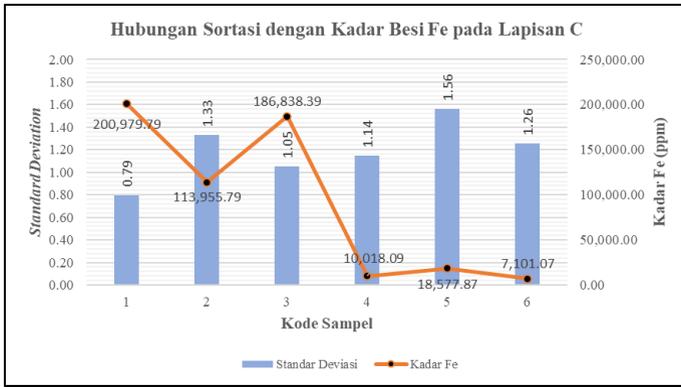


Fig. 8. Diagram of the relationship between sorting and Fe content on layer C

Based on the distribution of sediment sorting and Fe levels in layers A, B, and C are not significantly related to the deposition process. Where there is an increase in Fe content in samples with good sorting compared to poor sorting, which causes a decrease in the value of Fe content. However, some samples show that the changes in standard deviation and Fe content are not in line with this concept. This could be due to several factors, namely the position of the sample layer, river meandering, sampling elevation, river water condition, river current, anthropogenic activities, and the source of Fe content carriers.

### 3.4 Relationships between Skewness and Fe Content

The skewness value is used to describe the current and wave conditions during the sedimentation process. The higher the skewness value, the weaker the currents and waves. Conversely, the lower the skewness value, the stronger the currents and waves [11].

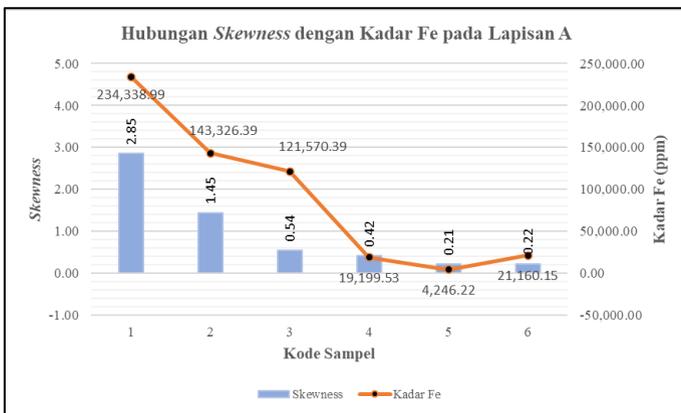


Fig. 9. Diagram of skewness relationship and Fe content on layer A

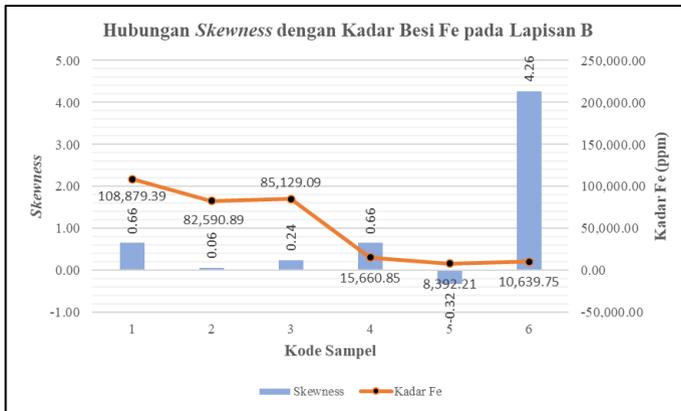


Fig. 10. Diagram of *skewness* relationship and Fe content on layer B

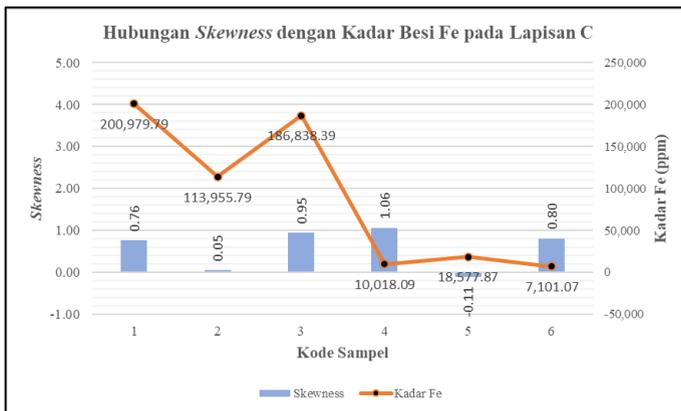


Fig. 11. Diagram of *skewness* relationship and Fe content on layer C

The decrease in skewness value affects the Fe content value, where the Fe content value will decrease. The Fe content value in the downstream part of the river has a much higher value compared to the upstream part of the river. The anomalous skewness value can also explain the distribution of Fe elements in the sample, which allows less Fe elements to be deposited and the lack of a main source causing the high distribution of Fe levels in the sample. Anomalies in skewness values that are not in line with changes in Fe values can occur due to river meanders that affect the deposition of sedimentary material and Fe levels.

The skewness value depicted on the graph can also explain the current and wave conditions at the sample point during deposition. The deposition process disturbed by strong currents and waves will be able to carry Fe elements dissolved and carried by river water, so that the level value will be lower. Conversely, calmer current and wave conditions during the deposition process will be able to precipitate more Fe elements, so the Fe content value will be higher [11].

### 3.5 Relationship between Kurtosis and Fe Content

The kurtosis value illustrates the stability of river waters to determine the sedimentation and redeposition process. If the kurtosis value increases, it describes stable water conditions. Conversely, the decreasing kurtosis value illustrates unstable water conditions [11].

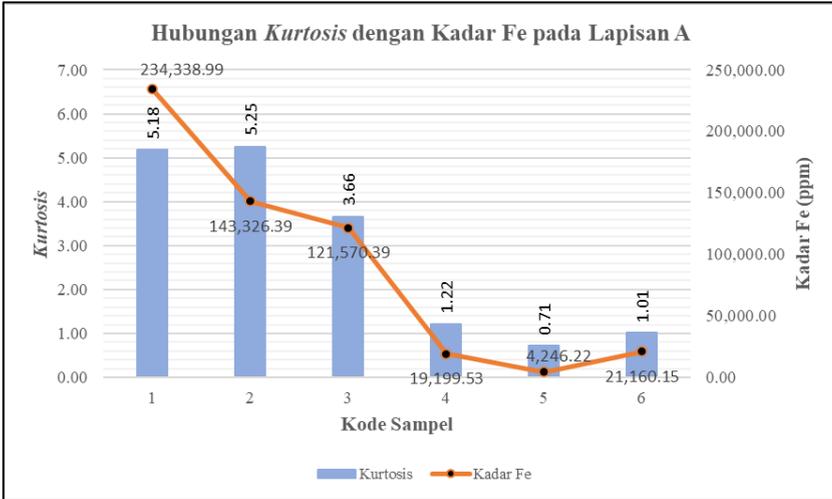


Fig. 12. Diagram of the relationship between *kurtosis* and Fe content on layer A

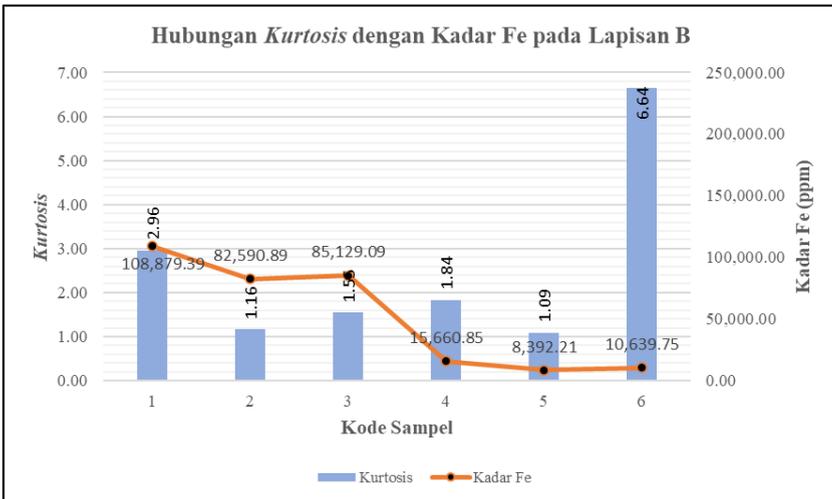


Fig. 13. Diagram of the relationship between *kurtosis* and Fe content on layer B

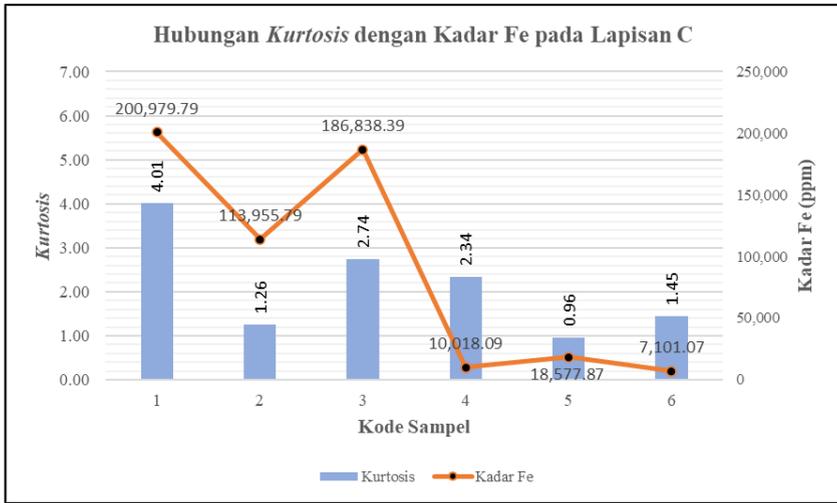


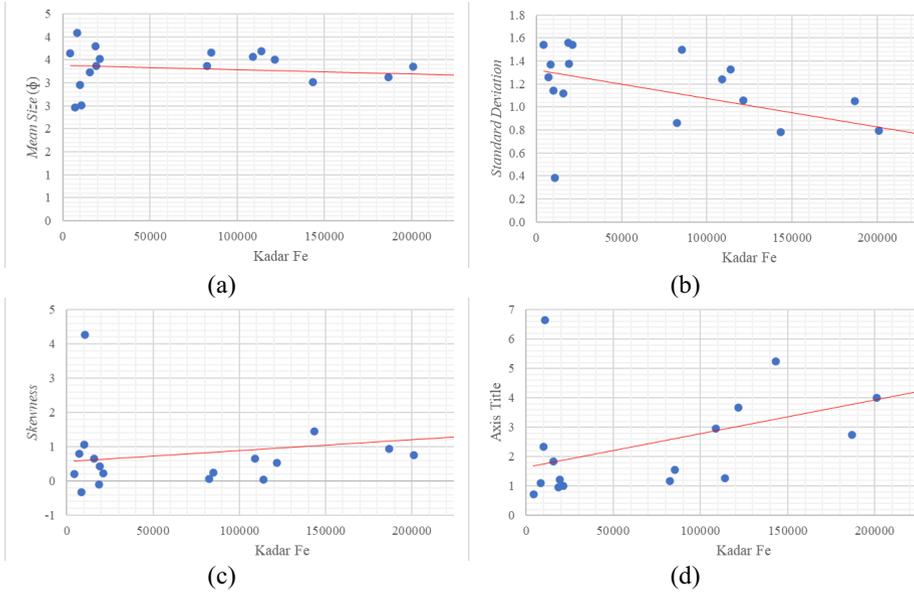
Fig. 14. Diagram of the relationship between *kurtosis* and Fe content on layer C

The decrease in kurtosis value affects the Fe content value, where the Fe content value will also decrease. Similar to the skewness value, changes in the Fe content value in the sample are divided into 2 river sections, namely the upstream and downstream samples. The Fe content value in the downstream of the river is much higher than the upstream of the river. The presence of kurtosis value anomalies can explain the distribution of Fe elements in the sample which allows the lack of Fe elements to be deposited or due to the disturbed transportation and deposition process due to unstable water conditions.

The kurtosis value depicted on the graph explains the condition of river waters at the sample point during the sedimentation process (transportation and redeposition). Stable water conditions will cause a high distribution of kurtosis values in the sample. This allows the Fe element to not dissolve carried by the river current and is able to precipitate the element in the sediment material. Conversely, a disturbed sedimentation process with unstable water conditions will be able to dissolve and carry Fe elements downstream. So that it causes a decrease in the kurtosis value or has a lower value [11].

### 3.6 Correlation of Granulometric and Fe Content

Based on the graphical depiction and calculation, it can be stated that the relationship between mean size and sorting values has a positive correlation. This also applies to the skewness and kurtosis relationship which has a positive correlation. However, between the values of mean size and sorting with skewness and kurtosis have a relationship that is not in line with the negative correlation results.



**Fig. 15.** Correlation diagram of granulometric distribution and Fe content; (a) Fe content against mean size, (b) Fe content against sorting, (c) Fe content against skewness, (d) Fe content against kurtosis

Based on graphical depictions and calculations, it can be stated that the Fe content value has a weak negative correlation to the meansize value (-0.15) as well as to the sorting value which has a moderate negative correlation (-0.52). On the other hand, the Fe content value has a weak positive correlation to the skewness value (0.07) and a moderate positive correlation to the kurtosis value (0.5).

From these results, it can be stated that the variation of Fe content data has a positive linear correlation that is in line with the variation of skewness and kurtosis data. Thus, the effect of changes in Fe content is in line with changes in skewness and kurtosis values.

## 4 Conclusions

Based on these results, it is known that the sedimentation process that occurs in the upstream part of the Pampang Kiri River is more active than the downstream part of the river. This can be influenced by elevation, river morphology, current speed, sediment supply, or anthropogenic activities that occur in the upstream and downstream areas of the river. The sedimentation process affects the different conditions of sediment particles that are transported upstream to downstream rivers which are then deposited.

The cause of high levels of Fe metal in the downstream part of the river in sediments can be caused by the process of transportation of materials containing Fe elements originating from upstream rivers and accumulating in the downstream part of the river. This

is in line with the dynamics of sedimentation in the upstream part of the river with a more active process where the Fe element is transported to the downstream part of the river. Thus, the Fe content value in the upstream part of the river is lower than the downstream part of the river. The calmer water conditions in the lower reaches of the river resulted in high Fe levels in the samples that were transported from the upper reaches of the river and accumulated in the lower reaches of the river.

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