The Effect of Jatigede Dam Construction towards the Spatial Pattern of Total Suspended Solids and Chl-a in Waters Areas around Mouth of Cimanuk River

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Abstract. Construction of dams in the upstream area will lead to changes in flow water, sediment output in the downstream area and change nutrients entry into estuaries then affects chl-a (Chl-a) concentration. The purpose of this paper is to investigate the influence of the functioning of the dam Jatigede in Sumedang District towards the condition of total suspended solids (TSS) and chl-a (Chl-a) concentration in the sea water around the mouth of the Cimanuk River. In this study, we used multi-temporal Landsat 8 OLI/TIRS imagery to determine the spatial pattern of TSS during the time before and after the functioning of dam Jatigede. The results showed that after the Jatigede Dam operated, the distributions and amounts of TSS concentration > 80mg/l tends to reduce, especially at the water areas close to the coast and the Cimanuk river discharge no longer significantly affects the spatial distribution of TSS concentrations. The watershed discharge also affects the distribution area of Chl-a 0.5-1 mg/m³ which tend to decrease in the water nearby to land.

1. Introduction

The existence of marine biota, the development of fishery or tourism sector in marine waters near the estuary is strongly influenced by the quality of the waters in the region. The water quality in the estuary and the surrounding waters is very dynamic as a result of a complex process between the hydrological factors of the terrain and the oceanographic factor [1]. Estuary of the River as the end of river water flow into the waters that are susceptible to pollution and can affect the quality of the waters in the surrounding area.

The total suspended solid (TSS) content in an area of marine waters, is one indicator of the presence or absence of water contamination that is physical. The high content of TSS in the waters can lead to increased turbidity, thus affecting the level of penetration of sunlight to the bottom of the river and further disrupt the process of marine biota metabolism. The Ministry of Environment establishes a standard TSS concentration in waters of 20 mg / liter for marine biota such as, seagrass and coral reefs, and a maximum of 80 mg / liter for mangrove biota [2]. Chl-a is also used as an indicator of water quality because of chl-a is an indicator of biomass phytoplankton, where the content describes thoroughly the effects of various factors that occur due to human activity [3]. Chl-a is a green pigment that phytoplankton requires for the process of photosynthesis and forming organic matter in the waters. The content of chl-a in waters can be used as an indicator of the level of water fertility, as a guide to the availability of nutrients in the water [4] and as an indicator of eutrophication in a water [5]. The content of TSS and Chl-a in the mouth of the river and surrounding area is very dynamic in
the dimensions of space and time. The river discharge factor becomes the key factor determining the amount of sediment and chl-a that can be transported to the estuary [6] and then the oceanographic factor determines the spatial distribution of the TSS content in the adjacent water territory [1]. The results of the study have shown that dam construction in a river can cause the decrease of sediment transported to river mouth [6], so it can interfere with the biogeochemical process in a watershed system especially at river mouth [7]. Jatigede dam is built to take advantage of Cimanuk river flow. Jatigede Reservoir will accommodate about 1 billion m$^3$ of water and potentially irrigate about 100,000 hectares of rice fields. In addition to irrigation sources, Jatigede Reservoir can also be used for hydroelectric power which generates electricity of 110 MW and raw water source [8]. Jatigede Reservoir construction project was built starting in 2007 and began to be inundated on 31 August 2015. The location of the dam is about 75 km from the mouth of the river in the Java Sea. Jatigede Dam built as reservoir of Cimanuk River is an example of river that has been exploited by human One of the estuary of the river and the territorial waters in Indonesia is Ci Manuk estuary. Muara and Ci Manuk waters area is the mouth of the second largest river in West Java [9]. Muara Ci Manuk is located in Indramayu District with its tributaries divided into two estuary branches of the Muara Timur and Muara Barat.

The purpose of this study was to determine whether the spatial pattern of TSS and chl-a concentrations in Estuari Cimanuk and surrounding areas changed after the functioning of the Jatigede dam. Spatial distribution of TSS and chl-a concentrations before and after the operation of the Jatigede dam was observed using remote sensing technology. Remote Sensing technology allows the observation of TSS in aquatic regions to be observed in a multi-temporal, rapid, wide-ranging and economical manner [10].

2. Study Area
The focus of the study area is the area of Cimanuk estuary and surrounding waters and geographically located at coordinates 6° 9' 32.4" LS - 6° 18' 10.8" LS and 108° 6' 25.4" BT - 108° 25' 33.6" BT. Administratively is a part of Indramayu District. The research focuses on watershed area of 35.2 km x 16 km (see figure 1), divided into 3 segments, namely Cimanuk Barat estuary area (Segment A), intercity of Ci Manuk Muara (Segment B), and East Cimanuk (Segment C). The next three segments are divided by the distance from the coast with each distance of 1 mile, up to 4 miles.

![Figure 1. (a) Research Area, (b). Segment of Research Area](image_url)
3. Methodology
TSS concentration data were obtained from Landsat 8 OLI / TIRS multi temporal image processing and direct measurement in the field. The Landsat image (path 121 row 64) is obtained from the US Geological Survey (USGS) website, https://earthexplorer.usgs.gov/ with cloud cover below 20%, and includes acquisition imagery as of June 2, 2014, June 18, 2014, August 21, 2014, March 17, 2015, May 20, 2015, June 21, 2015, July 7, 2015 and August 24, 2015 (before) and imagery dated September 9, 2015, April 4, 2016, June 7, 2016, August 10, 2016, October 29, 2016 And May 09, 2017 (after). The TSS concentration is obtained through image processing using the following algorithm equation [11].

\[
TSS (\text{mg/l}) = 8.1429 \times \exp (23.704 \times \text{red band}).
\]  

Information:
TSS : Total Suspended Solids

The Landsat 8 OLI / TIRS image processed using image processing software for radiometric correction, cropping, and algorithm application for chl-a which refers to the algorithm of Wibowo., et al in 1993. Band 3 and band 4 of Landsat TM satellite images can be used to detect chl-a concentration in the waters [12] so that the algorithm is as follows:

\[
\log \text{Chl} = (2.41 \times B4/B3) + 0.187
\]

Information:
Log Chl = Chl-a Concentration (mg/m³)

The TSS data in the field was obtained by sampling of seawater on May 09, 2017 and he chl-a data was also obtained from the field survey results on April 23, 2017 at 30 sites and the concentration of TSS was obtained through laboratory test results. Figure 2 show the flow chart of data processing of Landsat 8 OLI/TIRS:

![Figure 2. TSS Data Processing Flow Chart](image-url)
The TSS concentration data resulting from the image processing were processed and classified according to [2] in 5 classes (see Table 1) with class variations ranging from 0 to > 80 mg/l. The analysis of TSS distribution pattern in this study focused on TSS class > 80 mg/l.

### Table 1. Classification of Total Suspended Solids Class

| No | Class | Value of Imagery | TSS Concentration       |
|----|-------|------------------|-------------------------|
| 1  | 1     | 0 < R < 20       | 0 mg/l < TSS < 20 mg/l  |
| 2  | 2     | 20 ≤ R < 40      | 20 mg/l ≤ TSS < 40 mg/l |
| 3  | 3     | 40 ≤ R < 60      | 40 mg/l ≤ TSS < 60 mg/l |
| 4  | 4     | 60 ≤ R < 80      | 60 mg/l ≤ TSS < 80 mg/l |
| 5  | 5     | R < 80           | TSS < 80 mg/l            |

(Source: Ministry of Environment, 2004)

To prove the algorithm used to describe the condition of TSS in research area, then test image accuracy between field data and data from image using equation as follows [13]:

\[ \text{RMSE} = \sqrt{\frac{\sum (P_i - O_i)^2}{N}} \]

\[ \text{NOF} = \frac{\text{RSME}}{O} \]  

Information:
- **RMSE**: Root Mean Square Error
- **NOF**: Normalized Objective

The classification classes of chl-a is according on Arsjad., et al (2004) into 5 classes. For the processing of watershed discharge data, the data must be conversion into daily discharge data first then obtained the average weekly quantity at each time observation.

### Table 2. Classification of Chl-A Concentration

| Class | Concentration (mg/m³) | Description                      |
|-------|-----------------------|----------------------------------|
| 1     | < 0.3                 | Low Concentration                |
| 2     | 0.3 - 0.5             | Moderate Concentration           |
| 3     | 0.5 - 1               | High Concentration               |
| 4     | 1 – 2                 | Chl-a and High Suspension Charges|
| 5     | > 2                   | High Suspension Charges          |

(Source: Arsjad., et al, 2004)

### 4. Results and Discussion

#### 4.1 Spatial Pattern of TSS Concentration

From the result of image processing of Landsat 8 OLI / TIRS data was obtained the distribution of TSS concentration with range between 0 mg/l to > 80 mg/l. As shown in Figure 3, the waters with turbid water concentrations, with TSS values > 80 mg/l (above the quality standard) tend to be scattered close to the coast, so the spatial pattern tends to follow the shoreline pattern. The farther from the coast, up to 4 miles from the sea of murky waters are diminishing.
Spatially the TSS distribution pattern looks dynamic. If viewed from a temporal perspective then, it can be seen on March 17, 2015 (see Figure 3) the turbid waters tend to cluster westward as compared to other observation dates. While on August 24, 2015 turbid waters tend to cluster in the eastern and southeastern parts.

Temporarily turbid concentrations before the functioning of Jatigede Dam have a spread that goes away from the coast (up to 4 miles). This can be distinguished by the distribution of TSS concentrations after the functioning of Jatigede Dam TSS concentrations of turbid waters with large values tending to decrease and not having a distant distribution with the mainland. This indicates that the spread of TSS before and after the functioning of the Jatigede Dam has a different distribution pattern.

The results of data processing of Landsat 8 OLI / TIRS using algorithm Wibowo., Et al (1993) in the study area resulted in various values of chl-a concentration. Spatially, chl-a concentration tend to be higher in waters close to the mainland and further away from the mainland until the 4 miles distance, the concentration began to lower. It can be seen that the overall value of 0.5 - 1 mg/m$^3$ chl-a concentration was in waters close to land and tend to follow the pattern of landform. Meanwhile, the 0.3 - 0.5 mg / m$^3$ concentrations dominate the northern territorial waters.
In the prior functioning of Jatigede Dam, distribution of chl-a concentration of 0.5 - 1 mg/m$^3$ was large enough and its distribution away from the coast or up to a distance of 4 miles. It is in contrast to the distribution of chl-a concentration of 0.5 - 1 mg/m$^3$ after the functioning of Jatigede Dam whose values tend to decreased. An example can be taken on June 18, 2014 the concentration of chl-a 0.5 - 1 mg/m$^3$ tends to be more widespread to areas far offshore than in June 7, 2016, which is only in waters close to the mainland (up to 1 mile).

Temporally, it is shown that the distribution area of >1 mg/m$^3$ chl-a concentration has a large area on March 17, 2015 and October 29, 2016 in coastal waters of the western part. It can be caused by the high supply of nutrients to waters, either from land through streams or from the mixing / mass agitation process of water which lifts the water mass from the bottom to the surface layer.

![Figure 4. Distribution of Chl-a Concentrations Before The Functioning of Jatigede Dam](image)

### 4.2 Image Accuracy Test

Table 3 shows the TSS concentration value of water sample measurement at 28 locations and concentration value of OLI 8 Landsat image processing at the same location.

| No. | Direct Data | Imagery | No. | Direct Data | Imagery | No. | Direct Data | Imagery | No. | Direct Data | Imagery |
|-----|-------------|---------|-----|-------------|---------|-----|-------------|---------|-----|-------------|---------|
| 3   | 172         | 63      | 10  | 128         | 40      | 17  | 115         | 54      | 24  | 107         | 88      |
| 4   | 110         | 234     | 11  | 172         | 104     | 18  | 205         | 61      | 25  | 173         | 101     |
| 5   | 55          | 54      | 12  | 183         | 105     | 19  | 180         | 86      | 26  | 93          | 90      |
| 6   | 90          | 85      | 13  | 190         | 51      | 20  | 163         | 81      | 27  | 227         | 132     |
| 7   | 67          | 64      | 14  | 148         | 64      | 21  | 140         | 88      | 28  | 208         | 154     |
| 8   | 47          | 88      | 15  | 133         | 54      | 22  | 170         | 89      | 29  | 240         | 183     |
| 9   | 62          | 68      | 16  | 142         | 54      | 23  | 170         | 84      | 30  | 150         | 141     |

(Source: Data Processing, 2017)
Sample number 1 and 2 are covered with clouds so they cannot be compared. The value obtained from the Test Accuracy between Landsat 8 OLI / TIRS image processing with field observation on May 9, 2017 that is, the value of RMSE yield value of 77. As for the value of NOF generated that is equal to 0.841. Ideal NOF values range from 0-1 [11]. Then the algorithm used in identifying TSS can be accepted and used.

4.3 Concentration of TSS Based on Distance to the Coastline

In this sub-chapter, not all concentration classes will be discussed about its distribution. The focus of the concentration of TSS analyzed in this sub-chapter is the concentration of> 80mg/l. This is because the TSS with concentration >80mg/l is the threshold of concentration on the quality standards of marine waters for marine biota or can be said to include turbid water.

Table 4 shows the percentage (%) of TSS area above> 80mg / l for the three regional segments, namely segment A, segment B, and segment C which is then broken down by distance from the coastline. It appears that concentrations> 80 mg / l (cloudy waters) dominate the ocean waters near the coast (≤1mil) compared to other distances. The further away from the coast, the high turbidity area decreases. This happens in three segments of the research area. The average percentage of the turbid waters area prior to the Jatigede Dam was recorded at a distance (≤1mil) in segment A by 42%. Segment B by 13% and in the segment C by 56%.

Table 2 also shows that after the functioning of Jatigede Dam area, the concentration> 80mg / l is still bigger in the sea area close to the coast. However, at the time after the functioning of the Jatigede Dam, there was a decrease in the concentration area> 80mg / l. This happens in every research area in segment A, segment B, and segment C.

After the functioning of the Jatigede Dam, the turbid waters area still dominant in the marine waters near the coastline.

| Time            | 1 mile | 2 mile | 3 mile | 4 mile | 1 mile | 2 mile | 3 mile | 4 mile | 1 mile | 2 mile | 3 mile | 4 mile | Total |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Before The Functioning of Jatigede Dam (%) |         |        |        |        |        |        |        |        |        |        |        |        |       |
| 02/06/2014      | 35     | 7      | 4      | 1      | 14     | 0      | 0      | 0      | 58     | 29     | 9      | 0      | 33    |
| 18/06/2014      | 37     | 7      | 6      | 3      | 20     | 25     | 0      | 0      | 74     | 23     | 6      | 0      | 45    |
| 21/08/2014      | 30     | 3      | 4      | 2      | 4      | 0      | 0      | 0      | 58     | 54     | 0      | 0      | 33    |
| 17/03/2015      | 67     | 47     | 19     | 10     | 11     | 0      | 0      | 0      | 21     | 2      | 0      | 0      | 38    |
| 20/05/2015      | 47     | 6      | 5      | 2      | 26     | 0      | 0      | 0      | 80     | 29     | 6      | 0      | 44    |
| 21/06/2015      | 29     | 7      | 6      | 3      | 5      | 0      | 0      | 0      | 41     | 12     | 1      | 0      | 22    |
| 07/07/2015      | 40     | 8      | 6      | 3      | 3      | 0      | 0      | 0      | 34     | 3      | 0      | 0      | 19    |
| 24/08/2015      | 48     | 7      | 6      | 3      | 24     | 2      | 0      | 0      | 84     | 66     | 41     | 4      | 64    |
| Mean            | 42     | 12     | 7      | 3      | 13     | 3      | 0      | 0      | 56     | 27     | 8      | 1      | 37    |

| After The Functioning of Jatigede Dam (%) |         |        |        |        |        |        |        |        |        |        |        |        |       |
| 09/09/2015      | 35     | 6      | 5      | 2      | 5      | 0      | 0      | 0      | 70     | 45     | 19     | 0      | 40    |
| 25/09/2015      | 56     | 8      | 7      | 4      | 12     | 0      | 0      | 0      | 80     | 52     | 17     | 0      | 50    |
| 12/11/2015      | 13     | 5      | 5      | 3      | 1      | 0      | 0      | 0      | 17     | 0      | 0      | 0      | 9     |
| 04/04/2016      | 32     | 2      | 1      | 1      | 1      | 0      | 0      | 0      | 5      | 0      | 0      | 0      | 8     |
| 07/06/2016      | 24     | 6      | 7      | 3      | 0      | 0      | 0      | 0      | 12     | 0      | 0      | 0      | 11    |
| 10/08/2016      | 34     | 2      | 1      | 2      | 4      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 10    |
| 29/10/2016      | 58     | 31     | 15     | 5      | 1      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 23    |
| 09/05/2017      | 48     | 11     | 9      | 1      | 56     | 0      | 0      | 0      | 73     | 29     | 7      | 0      | 37    |
| Mean            | 37     | 9      | 6      | 3      | 10     | 0      | 0      | 0      | 32     | 16     | 5      | 0      | 24    |

(Source: Data Processing, 2017)
In this section, not all classes of chl-a concentration will be discussed only class 0.5 - 1 mg/m$^3$. In waters close to the mainland (up to 1 miles), the area percentage of 0.5 - 1 mg/m$^3$ concentration of chl-a is higher than in areas far from the mainland. The farther from the land, the area percentage with chl-a concentration of 0.5 - 1 mg/m$^3$ decreases. That phenomenon occurs in western Cimanuk Estuary region, eastern Cimanuk Estuary region, and the waters between the two estuaries on before and after the Functioning Jatigede Dam.

The average percentage of area concentration of chl-a 0.5 - 1 mg/m$^3$ in western Cimanuk Estuary region before the functioning of Jatigede Dam at 1 miles was recorded at 71.58%, then in the waters between two estuaries of 56.72%, while in eastern Cimanuk Estuary region of 90.22%. After the functioning of Jatigede Dam, the average percentage of area concentration of chl-a 0.5 - 1 mg/m$^3$ decreased at a distance of 1 miles with the average percentage in western Cimanuk Estuary region of 60.14%, in the waters between two estuaries of 29.38% and eastern Cimanuk Estuary region of 66.20%. It can be said that there is a decrease of the area concentration of chl-a 0.5 - 1 mg/m$^3$ at the time before and after the Functioning Jatigede Dam in all segments.

Temporally, the area percentage of chl-a concentration 0.5 - 1 mg/m$^3$ at the time before and after the functioning of Jatigede Dam fluctuated, but before the functioning of Jatigede Dam, the percentage of the area concentration of chl-a 0.5 - 1 mg/m$^3$ at a distance of 1 miles in western Cimanuk Estuary region more temporally stable between the other two segments. The total area of chl-a concentration will vary temporally due to the character of chl-a example on June 18, 2014, the entire segment of the study area at a distance of 1 miles has a high percentage whereas on June 21, 2015 only in eastern Cimanuk Estuary region.

4.4 Water Discharge Relationship with TSS Concentration >80mg/l and chl-a 0.5 - 1 mg/m$^3$ before and after functioning of Jatigede Dam.

The correlation coefficient (r) of the water discharge relationship with the area of turbid waters in segment A at a distance of ≤1 mil on prior to the functioning of the Jatigede Dam yields a value (r) 0.848. This figure shows that 74% of variation in the magnitude of the concentration is influenced by the discharge. In the segments B and C at ≤1-mile distance, there is no correlation between the flow rate with the area, with only r values of -0.045 and -0.593. While in segment A each at a distance of 2 miles to 4 miles, the amount of coefficient correlation between the water discharge and the area of TSS tends to be high.

| Distance | Segment A  | Segment B  | Segment C  |
|----------|------------|------------|------------|
|          | r (Before) | r (After)  | r (Before) | r (After)  | r (Before) | r (After)  |
| 1 Mile   | 0.848      | 0.341      | -0.045     | -0.25      | -0.593     | -0.53      |
| 2 Mile   | 0.990      | 0.553      | -0.171     | -          | -0.449     | -0.53      |
| 3 Mile   | 0.978      | 0.333      | -          | -          | -0.238     | -0.56      |
| 4 Mile   | 0.955      | 0.032      | -          | -          | -0.160     | -          |

(Source: Data Processing, 2017)
The results of this correlation show that the farther from the coastline, the more stable the influence of water discharge in affecting the area of TSS in the water area. While at a close distance to the beach the influence of the discharge tends to be dynamic. This applies only in segment A. As for other research areas, correlation results tend to be small and nonexistent.

After the functioning of Jatigede Dam in Segment r value of 0.341, this figure indicates that 11% of the spread of TSS concentration is influenced by water discharge and the rest is influenced by other factors. While in segment 2 there is no correlation, with result value r -0.250. In segment C, the correlation value is small by only 2%. (See Table 5)

Small correlations are also seen at a distance of 2 miles to 4 miles in segment A, different from the time before the functioning of the dam. While in segment B and segment C, tend to correlation show the direction of negative correlation.

**Table 6. Correlation Value (R) Between Watershed Discharge Cimanuk River with Area of Chl-a Concentration 0.5 - 1 mg/m³ Before The Functioning Jatigede Dam**

| Segment                     | Range    | 1 miles | 2 miles | 3 miles | 4 miles |
|-----------------------------|----------|---------|---------|---------|---------|
| Western Cimanuk Estuary Region | 0.636   | 0.657   | 0.425   | 0.015   |
| The Waters Between Two Estuaries | 0.401   | 0.232   | 0.222   | 0.213   |
| Eastern Cimanuk Estuary Region | 0.673   | 0.410   | 0.299   | 0.284   |

(Source: Data Processing, 2017)

The relations between the watershed discharge and the chl-a concentration of 0.5 - 1 mg/m³ in western Cimanuk Estuary region in waters close to land (1 miles) before the functioning Jatigede Dam has a correlation value of 0.636 (Table 6). In waters at a distance of 2 miles, 3 miles, and 4 miles have correlation value of 0.657, 0.425, and 0.015. The farther the distance from the mainland the correlation value tends to be smaller than the correlation value of the waters close to the mainland. This indicates that the farther from the mainland, the smaller influence of watershed discharge to an area of chl-a is.

For the waters between two estuaries at a distance of 1 miles has a correlation value of 0.401 (Table 6). This figure is smaller than the correlation value at a distance of 1 mile in western Cimanuk Estuary region. Just like in western Cimanuk Estuary region, in the waters between the two estuaries is also the further distance from the mainland, the smaller correlation is, with the value of 0.232, 0.222, and 0.213.

The eastern Cimanuk Estuary region has the value of correlation at a distance of 1 miles of 0.673 (Table 6). This value is not much different from the correlation value at a distance of 1 miles in western Cimanuk Estuary region. In the eastern Cimanuk Estuary region also the further the distance from the mainland then the correlation tends to be smaller than the correlation value of the waters closes to land with a value of 0.410, 0.299, and 0.284.

**Table 7. Correlation Value (R) Between Watershed discharge Cimanuk River with Area of Chl-a Concentration 0.5 - 1 mg/m³ After the Functioning Jatigede Dam**

| Segment                     | Range    | 1 miles | 2 miles | 3 miles | 4 miles |
|-----------------------------|----------|---------|---------|---------|---------|
| Western Cimanuk Estuary Region | 0.959   | 0.364   | 0.450   | 0.567   |
| The Waters Between Two Estuaries | 0.747   | 0.610   | 0.610   | 0.000   |
| Eastern Cimanuk Estuary Region | 0.972   | 0.735   | 0.741   | 0.407   |

*Level of Significant 5%*  
(Source: Data Processing, 2017)

After functioning of Jatigede Dam, the relationship between distribution variations and watershed discharge tend to be large in close range to the mainland. The correlation value at a distance of 1 miles
in three segments are increased. In western Cimanuk Estuary region, the value turns 0.959, in the waters between two estuaries turns 0.747 and in eastern Cimanuk Estuary region turns 0.9453 (Table 7). It can be said that after the functioning of Jatigede Dam, the watershed discharge factor influenced the distribution of chl-a concentration in the three segments significantly compared to the period before the functioning Jatigede Dam.

5. Conclusion
Construction of Jatigede Dam resulted in changes in the pattern of total suspended solids distribution (TSS). This change can be seen from the area of turbid waters (concentration > 80mg/l) whose extent tends to decrease. The area of turbid waters which previously had a total average value of 37%, then now at after the functioning of the dam is reduced to 24%. The spatial diminishing of the murky waters occurred both in the three research areas. Temporally also wide murky waters are inseparable from the factors of water discharge and oceanography. After the functioning of Jatigede Dam, the area of water with chl-a concentration of 0.5 - 1 mg/m³ tends to decrease significantly by 30%. Spatial variation of chl-a concentration influenced by oceanographic and watershed discharge.

Before to the functioning of the Jatigede Dam the discharge factor significantly affected the area of the turbid waters (concentration > 80mg/l) in the West area of Cimanuk River Mouth. However, after the functioning of the dam, discharge no longer affects TSS well across all three research areas, but affect the chl-a significantly with the value of correlation (R) in western Cimanuk Estuary region of 0.959, the waters between the two estuaries of 0.747 and at eastern Cimanuk Estuary region of 0.9453.

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