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Original paper

PRELIMINARY STUDY OF THE POTENCY OF SEDIMENTATION RATE IN BANJIR KANAL TIMUR SEMARANG COASTAL WATERS

By: Tonny Bachtiar [*)] [(1, 2, 3)]

[(1)] Oceanography Study Program, Department of Marine Science,
[(2)] Center for Tropical Coastal and Marine Studies, Research Institute,
[(3)] Graduate School of Environmental Science, Diponegoro University, Semarang 50239, Indonesia

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ABSTRACT

Five sets of sediment traps were installed for thirty days (Oct.- Nov. 1999) in Banjir Kanal Timur Semarang coastal waters to examine the potency of sedimentation rate. Two sediment traps were lost in the second week of measurement. Based on the average data of three sets of sediment traps, the potency of sedimentation rate in Banjir Kanal Timur Semarang coastal waters was 6.10 cm/month. The result did not reflect the fact of the field condition. Based on the correction made on the input of suspended discharge into Banjir Kanal Timur Semarang coastal waters and the average area of sediment distribution, the potency of sediment rate in Banjir Kanal Timur Semarang coastal water during transition of dry season to rainy season was 0.35 cm/month.

Key words: Sediment, sedimentation, suspended, traps, and rate

[*)]**Correspondence**: Phone/Fax: (+62)(24) 7474698, 7460038, and 8453635
Email: tonny_bachtiar@hotmail.com

INTRODUCTION

Sediments have an important role regarding environmental pollution, especially in water environment. Water environment is very dynamic, therefore to understand the condition of pollution in water environment, bottom sediment of the water environment can be used as an environmental information bank (Håkanson and Jasson 1983). By analyzing the bottom surface sediments of water environment, the polluted and unpolluted areas can be determined, including the identity and intensity of the pollutant in that area, distribution pattern of pollutant, and the tendency of historic pollution.

Analysis of fine sediments will be useful to understand the distribution pattern of pollutants (Coakley and Poulton 1991). Most of organic pollutants will be found in fine sediment (clay) because of its characteristic. Colloid organic pollutant will be adsorbed by organic material in clay sediments, and be transported in concert. In certain condition, the sediments will be deposited and accumulated in the bottom of waters, and create layers of sediments. Each layer reflects the condition of environmental condition, including the pollution at that time. By

analyzing sediment characteristic vertically using core sediment samples, abundance information will be obtained. To interpret the data of core sediment sample, it is necessary to know the potency of sedimentation rate in that area (Bachtiar 2002).

To better understand the potency of sedimentation rate is necessary to measure the rate in each season condition for at least 30 days. By analyzing the rainfall data, the duration of each season condition can be determined. In Indonesian region, there are four seasons, namely: rainy season, transition of rainy season to dry season, dry season, and transition of dry season to rainy season. For this preliminary study, the measurement was done only during transition of dry season to rainy season (Oct.– Nov. 1999).

MATERIAL AND METHODS

Equipment

- Sediment traps
  One set of sediment traps which consists of three plastic tubes with 6.5 cm in diameter and 50 cm length. The top of the tube was covered by baffles to trap the suspended sediment and to protect the sediment that was already trapped in the tubes.
- Tripods
  The bamboo tripods were used as a marker of the station and to protect the sediment traps from the activities of fishermen.
- SCUBA gear
  SCUBA gears were used to install and uninstall the tripods and sediment traps, and for weekly monitoring. The sediment traps were set at 50 cm from the bottom of waters.

Method

There were several steps that had been done to examine the potency of sedimentation rate in Banjir Kanal Timur Semarang coastal waters (Figure 1).

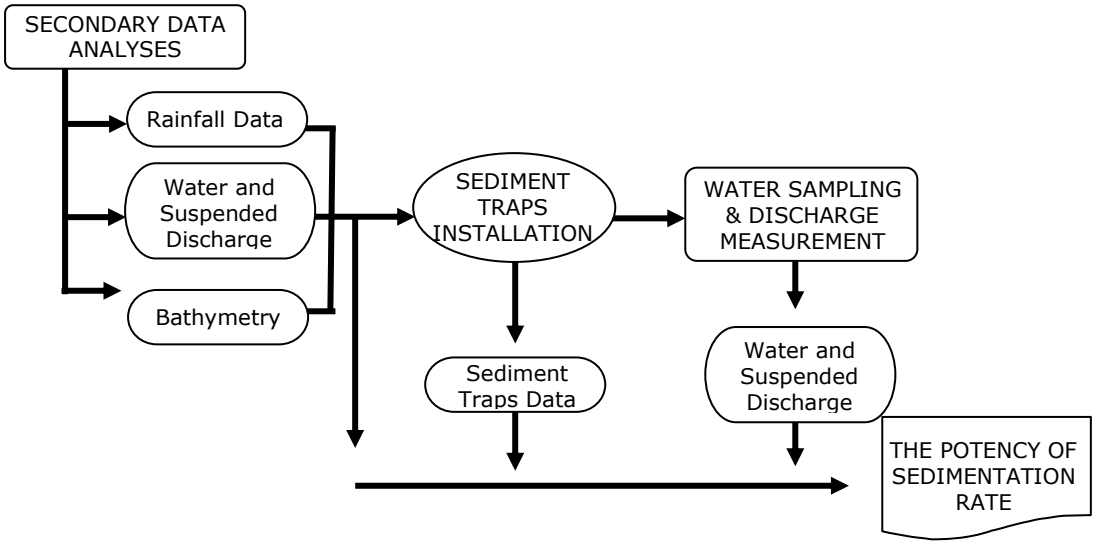

Fig. 1. Flowchart of determination of the potency of sedimentation rate

- Secondary data analyses
  Rainfall data (1977 –1997) of Maritime Meteorology Station in Semarang were analyzed to determine the duration of seasons in Semarang. The correlation of rainfall data and Banjir Kanal Timur discharge was determined using the monthly data of 1980 to 1997. Discharge data of Banjir Kanal Timur Semarang were recorded at Pucanggading check dam. Base on the water and suspended discharge at Pucanggading check dam in 1990 – 1991, the correlation of water discharge and suspended discharge was determined. The bathymetry data of February 1998 survey were used to determine the position of sediment trap station. The station positions were designed to cover the study area.

- Sediment trap installation
  Five sediment traps were installed in Banjir Kanal Timur Semarang coastal waters (Figure 2) for 30 days (20 Oct. to 19 Nov. 1999). Tripods were installed at the positions that had been determined based on the bathymetry map of the study area. As a marker of station and to protect the sediment traps, the top part of the tripod (about 1.5 m) was placed be on the surface of waters during the high tide. After the condition of suspended sediment in water became in natural condition, the sediment traps were installed at 50 cm from the bottom at the center of the tripods using SCUBA gears. Weekly monitoring was done to check the conditions of each station.

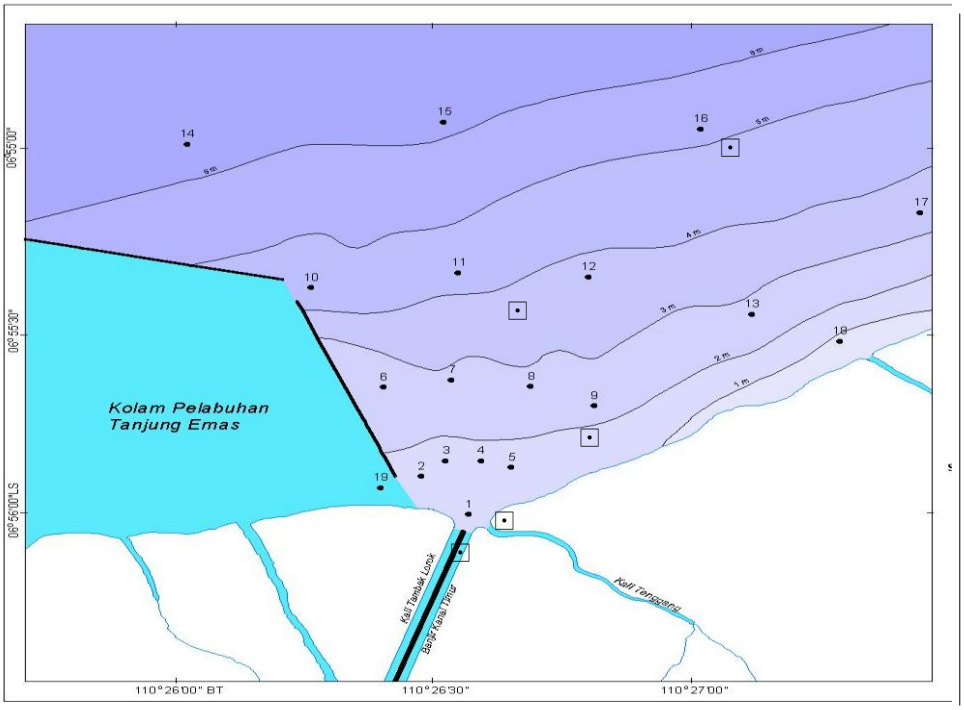

Fig. 2 The bathymetry of Banjir Kanal Timur Semarang costal waters (in meter), and ⊡ is the position of sediment traps (S-2, S-3, S-8, S-11, and S-16).

- Water sampling and discharge measurement
  Water sampling and discharge measurement were done in the station of Banjir Kanal Timur that was not effected by seawater. The water sample was used for analyzing the total suspended solid (TSS) on a dry-weight basis (Caphra 1997).

- Sedimentation rate analysis
  Based on the volume of sediments trapped in each tube of one sediment trap, basically the potency of sedimentation rate can be determined using the formula as follows (after English *et al.* 1994):

$$r_s = \sum_{1}^{n}\left(\frac{V_{st}}{\pi.r^2} \times \frac{1}{t}\right) \times \frac{1}{n} \qquad (1)$$

Where: r_s = potency of sedimentation rate (cm/month)
V_{st} = Volume of sediment trapped (cm^3)
r = ½ diameter of sediment trap (cm)
t = duration of measurement (month)
n = number of tubes

The potency of sedimentation rate of the study area is the average of r_s of total sediment traps.

RESULTS AND DISCUSSION

Based on sediment trap data and using formula (1), the potency of sedimentation rate at Banjir Kanal Timur Semarang coastal waters was 6.10 cm/month (Table 1). The result did not reflect the field condition, because there were no indications in the field that the sedimentation was that high (6.10 cm/month).

Table 1. The Potency of Sedimentation Rate at Banjir Kanal Timur Semarang Coastal Waters During the Transition of Dry season to Rainy Season (Oct.-Nov. 1999).

No. ST	Station Position	Volume ST (cm^3)			The Potency of Sedimentation Rate (cm/30 days)			
		a	b	c	a	b	c	r_s
1	S-2	202	192	212	6.1	5.8	6.4	6.1
2	S-3	232	245	248	7.0	7.4	7.5	7.3
3	S-8	159	172	162	4.8	5.2	4.9	5.0
4	S-11	na	na	na	-	-	-	-
5	S-16	na	na	na	-	-	-	-
						Average		6.1

Note: ST = Sediment Trap
na = not available (ST 4 and ST 5 were lost in the second week of measurement)

The study area is shallow water (< 7 m) and the bottom was covered by fine sand to clay sediments. The height of significant wave ($H_{1/3}$) during the transition of dry season to rainy season in the study area was 1.32 m (Bachtiar 2002). Waves at certain depth of waters would be broken and caused alongshore currents. The orbital of waves and total currents would affect the bottom sediments and caused resuspended sediments. Beside that, the activities of fishermen to catch the shrimp and clamp by using a traditional dredge are very active in this area, and also affect the process of resuspended sediment. The natural process (waves and currents) and fishermen activities caused the high volume sediment trapped in the sediment traps. Based on those facts, the data of sediment traps should be corrected by calculating the input of suspended sediments and the area of sediment distribution in coastal area. To make that correction, we have to know the input of suspended sediment to the Banjir Kanal Timur Semarang coastal waters during the measurement and the area of sediment distribution in coastal waters.

Based on the results of rainfall data analyses of Maritime Meteorology Station in Semarang (1977-1997), the duration of each season in Semarang coastal region could be determined and were listed on Table 2. According to those results, this preliminary study was done on transition of dry season to rainy season, where the average of season rainfall was 180.8 mm. It is clear that the result of this preliminary study is only a part of the whole season in one year. To better understand of the potency of sedimentation rate, it is necessary to do measurement: (1) on January-February for rainy season, (2) on April-May for transition of rainy to dry season, and (3) on July-August for dry season.

Table 2. Duration of each season in Semarang coastal region based on the rainfall data of Maritime Meteorology Station (1977-1997)

Season	Month	Monthly Rainfall (mm)	Season Rainfall (mm)
Rainy season	December	294.4	336.5
	January	443.7	
	February	315.0	
	March	293.1	
Transition of Rainy season to	April	260.7	207.5
Dry season	May	154.3	
Dry season	June	80.3	69.6
	July	65.4	
	Augustus	48.5	
	September	84.1	
Transition of Dry season to	October	121.3	180.8
Rainy season	November	240.4	

The further analyses of water and suspended discharges were based on the condition of transition of dry season to rainy season, October to November. There are three streams, Banjir Kanal Timur (BKT), Kali Tambak Lorok (KTL), and Kali Tenggang (KT), which come into the Banjir Kanal Timur Semarang coastal waters together through the same river's mouth, and Banjir Kanal Timur is the main stream. Some data of Banjir Kanal Timur discharge during 1980-1997 were blank. To fill up those data, firstly the correlation of rainfall data and the discharge of Banjir Kanal Timur was determined by using monthly rainfall data of Maritime Meteorology Station and discharge of Banjir Kanal Timur Semarang (Pucanggading check dam) for the duration of 1980-1991. The correlation equation of rainfall data and the discharge of Banjir Kanal Timur Semarang during 1980-1997 was shown on Figure 3.

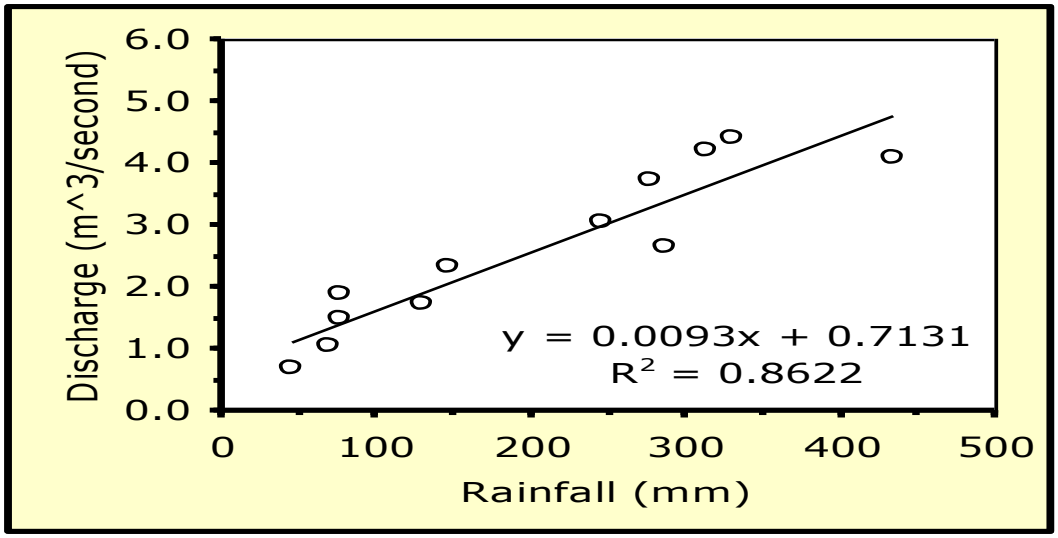

Fig. 3 Correlation of rainfall data and discharge of Banjir Kanal Timur Semarang (Pucanggading check dam), based on monthly data from 1980 to 1997.

The average discharge of Banjir Kanal Timur used to analyze the potency of sedimentation rate was the average of five years monthly data (1993-1997) of October and November. Based on that data, the average discharge of Banjir Kanal Timur Semarang was 0.91 m^3/second on October, and 1.46 m^3/second on November. Therefore the average discharge of Banjir Kanal Timur during the measurement of sedimentation rate was 1.18 m^3/second. To know the suspended discharge of Banjir Kanal Timur for the duration of October to November, the correlation of water discharge and suspended discharge was determined by using the data of Pucanggading check dam on 1990 to 1991 (Supputra 1993). The correlation equation of water discharge and suspended discharge of Banjir Kanal Timur Semarang was shown in Figure 4.

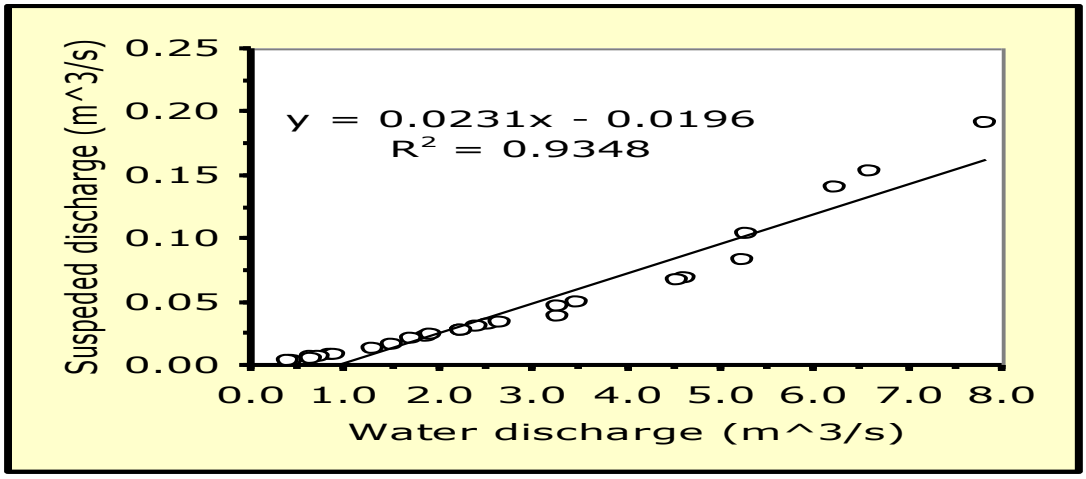

Fig. 4. Correlation of water discharge and suspended discharge of Banjir Kanal Timur Semarang, based on data of 1990-1991 (Supputra 1993).

Based on that correlation the suspended discharge could be determined by using the formula as follows:

$$Qs = 0.0231\ Qw - 0.0196 \quad (2)$$

Where: Qs = suspended discharge (m^3/second)
Qw = water discharge (m^3/second)

According to formula (2), the suspended input from Banjir Kanal Timur Semarang during the measurement was 19,854.7 m^3. If suspended input of Kali Tambak Lorok and Kali Tenggang was assumed as 25% of suspended input of Banjir Kanal Timur, therefore the total suspended input to Banjir Kanal Timur Semarang coastal waters was 24,818.4 m^3. The area of study site was about 14 km^2. If the input of suspended sediments was deposited on the average 50 % of total study site (7 km^2), as a result the potency of sedimentation rate was 0.35 cm/month.

Supputra (1993) in his study on sedimentation at Tanjung Emas Harbour Semarang using the time series data of bathymetry found that the potency of sedimentation rate at Tanjung Emas Harbour Semarang was 0.65 cm/month. This rate was almost double of Banjir Kanal Timur sedimentation rate. This condition may be affected by: (1) the condition of water at Tanjung Emas Harbour Semarang is more calm compared

to the condition of water outside of the harbour, because of breakwater protection, and (2) the harbour received suspended input from both Banjir Kanal Timur and Banjir Kanal Barat.

Based on the different results of the potency of sedimentation rates (6.10 cm/month and 0.35 cm/month), it could be understood that resuspended sediment effected by natural process (waves and currents) and fishermen activities was dominant. Because the input of suspended sediments into Banjir Kanal Timur Semarang coastal waters caused the potency of sedimentation rate 0.35 cm/month, and the data of sediment traps were 6.10 cm/month, therefore the percentage effect of resuspended sediments to sediment traps data basically determined was about 94%. It means that the process of resuspended sediments in the study site is very active.

CONCLUSION

The results of this preliminary study show that: (1) the potency of sedimentation rate during the condition of transition of dry season to rainy season in Banjir Kanal Timur Semarang coastal waters was 0.35 cm/month, (2) it is very important to do field observation carefully to understand the condition of study site, that later will be very useful for interpreting the result of measurements, and (3) the process of resuspended sediment in the study site was very active that was affected by natural process (waves and currents) and fishermen activities.

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