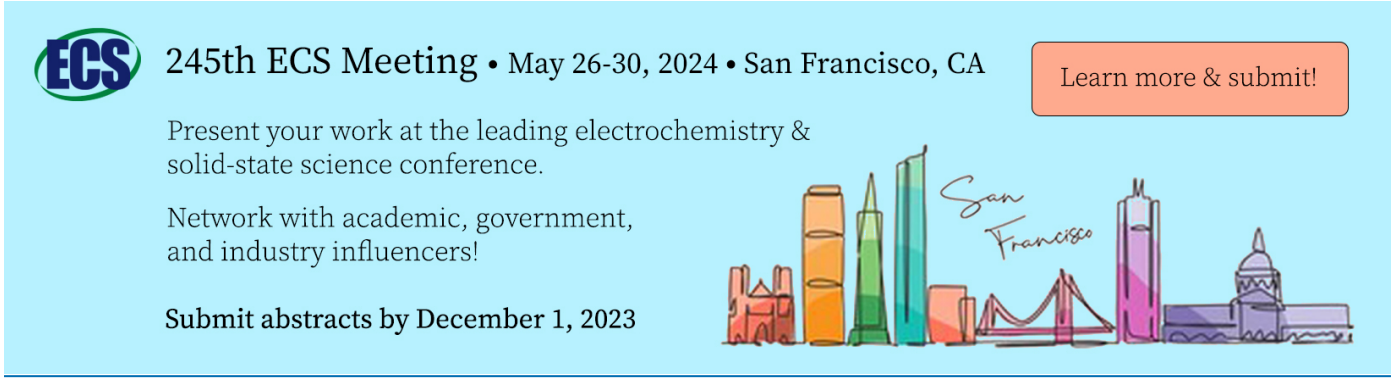
Changes in the spatial-temporal of the amount of sediment suspended in the Mekong Delta in Vietnam



Changes in the spatial-temporal of the amount of sediment suspended in the Mekong Delta in Vietnam

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Abstract

Sediment depletion in the Vietnamese Mekong Delta (VMD) has brought threats to riverbed and riverbank dynamics. The main objective of this research is to make a relationship between turbidity and suspended sediment concentration (SSCs) and to assess temporal-spatial variations of SSCs in the VMD. In this regard, the SSCs were measured and monitored along the Tien and Hau Rivers under the Japan-ASEAN Science, Technology, and Innovation Platform (JASTIP) project and Mekong River Commission (MRC). Particularly, we installed three monitoring stations in main rivers and conducted two field surveys to collect data for assessing SSC values in the VMD. The results show that the SSCs in the delta are changeable seasonally with high values in the high-flow season and low values in the low-flow season. The Tien and Hau Rivers can be divided into two reaches. The upper reach has high SSC, decreasing seaward, whereas the lower reach has lower SSC, increasing seaward.

1. Introduction

The Vietnamese Mekong Delta (VMD) is the third-largest delta worldwide, with flat topography and a dense network of rivers and channels. Recently, the VMD is suffered from riverbank erosion, high sea-level rise, and a poured sediment decrease of about 74% due to dam development [1]. Besides, sand mining contributes significantly to a decrease in the sediment budget of the VMD [2], reducing the sediment flux from the river to the sea. Declined sediment load in the delta has caused erosion of the coastlines and riverbank and incision of the riverbed [3]. Dams and sand mining may cause changes in the erosion processes. Although the

understanding of the flow regime and sediment load in the VMD, the understanding of spatial-temporal variations of the suspended sediment in the VMD is limited.

Previous research has been conducted to assess sediment dynamics, suspended sediment dynamics, impacts of dams and sediment budget. According to the case study in Vinh Long Province (in the VMD), the sediment load decreased about 30% from 2007 to 2008 due to riverbank erosion issues from natural processes and human activities [4]. In addition, sediment reduction in the VMD is caused by other drivers, especially the dam development in the Mekong River seems to reduce the supply source of sediment to the VMD, for example, the ratio of sediment reduction might make up 96% if building all planned dams [5]. However, the research relating to spatial-temporal variations of the SSCs is still limited in the VMD. Therefore, this study examines sediment dynamics in the VMD using the in-situ and historically measured data. The specific objectives are (1) establishing the relationship between turbidity and the suspended sediment concentration (SSC) and (2) examining spatiotemporal variations of the SSC in the delta.

2. Regional setting and method

The VMD is in the South of Vietnam with the total area of nearly 40.547,2 km^2 and its population accounts for 17 million dwellers having the living demands from agriculture (contributing to 18% GDP in Vietnam) [6]. For many thousand years, the VMD has been formed by the sediment deposition [7], and the sediment is considered as one of the crucial elements in shaping delta's topography. Therefore, it is essential to conduct research in suspended sediment to protect this delta structure and avoid negative impacts from sediment reduction. In the VMD, the Mekong River is split into two main river reaches, including Tien River (Mekong River) and the Hau River (Bassac River) before discharging to the sea, with a Vam Nao Channel to divert sediment from the Tien River to the Hau River. There are four monitoring stations located in the Tien and Hau Rivers, Tan Chau and My Thuan stations were installed in the Tien River, and the remaining stations of Chau Doc and Can Tho belong to the Hau River.

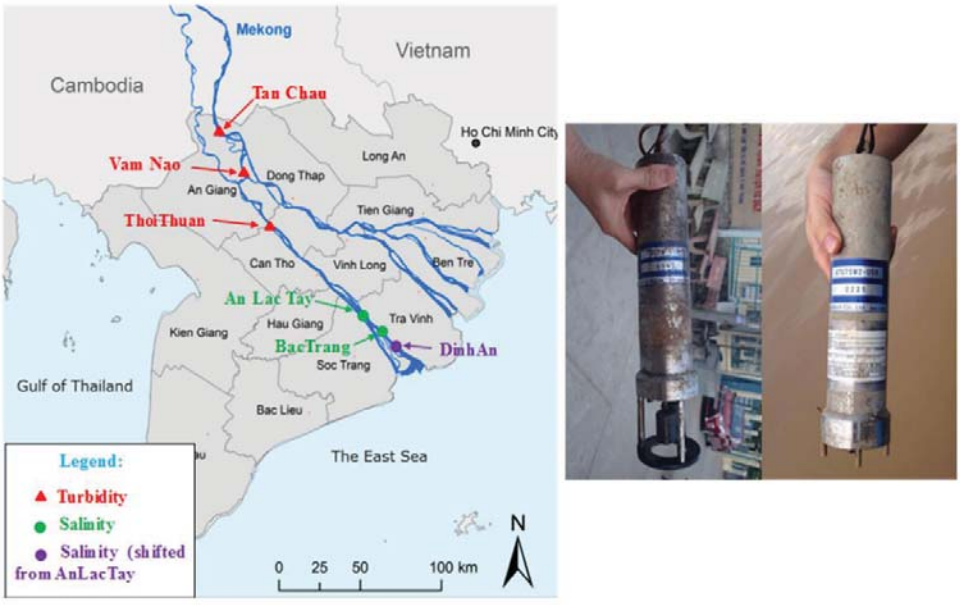

Figure 1. (a) Three SSC monitoring stations by JASTIP project. (b) Infinity Turbidity Meter used for SSC monitoring and field measurement.

To achieve the research objectives, we conducted two campaigns to install three stations that monitor turbidity in the VMD under the Japan-ASEAN Science, Technology, and Innovation Platform (JASTIP) project led by Kyoto University (Figure 1a). In the first campaign (February 26-28, 2016), we set up two stations at Tan Chau and Vam Nao to measure the turbidity using an Infinity-ATU75W2-USB turbidity meter (Figure 1b). In the second campaign (August 2017), we installed a turbidity station at Thot Not (about 20 km from the Can Tho City). The measurement interval at these three stations is 30 minutes. On the other hand, we conducted two field surveys in August 2017 (high-flow season) and March-April in 2018 to measure the SSCs, river bathymetry, and flow parameters. The measurement was conducted along nearly 600 km in the entire Tien and Hau Rivers and the Vam Nao diversion channel. The instrument used were an acoustic Dopper current profiler (ADCP) and an Infinity-ATU75W2-USB turbidity meter. In the second field survey, we also measured the vertical distribution of the SSCs and flow velocity using the Infinity turbidity and velocity meters, respectively. In addition, SSC values under the MRC Program have been monitored yearly by the Vietnamese National for Hydro-meteorological Data. Therefore, the data source is not good for assessing tidal effects on sediment dynamic. From this, we installed additional hydrology monitoring stations to check the reliability of annual existing data from available source of the Vietnamese National for Hydro-meteorological Data.

3. Results and discussions

3.1 Relationship between turbidity and suspended sediment concentration

The samples of suspended sediment were collected at 1 m below the water surface at My Thuan and Mang Thit which are located about 100 and 65 km from the river mouth of the Tien River, respectively. We determined the grain size distribution by using Shimadzu SALD-2300 Laser Diffraction Particle Size Analyzer to measure particle size between 17 nm and 2,500 μm. The results show that the suspended sediment diameters are 12.6 μm at My Thuan and 6.1 μm at Mang Thit. Approximately 95% of the suspended sediment is composed of silt and clay.

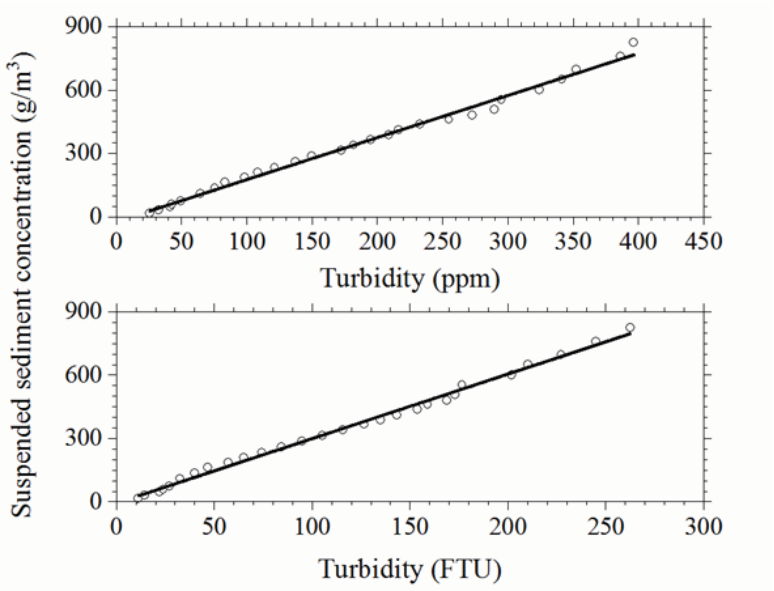

Figure 2. The relationship of turbidity and SSC.

The data measured in the field campaigns are the turbidity with units of ppm and FTU. To synchronize with collected SSC data (unit is g/m^3); we converted the turbidity to SSCs. To form a relationship between the turbidity and SSC, we collected samples during the field surveys, and then analysed them in the laboratory. In Figure 2, the relationships between turbidity and SSC are in the forms of linear correlation shown in equations (1) and (2) with the coefficient of determinations (R^2) of 0.9925 and 0.9945, respectively.

$$SSC\ (g/m^3) = 1.9922 \times Turbidity\ (ppm) - 23.981 \quad (1)$$

$$SSC\ (g/m^3) = 3.0572 \times Turbidity\ (FTU) - 6.8179 \quad (2)$$

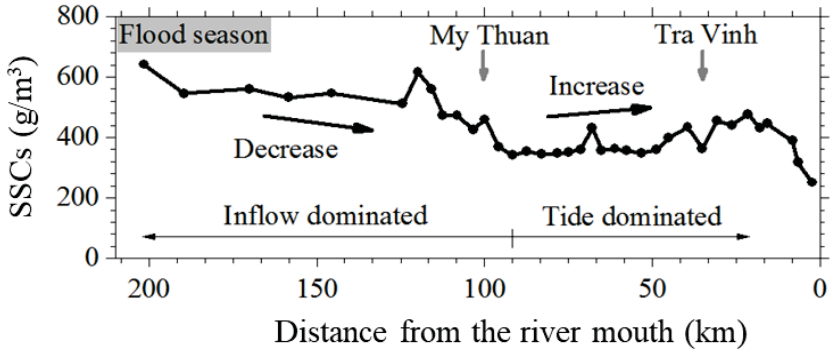

Figure 3. Longitudinal SSC variations in the Tien River in the high-flow season in August 2017.

3.2 Temporal and spatial variations of SSCs

In the VMD, the SSCs is changeable; it is usually high in the high-flow season and low in the low-flow season. At Tan Chau in the Tien River, the recorded SSCs got the highest value of 1,300 g/m^3, and its range was from 5 to 70 g/m^3 in the low-flow season (in March-April 2018). However, in the regions of the turbidity maximum, the SSCs were relatively similar in both high-flow and low-flow seasons. For example, the SSC at Tra Vinh (in the Tien River) was 364 g/m^3 (in August 2017) and 295 g/m^3 (in April 2018).

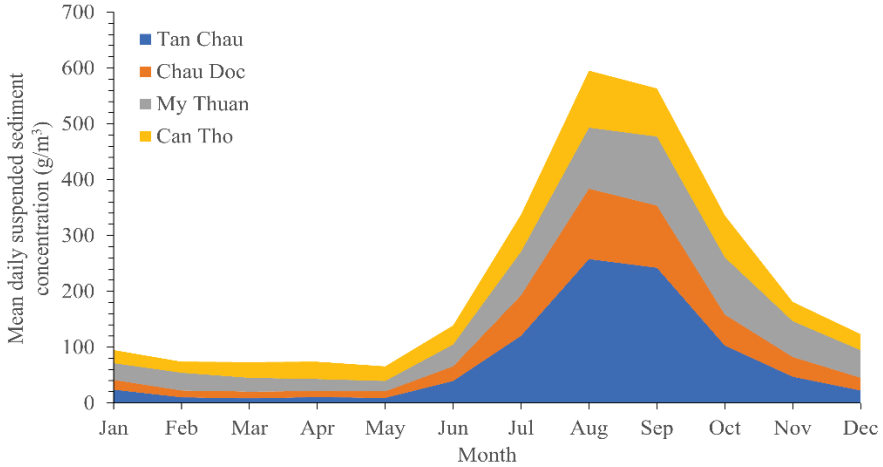

Figure 4. Mean daily SSCs at Tan Chau, Chau Doc, My Thuan and Can Tho from 2012 to 2015.

In the high-flow season, the SSCs in the Tien River were high from Tan Chau to My Thuan and decreased seaward, while they were low from My Thuan to the river mouth and decreased seaward. Similarly, the SSCs in the Hau River were high upstream of Can Tho and decreased seaward, while they were low from Can Tho to the river mouth and increased seaward (Figure 3). The daily SSC values at four stations remained below 100 g/m^3 and were high from August to October (Figure 4). In August, the highest SSC values were 258 g/m^3 at Tan Chau station, followed by 126 g/m^3 at Chau Doc station, and 102 g/m^3 at Can Tho station. After October, SSCs at four stations had a gradually decrease trend, and the SSC values declined to under 64 g/m^3.

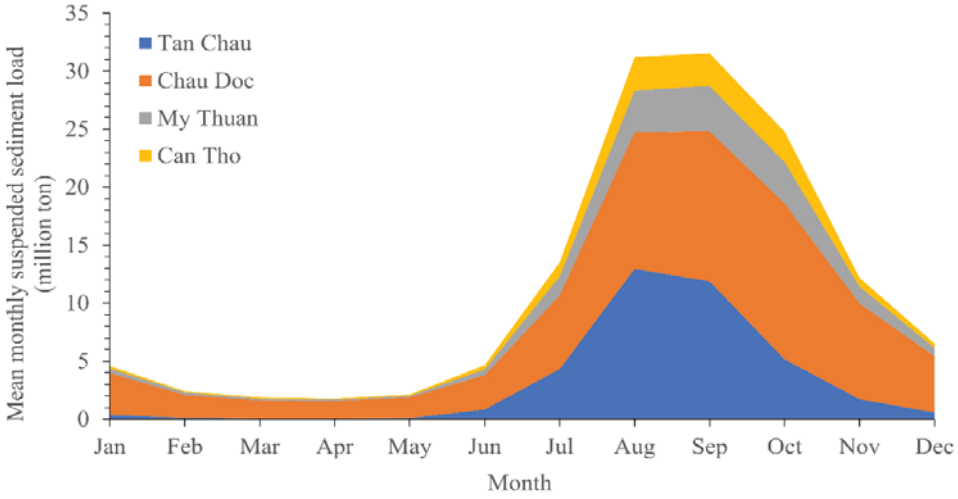

Figure 5. Mean monthly suspended sediment load at Tan Chau, Chau Doc, My Thuan, and Can Tho from 2012 to 2015.

In term of mean monthly suspended sediment load (SSL), the SSL values at Chau Doc station were highest with the range from 1.49 to 3.60 million tons during January-May, while those at three remaining stations were under 0.38 million tons at the same time (Figure 5). However, SSL at Tan Chau station was the highest level of 12.97 million tons in August and declined remarkably to 0.57 million tons in December. Followed by SSLs at Chau Doc station, those values were high from 11.77 million tons to 13.43 million tons between August and October. At both My Thuan and Can Tho stations, the SSL values were similar, with the peak of 3.92 million tons in September at My Thuan station, and 2.87 million tons in August at Can Tho station.

4. Conclusion

To clearly show the relationship of turbidity and SSCs, we collected and analysed samples in the laboratory, and then conducted to convert the turbidity into SSCs. As a result, approximately 95% of the suspended sediment includes silt and clay, and the suspended sediment diameter is 12.6 μm and 6.1 μm at My Thuan and Mang Thit respectively.

The sediment dynamics in the Tien and Hau Rivers are changeable reasonably. The SSCs are high in the high-flow season and low in the low-flow season. The VMD's main rivers can be divided into two reaches: upper and lower. In the flood season, the upper reach has high SSC, decreasing seaward, while the lower reach has lower SSC, increasing seaward.

The SSCs were highest from August to October from 2012 to 2015, those values are seasonally changeable. It is estimated that the highest value was 1,300 g/m^3 in high-flow season, and the range from 5

to 70 g/m^3 in the low-flow season. Besides, the highest values of daily SSCs were highest at the same time of SSCs. In term of SSL values, those were high during August-October, the lowest values between January and May, and had the decrease trend in the December.

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