UDC 631.459.6
DOI: 10.18799/24131830/2024/11/4529

Monsoonal effect on sediment grain distribution along the subaqueous Mekong Delta coastal, Vietnam

N.C. Thanh[1,2], D.T. An[1,2]✉

[1] University of Science, HCM City, Viet Nam
[2] Viet Nam National University, HCM City, Viet Nam

✉dtan@hcmus.edu.vn

Abstract. ***Relevance.*** Annually, the coastal areas of the Mekong Delta receive approximately 50% of the total sediment load from the Mekong River, primarily during the southwest monsoon. During the northeast monsoon, this coastal sediment undergoes reworking and is transported southwestward along the coastal areas of the Mekong delta. ***Aim.*** Analyzing the grain-size distribution of sea-bed surface sediment helps improve our understanding of sediment redistribution along the coastal areas of the Mekong Delta. ***Methods.*** In order to illustrate changes in sea-bed surface sediment grain size between the two monsoons, we focused on the median grain size, a widely used parameter for sediment transport calculation, and created spatial maps of median grain size along the coastal areas of the Mekong Delta. The analysis was based on sediment samples collected along the coastal areas of the Mekong Delta during field excursions in the southwest and northeast seasons. ***Results.*** The results reveal that median grain size during northeast (mainly ranging from 0.005 to 0.01 mm) are larger than those during southwest (primarily ranging from 0.01 to 0.05 mm). These changes in median grain size and spatial distributions are most prominent along the east coast, specifically from Soc Trang to Bac Lieu. In contrast, median grain size along the west side does not exhibit significant differences between the southwest and northeast monsoons. These observations imply a more significant sediment transport along the east coastal areas of the Mekong Delta during the northeast monsoon and provide evidence for the transportation of sediment from the east coast to the west coast during the monsoons.

Keywords: coastal processes, median grain size, Mekong Delta, seabed grain-size, sediment transport

Acknowledgements: This research is funded by the University of Science, VNU-HCM under grant number T2023-14 project entitled “Distribution of seabed surface sediment sizes along the coastal areas of the Mekong Delta under the influence of seasonal features”. The authors express their sincere thanks to the anonymous reviewers for their comments, which helped improve this draft.

For citation: Nguyen Cong Thanh, Dang Truong An. Monsoonal effect on sediment grain distribution along the subaqueous Mekong Delta coastal, Vietnam. *Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering*, 2024, vol. 335, no. 11, pp. 104–111. DOI: 10.18799/24131830/2024/11/4529

УДК 631.459.6
DOI: 10.18799/24131830/2024/11/4529

Влияние муссона на распределение зерна отложений вдоль подводного побережья дельты Меконга, Вьетнам

Н.К. Тхань[1,2], Д.Ч. Ан[1,2]✉

[1] Университет науки, Хошимин, Вьетнам
[2] Национальный университет Вьетнама, Хошимин, Вьетнам

✉dtan@hcmus.edu.vn

Аннотация. Каждый год прибрежный регион дельты Меконга получает около 50 % от общего объема наносов из реки Меконг, которые в основном концентрируются в сезон юго-западных ветров. Во время сезона северо-восточных муссонов эти прибрежные отложения подвергаются эрозии и переносятся в юго-западном направлении вдоль побережья дельты Меконга. Анализ распределения частиц донных отложений по размерам на поверхности морского дна помогает лучше понять перераспределение донных отложений по прибрежному региону дельты Меконга. Чтобы проиллюстрировать изменения размера частиц наносов на поверхности морского дна между сезонами юго-западных и северо-восточных ветров, мы сосредоточились на анализе среднего размера частиц наносов. Этот параметр широко используется для расчета переноса наносов и составления карт распределения среднего размера частиц наносов по прибрежному региону дельты Меконга. Анализ основан на образцах донных отложений, собранных вдоль прибрежного региона дельты Меконга во время полевых исследований в сезоны юго-западных и северо-восточных муссонов. Результаты показали, что средний размер частиц в сезон северо-восточных ветров (от 0,005 до 0,01 мм) был больше, чем в сезон юго-западных ветров (от 0,01 до 0,05 мм). Изменения в среднем размере частиц и их пространственном распределении более выражены вдоль восточного побережья, особенно от Сок Транга до Баклиу. В то же время средний размер частиц вдоль Западного побережья практически не различается между сезонами. Эти наблюдения указывают на более значительный перенос наносов вдоль восточного побережья во время северо-восточного муссона и предоставляют доказательства переноса наносов с восточного побережья на западное во время муссонных сезонов.

Ключевые слова: прибрежные процессы, средний размер зерен, дельта Меконга, размер зерен морского дна, перенос наносов

Благодарности: Исследование финансируется Научным университетом ВНУ-ХКМ в рамках гранта № T2023-14 по проекту «Распределение размеров донных отложений вдоль прибрежных районов дельты Меконга под влиянием сезонных особенностей». Авторы выражают искреннюю благодарность анонимным рецензентам за их полезные комментарии, которые помогли нам улучшить этот проект.

Для цитирования: Нгуен Конг Тхань, Данг Чыонг Ан. Влияние муссона на распределение зерна отложений вдоль подводного побережья дельты Меконга, Вьетнам // Известия томского политехнического университета. Инжиниринг георесурсов. – 2024. – Т. 335. – № 11. – С. 104–111. DOI: 10.18799/24131830/2024/11/4529

Introduction

The Mekong Basin is globally recognized as one of the largest deltas, with an annual sediment discharge of approximately 160 Mt [1–4]. A significant portion, accounting for more than 50% of this sediment load, is transported to the Vietnamese Mekong Delta [2, 4–6]. Presently, coastal areas of the Mekong Delta (CAMD) are confronted with severe challenges, including coastal erosion and mangrove degradation [1, 5], primarily due to the combined effects of climate change and unsustainable anthropogenic activities [1, 6–10]. These issues primarily stem from rising relative sea levels and a shortage of sediment supply from the upper of the Mekong River to the coastal regions [2, 5]. In recent years, the effects of climate change combined with unsustainable anthropogenic activities in the Mekong has led to a concerning decline in the transport of alluvial sediment from the upstream to the downstream of the Mekong River [11–13]. This decline has become particularly noticeable since the 1990s when hydropower dams were constructed along the main branches of the Mekong River [12, 14]. Research conducted by the authors in [3] estimated a suspended sediment discharge of only 87.4 Mt/yr at the Kratie cross-section. This finding indicates a significant reduction in sediment supply to the downstream areas, including the coastal regions. Additionally, [15] identified a downward trend of 5% per year in suspended sediment from 2003 to 2012, further highlighting the decrease in sediment reaching the coastal areas.

Numerous studies have highlighted the significant reduction in sediment supply to the Vietnamese Mekong Delta, attributing this phenomenon to dams' location of the Mekong River upstream [12] as well as sediment mining activities in the Mekong River downstream [12, 16]. In the study investigating the effects of climate change and upstream hydropower dams on the Mekong Delta, [12] reported that during the flood season period (September–November), approximately 48 to 60% of sediment discharge from the Mekong River upstream will flow downstream of the Vietnamese Mekong Delta. These sediment budgets typically accumulate along the estuaries of the CADC during the prevailing stage of the northeast (NE) monsoon [2, 12]. P. Marchesiello et al. [17] conducted a study focusing on the impact of hydrodynamic factors on sediment redistribution. Their findings revealed that sediment transport primarily occurs from the eastern to western sides of the CAMD. These sediment transports play a significant role in shaping the surficial grain-size distribution (GSD) between the southwest (SW) and northwest (NW) seasons. Understanding the relationship between hydrodynamic factors and sediment transport is crucial in gaining insights into the GSD of sea-bed surface sediment (SSS). This knowledge contributes to a better understanding of erosion and deposition along the CAMD [1, 9].

Several studies have focused on analyzing the GSD of surficial sediment along the CAMD, primarily through the collection of sediment samples during various field surveys [2, 7, 13]. For example, [7] conducted field surveys in 2007 and 2008 and used collected sediment samples to establish distribution maps of surficial sediment from the Bassac River estuary in the East Sea to the West Sea. Building upon the sediment data collected by [8, 13] further analyzed the data to establish the GSD maps of SSS across the CAMD. Additionally, [11] conducted field surveys between 2014 and 2015, utilizing seismic profiles and collected sediment samples to investigate the degradation and aggradation of the seabed along the CAMD.

However, the aforementioned studies have not specifically addressed the changes in GSD of the seabed surface sediment along the CAMD in response to seasonal variations. The objective of this study, therefore, is to fill this research gap by mapping the distribution of median grain size along the CAMD during the SW and NE seasons.

Materials and methods

Materials

In this study, sediment grab samples were obtained from multiple locations along the CAMD (Fig. 1). Two field investigations were conducted, corresponding to the period of highest discharge from the Mekong River to the East Sea at the end of the SW monsoon in October 2016 and the NE monsoon between February and March 2017. A total of 183 sediment samples were collected across 49 transects, encompassing a range of water depths from 1.2 to 25.0 m. The coastal hydrodynamic processes in the study area are affected not only by the peak discharge occurring from September to November but also by seasonal variations in wind, wave, and water levels due to tidal fluctuations, which differ between the eastern and western sides of the Mekong Delta.

The NE monsoon typically occurs from November to March, characterized by prevailing wind and wave directions from the NE or east. On the other hand, the SW monsoon occurs from May to September, resulting in wind and wave directions primarily from the SW [2, 7]. During the NE and SW seasons, wave generation patterns and coastal currents affected by waves exhibit variations, leading to a reversal of sediment transport directions between the eastern and western sides of the CAMD [13, 18]. Nevertheless, when considering the annual time scale, a larger amount of sediment is transported from the eastern side to the western side of the CAMD [13, 17].

Methods

The grain-size data utilized in this study were obtained from the LMDCZ projects (2018). Sediment samples were analyzed to determine the median grain size, classified according to the Vietnam national standard (TCVN4198:2014) [19] (Table 1). The examination of median grain size involved initial sieving to capture particle sizes ranging from very fine sand to coarser grains. Subsequently, the remaining samples were placed in settling tubes to measure particle sizes ranging from silt to clay using hydrometers. The median grain size values, representing the median grain size in the sediment samples GSD, were determined. These median grain size values were then used to generate spatial distribution maps of median grain size using the QGIS software.

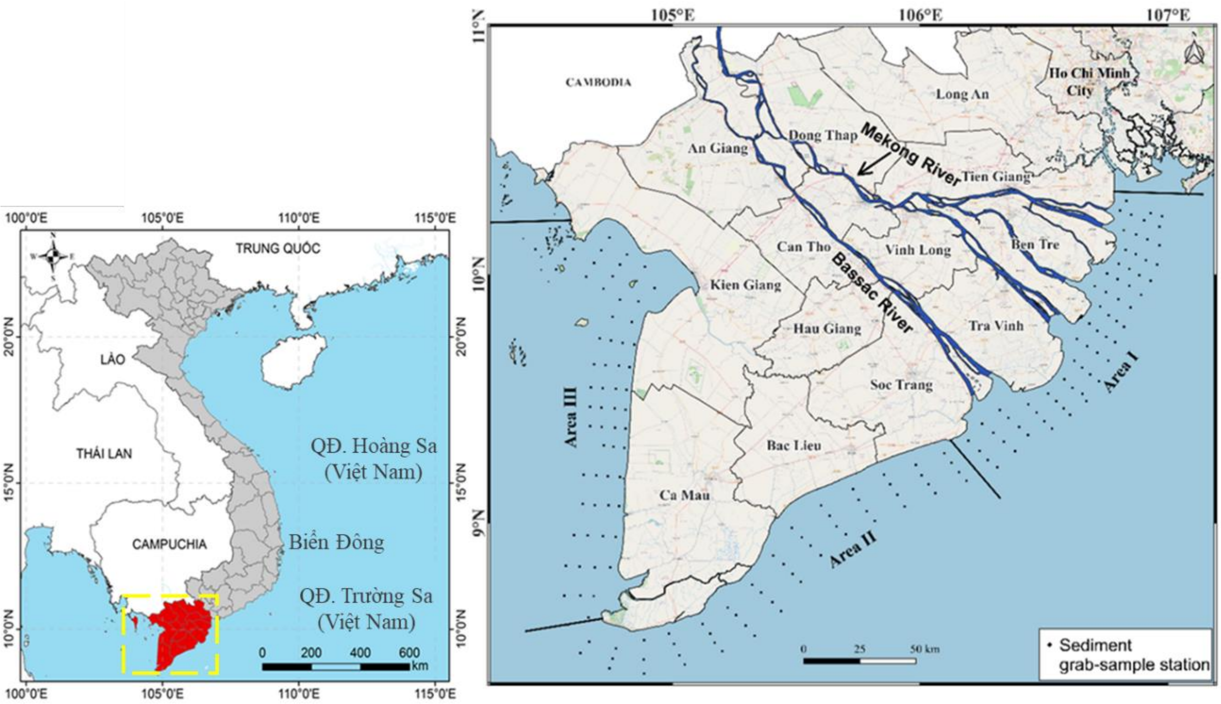

Fig. 1. Map of the study area and location of collected sediment samples
Рис. 1. Карта района исследований и расположение собранных проб отложений

Results and discussion

Spatial distribution of median grain size in the southwest monsoon

The findings from the analysis of the GSD of SSS representing the SW and NE monsoons are visually presented in Fig. 2, 3, and Table 2. Table 2 provides frequency distribution of median grain size values which are categorized into three areas: Area I (river mouths), Area II (along the east coast of the Mekong Delta towards Cape of Ca Mau), and Area III (west coast of the Mekong Delta) in SW and NE monsoons. The results pointed out that, out of the 183 samples analyzed, only two contained gravels, indicating a predominance of fine grains in the SSS along the subaqueous Mekong Delta.

During the SW monsoon in October 2016, the size range of 0.005 to 0.250 mm exhibited notable variations across different areas, as illustrated in Fig. 2 and detailed in Table 2. The I area (river mouths) displayed a higher frequency distribution of fine grains (0.10–0.25 mm), reaching up to 38.8%. In contrast, the II area (eastern side of the Mekong Delta) and the III area (western side of the Mekong Delta) had frequency distributions of approximately 5.7 and 4.5%, respectively (Table 2). These findings confirm the presence of sediment particles throughout the study area, with fine grains (0.10–0.25 mm) being the dominant particle type.

Table 1. *Sediment types classified following the TCVN 4198:2014*

Таблица 1. *Типы отложений, классифицированные в соответствии с TCVN 4198:2014*

Sediment type Тип осадка		Grain size (mm) Размер зерна (мм)
Gravel/гравий	coarse крупное зерно	25.4–20.0
	medium среднее зерно	20.0–10.0
	fine мелкое зерно	10.0–5.0
	very fine очень мелкое зерно	5.0–2.0
Sand/песок	coarse крупное зерно	2.0–0.5
	medium среднее зерно	0.5–0.25
	fine мелкое зерно	0.25–0.1
	very fine очень мелкое зерно	0.10–0.05
Silt/ил	coarse крупное зерно	0.05–0.01
	fine	0.01–0.005
Clay/глина	мелкое зерно	<0.005

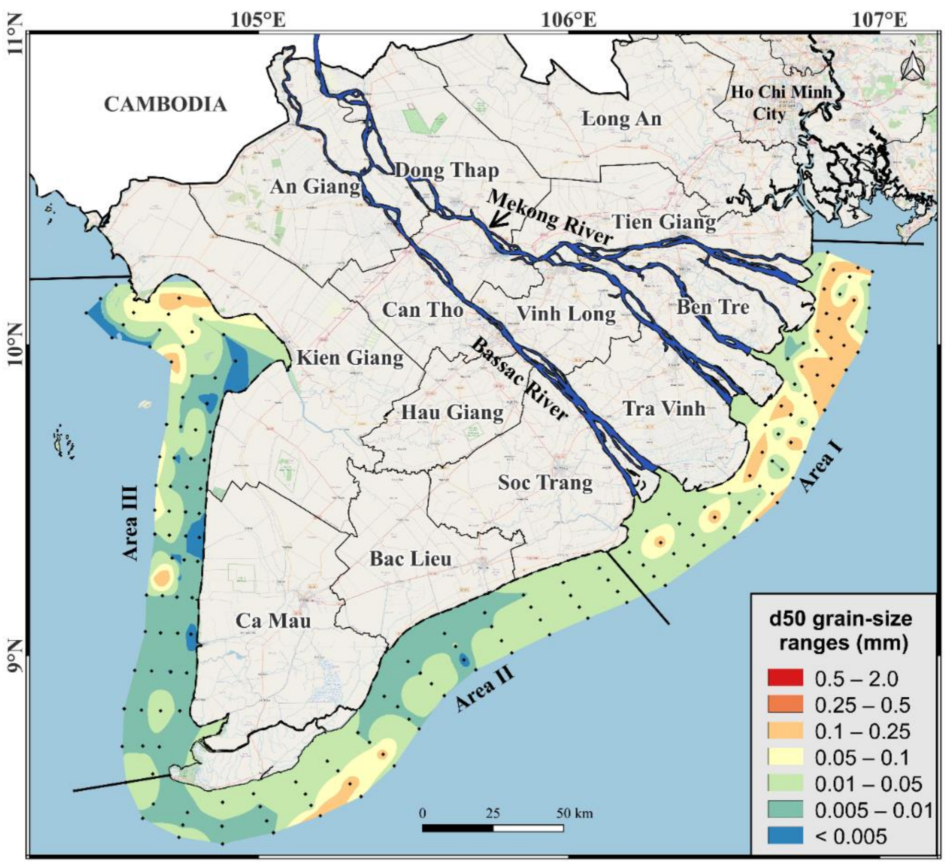

Fig. 2. *Map of spatial distribution of median grain size ranges in SW season*

Рис. 2. *Карта пространственного распределения средних диапазонов размеров зерен в сезон юго-западных ветров*

Table 2. *Frequency distribution of median grain size values analyzed across the CAMD*

Таблица 2. *Частотное распределение средних значений размера зерна, проанализированных по CAMD*

Size range (mm) Диапазон размеров (мм)	Frequency distribution (%) Частотное распределение (%)					
	Southwest monsoon Юго-западный муссон			Northeast monsoon Северо-восточный муссон		
	Area I	Area II	Area III	Area I	Area II	Area III
0.5–2.0	0.0	0.0	0.0	0.0	1.9	0.0
0.25–0.5	0.0	0.0	0.0	0.0	0.0	1.6
0.1–0.25	38.8	5.7	4.5	52.2	9.6	6.3
0.05–0.1	13.4	1.9	9.1	10.4	9.6	4.7
0.01–0.05	20.9	37.7	7.6	17.9	46.2	20.3
0.005–0.01	22.4	52.8	59.1	17.9	30.8	39.1
<0.005	4.5	1.9	19.7	1.5	1.9	28.1

Spatial distribution of median grain size in the northeast monsoon

Similar findings were obtained from the analysis of the GSD of the SSS during the NE monsoon (February–March 2017). The results demonstrated that fine grains, ranging in size from 0.005 to 0.25 mm, dominated the sediment composition. Notably, Area I exhibited a substantial frequency distribution percentage of up to 52.2%, indicating a prevalence of fine grains. In the river mouths (Area I), it is observed that the median grain size values of fine grains are primarily concentrated near the mouths of the Mekong River branch along the coast from Tien Giang to Tra Vinh, as well as in the vicinity of the Bassac river mouth. Conversely, in the offshore areas of this region, the median grain size values of coarser grains predominantly fall within the size ranges of 0.1–0.25 and 0.05–0.10 mm (Table 2, Fig. 3).

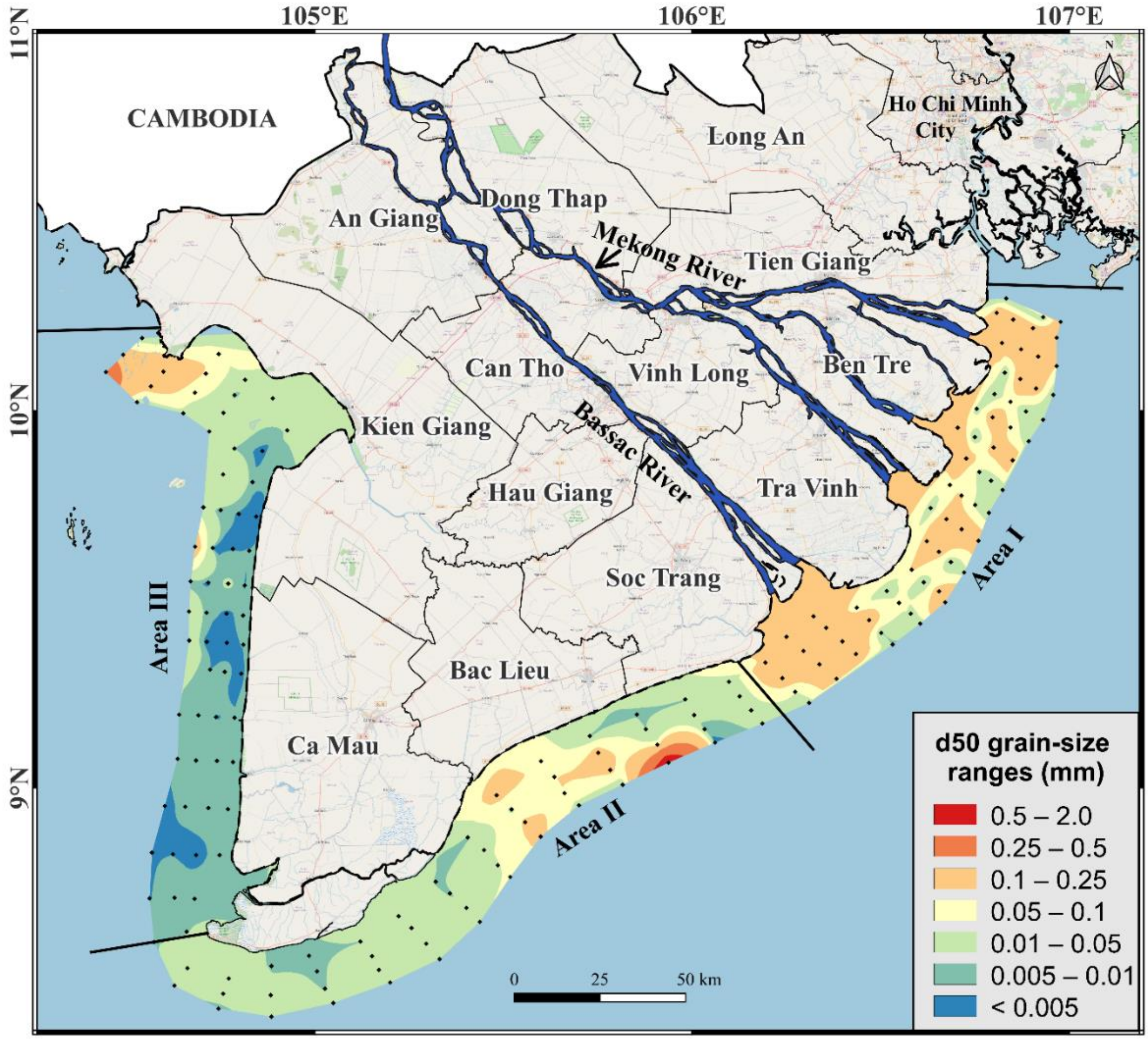

Fig. 3. *Map of spatial distribution of grain size ranges in NE season*

Рис. 3. *Карта пространственного распределения диапазонов размеров зерен в северо-восточном сезоне*

In the Bassac river mouth region (Area I) and along the coast of Soc Trang (Area II), the median grain size values primarily consist of coarse silt grains (0.01–0.05 mm). On the other hand, along the coast of Bac Lieu and Ca Mau in Area II, the median grain size values are predominantly within the size range of 0.01–0.05 to 0.005–0.01 mm. Conversely, Area II and Area III accounted for approximately 9.6 and 6.3%, respectively (Table 2). Moreover, the NE monsoon analysis revealed that only 2 out of the 183 collected samples contained medium grain sizes within the range (0.25–0.5 mm) and coarse grain sizes (0.5–2.0 mm), with a relatively low frequency distribution of 1.9 and 1.6% respectively (Table 2). The transition from the SW to the NE season maybe resulted in notable changes in the grain composition, particularly in Area I and Area II. These changes pointed out a shift towards coarser grain components, suggesting the removal of fine grains during the NE season. It is possible that these fine grains were transported to the western side of the CAMD (Area III), where the composition of very fine grains exhibited a noticeable increase during the NE season (Fig. 3).

The spatial distribution observed during the SW season implies that the deposition of fine-sized grains, possibly delivered from the Mekong River, predominantly occurs near the mouths of the Mekong River branches. Specifically, significant deposition is observed in the Bassac river mouth and along the Soc Trang coast, indicating that the finest-sized grains are primarily transported through the Bassac river branch. In general, the median grain size values of SSS in Area II vary from 0.01–0.05 to 0.005–0.01 mm. In Area III, along the west coast of the CAMD, the grain size ranges between 0.005–0.01 mm (Table 2), and near the shoreline, the grain size is even smaller than 0.005 mm. Offshore locations and the northern part of the CAMD, specifically the Kien Giang coast, exhibit concentrated median grain size values ranging from 0.05–0.1 to 0.1–0.25 mm. During the NE season, there are significant changes in the median grain size values compared to the spatial distribution observed during the SW monsoon. These changes indicate a shift towards coarser size grains, particularly in Area I and Area II (Table 2).

Discussions

The GSD map of SSS for the SW season (Fig. 2) shows that size range of fine grain types (0.005–0.25 mm) are predominant near the mouths of the Mekong Delta Coastal (Area I) and along the eastern coast of the Mekong Delta Coastal (Area II). These size ranges of fine grain types are possibly delivered to these areas from the Mekong River Basin, which have been reported in [2]. The GSD map for the NE season (Fig. 3) also revealed a large variation in grain size range along Area I and Area II.

The change of GSD of SSS between the SW and NE seasons strongly proven the changing trend in grain distribution from very nine grains to coarser size grains in the estuary areas (Area I, Fig. 2) and in the coastal areas from Soc Trang to Ca Mau (Area II) (Fig. 3). These changes imply that the seasonal sediment transport during NE monsoon obviously happens during only one season. Finer-grain on SSS can easily transport southwest-west through Ca Mau Cape towards the western side of the Mekong Delta only in the active period of the NE monsoon.

The GSD map of SSS along the CAMD in SW and NE seasons demonstrates sediment transport along the coast. These results give evidence to support modelled results of [17]. The GSD map in the SW season shows a similar pattern to those maps designed by [13, 20].

The GSD map showed coarser size grain are forwarded in the eastern side of the Mekong Delta (along the river mouths and the eastern coast from Soc Trang to Ca Mau). These changes imply finer size grains are transported occurring NE season and present over the Ca Mau Cape to the western side of the Mekong Delta where the grain size ranges varying from 0.005–0.01 mm (Fig. 2, 3).

The findings of GSD are conducted through this work for SW and NE seasons, which presents a picture of strongly variation in sediment grain size along the CAMD during the timing of the changing season as well as the impacts of hydrodynamics factors (wave, current and tidal). These GSD maps are one of the best supportive pictures demonstrating the spatial distribution of sediment along the CAMD and how sediment grains can be redistributed under the impacts of hydrodynamics factors. Overall, the sediment delivery from the east coast to the west coast is not significantly detected from the changes in median grain size values between the SW and NE seasons. These confirm that sediment grains transport from the east coast to the west coast might be limited in the tip of Ca Mau and therefore, it is possibly limited sediment grain delivery to the further northern part of the west coast of the Mekong Delta during the NE season.

Conclusions

We investigated the seasonal changes in the grain-size distribution of sea-bed surface sediment along the subaqueous Mekong Delta, Vietnam. Our analysis focused on the median grain size to gain insights into sediment redistribution along the Mekong Delta Coastal during the southwest and northeast monsoons. By examining median grain size and creating spatial maps of median grain size along the Mekong Delta Coastal, significant variations in the median grain size of sea-bed surface sediment between the two monsoons were observed.

The findings indicate that the median grain size values in the northeast monsoon were generally larger compared to those during the southwest monsoon. This suggests that sediment transport is more prominent along the eastern part of the Mekong Delta during the northeast monsoon, indicating the transportation of sediment from the east coast to the west coast during the monsoons. The observed disparities in median grain size values and spatial distributions between the southwest and northeast monsoons underscore the significance of accounting for seasonal variations when investigating sediment transport in this region. Moreover, these findings contribute to explaining the erosion-accretion phenomenon along the eastern coast, particularly from Soc Trang to Ca Mau.

REFERENCES

1. Besset M., Gratiot N., Anthony E.J., Bouchette F., Goichot M., Marchesiello P. Mangroves and shoreline erosion in the Mekong River Delta, Viet Nam. *Estuarine Coastal Shelf Sci.*, 2019, vol. 226, 106263.
2. Binh D.V., Kantoush S., Sumi T. Changes to long-term discharge and sediment loads in the Vietnamese Mekong Delta caused by upstream dams. *Geomorphology*, 2020, vol. 353 (15), 107011.
3. Darby S.E., Hackney C.R., Leyland J., Kummu M., Lauri H., Parsons D.R., Best J.L., Nicholas A.P., Aalto R. Fluvial sediment supply to a mega-delta reduced by shifting tropical-cyclone activity. *Nature*, 2016, vol. 539 (7628), pp. 276–279.
4. Le X.T., Vo Q.T., Johan R., Song P.V., Duong T.A., Thanh D.D, Dano R. Sediment transport and morphodynamical modeling on the estuaries and coastal zone of the Vietnamese Mekong Delta. *Cont. Shelf Res.*, 2019, vol. 186, pp. 64–76.
5. Li B., Liu J.P., Jia Y. Comparison of the causes of erosion-deposition between Yellow River, Yangtze River and Mekong River Subaqueous Deltas II: Comparative Analysis. *Water*, 2023, vol. 5 (38), pp. 2–18.
6. Li X., Liu J.P., Saito Y., Nguyen V.L. Recent evolution of the Mekong Delta and the impacts of dams. *Earth Sci. Rev*., 2017, vol. 175, pp. 1–17.
7. Tamura T., Nguyen V.L., Ta T.K.O., Bateman M.D., Gugliotta M., Anthony E.J., Nakashima R., Saito Y. Long-term sediment decline causes ongoing shrinkage of the Mekong megadelta, Vietnam. *Sci. Rep*., 2020, vol. 10, 8085.
8. Unverricht D., Nguyen T.C., Heinrich C., Szczuciński W., Lahajnar N., Stattegger K. Suspended sediment dynamics during the inter-monsoon season in the subaqueous Mekong Delta and adjacent shelf, Southern Vietnam. *J. Asian Earth Sci.*, 2014, vol. 79 (A), pp. 509–519.
9. Xuan T.L., Ba H.T., Thanh V.Q., Wright D.P., Tanim A.H., Anh D.T. Evaluation of coastal protection strategies and proposing multiple lines of defense under climate change in the Mekong Delta for sustainable shoreline protection. *Ocean Coast. Manag*., 2022, vol. 228 (1), 106301.
10. Nguyen C.T., Dang T.A., Tran N.T.K. Monsoonal sediment transport along the subaqueous Mekong Delta: An analysis of surface sediment grain-size changes. *Ocean Systems Engineering*, 2023, vol. 12, pp. 403–411.
11. Liu J.P., DeMaster D.J., Nittrouer C.A., Eidam E.F., Nguyen T.T. A seismic study of the Mekong Subaqueous Delta: proximal versus distal sediment accumulation. *Cont. Shelf Res*., 2017, vol. 147, pp. 197–212.
12. Manh N.V., Dung N.V., Hung N.N., Kummu M., Merz B., Apel H. Future sediment dynamics in the Mekong Delta floodplains: impacts of hydropower development, climate change and sea level rise. *Global Planet. Change*, 2015, vol. 127, pp. 22–33.
13. Nguyen T.T., Stattegger K., Unverricht D., Nittrouer C., Phung V.P., Liu P., DeMaster D., Bui V.D., Le D.A., Mai D.D. Surface sediment grain-size distribution and sediment transport in the subaqueous Mekong Delta, Vietnam. *Vietnam Journal of Earth Sciences*, 2017, vol. 39 (3), pp. 193–209.
14. Unverricht D., Szczuciński W., Stattegger K., Jagodziński R., Le X.T., Kwong L.L.W. Modern sedimentation and morphology of the subaqueous Mekong Delta, Southern Vietnam. *Global Planet Change*, 2013, vol. 110 (B), pp. 223–235.
15. Loisel H., Mangin A., Vantrepotte V., Dessailly D., Ngoc Dinh D., Garnesson P., Ouillon S., Lefebvre J.-P., Mériaux X., Minh Phan T. Variability of suspended particulate matter concentration in coastal waters under the Mekong's influence from ocean color (MERIS) remote sensing over the last decade. *Remote Sens. Environ.*, 2014, vol. 150, pp. 218–230.
16. Räsänen T.A., Someth P., Lauri H., Koponen J., Sarkkula J., Kummu M. Observed River discharge changes due to hydropower operations in the Upper Mekong Basin. *J. Hydrol*., 2017, vol. 545, pp. 18–41.
17. Marchesiello P., Nguyen N.M., Gratiot N., Loisel H., Anthony E.J., Dinh C.S., Nguyen T., Almar R., Kestenare E. Erosion of the Coastal Mekong Delta: assessing natural against man induced processes. *Cont. Shelf Res*., 2019, vol. 181, pp. 72–89.
18. O'Malley J. *U.S Geological survey ArcMap sediment classification tool: installation and user guide*, 2007.
19. TCVN4198:2014. *Soils – Laboratory methods for particle – size analysis*, *Viet Nam Standards and Quality Institute*, 2014. (in Vietnamese).
20. Shepard F.P. Nomenclature based on sand-silt-clay ratios. *J. Sediment. Petrol*., 1954, vol. 24 (3), pp. 151–158.

Information about the authors

Nguyen Cong Thanh, PhD, Lecturer, University of Science, Lihg Chung Word, Thu Dyk, HCM City, Viet Nam; Viet Nam National University, 227, Nguyen Van Cu street, 5 district, HCM City, Viet Nam; ncthanh@hcmus.edu.vn; https://orcid.org/0000-0003-1780-6265

Dang Truong An, PhD, Associate Professor, Lecturer, University of Science, Lihg Chung Word, Thu Dyk, HCM City, Viet Nam; Viet Nam National University, 227, Nguyen Van Cu street, 5 district, HCM City, Viet Nam; dtan@hcmus.edu.vn; https://orcid.org/0000-0003-2237-8031

Received: 19.01.2024
Revised: 09.02.2024
Accepted: 01.10.2024

Информация об авторах
Нгуен Конг Тхань, доктор философии, преподаватель, Университет науки, Вьетнам, г. Хошимин, Тху Дык, Линь Чунг Уорд; Национальный университет Вьетнама, Вьетнам, г. Хошимин, ул. Нгуен Ван Ку, 227, район 5; ncthanh@hcmus.edu.vn; https://orcid.org/0000-0003-1780-6265
Данг Чыонг Ан, доктор философии, доцент, преподаватель, Университет науки, Вьетнам, г. Хошимин, Тху Дык, Линь Чунг Уорд; Национальный университет Вьетнама, Вьетнам, г. Хошимин, ул. Нгуен Ван Ку, 227, район 5; dtan@hcmus.edu.vn; https://orcid.org/0000-0003-2237-8031

Поступила в редакцию: 19.01.2024
Поступила после рецензирования: 09.02.2024
Принята к публикации: 01.10.2024