Organic pollution (pH and TOC) in sediments at tidal sluice gates in the Saigon river basin

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Abstract
The Saigon river plays a crucial role in the ecosystem and socio-economic development of Ho Chi Minh City but is affected by industrial activities, urbanization, and domestic wastewater, particularly in river branches with tidal sluices. This study assesses organic pollution in sediment through pH and total organic carbon (TOC) during the period 2022 – 2024. Monitoring results from 2022 to 2024 indicate that pH values remained stable and within the permissible limits set by QCVN 07:2009/BTNMT. Meanwhile, TOC exhibited an increasing trend along the sampling locations, with significant fluctuations during the rainy season, particularly at certain sites with sudden high values, such as B3 (2.15%), B5 (2.36%), B6 (2.36%), and B7 (2.15%). In contrast, TOC levels during the dry season showed a more stable increase, with higher concentrations observed at locations B5 (2.14%), B7 (2.24%), B8 (2.24%), and B9 (1.92%). These seasonal variations reflect the influence of rainfall and surface runoff. The study provides a scientific basis for pollution management and proposes effective solutions for sediment environment protection. [1]; [2];[4];[5];[6];[7]

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1. INTRODUCTION

The Saigon River basin is a region experiencing rapid urbanization and industrialization, which exerts significant pressure on the water and sediment environments. Notably, the tidal sluice system on the river branches not only serves to control tidal flooding and saltwater intrusion but also alters hydrodynamic conditions, thereby influencing the accumulation of pollutants in sediments. Among these, organic pollution—represented by indicators such as pH and total organic carbon (TOC) - is a critical concern in environmental studies. Assessing the level of organic pollution at tidal sluice points provides essential scientific data for environmental quality management and supports sustainable development efforts.

This study focuses on the level of organic pollution in sediments at tidal sluice points located along the tributaries of the Saigon river basin. Previous studies have mainly concentrated on water quality or heavy metal contamination in sediments, while organic indicators such as TOC and pH have received limited attention [3]; [4]; [5]. The novelty of this research lies in its evaluation of organic pollution within tidal sluice systems and its analysis of how these systems affect pollutant accumulation processes. By utilizing pH and TOC indices, the study aims to determine the extent of organic pollution in sediments and propose effective management solutions to mitigate the impact of organic contaminants on the sedimentary environment and aquatic ecosystems.[7]

2. DATA AND RESEARCH METHODOLOGY

2.1. The data

The database in the study of assessing organic pollution in sediments at tidal sluice points in the Saigon river basin includes information collected from the field and laboratory analysis results. The data is recorded at various observation points, including location coordinates, sample collection time, sediment depth, along with important environmental parameters such as pH, total organic carbon (TOC) content, and concentrations of organic pollutants.

2.2. Research methodology

The research methodology includes collecting sediment samples at tidal sluice gates, analyzing pH and TOC indices in the laboratory, and using Excel software for data statistics and processing to assess the level and trends of pollution in space and time.

2.3. Sampling and Sample Analysis Methods

All samples were collected according to the appropriate sampling and sample preservation procedures in accordance with the Vietnamese Standards TCVN 6663-13: 2015 and TCVN 6663-15: 2004. Sampling was conducted during both the dry and rainy seasons. In the laboratory, the samples were analyzed following approved procedures to determine the presence and concentration of pollutants or to assess

their impacts under various conditions. These analytical methods adhere to the standards set by the United States Environmental Protection Agency (EPA) [8] and are in compliance with current Vietnamese standards. Samples were collected during the dry season (March, April) and the rainy season (October, November) at 9 sampling sites in the Saigon river basin from 2022 to 2024. The sampling locations were chosen in areas affected by discharge sources from domestic waste, industrial zones, and waterway traffic, among others. The sampling locations are presented in Table1.

3. RESULTS

The survey results indicate that the pH values during the rainy season range from 5.18 to 7.28, with many points exhibiting pH values above 7, reflecting a mildly alkaline environment. However, some locations, such as B3, B4, and B5, have relatively low pH values (pH < 6), suggesting a slightly acidic environment. The variation between survey points is relatively large, which may be due to the influence of flow, pollution sources, or other environmental factors during the rainy season. In contrast, during the dry season, the pH values range from 5.33 to 7.28. Compared to the rainy season, pH at some points shows a slight decrease, particularly at locations B3, B6, B7, and B9, where pH values are lower than 5.5. Overall, the average pH values in both seasons are mostly within the permissible limits according to QCVN 07:2009/BTNMT (pH: 2.0 – 12.5). However, the pH variation between locations during the dry season is somewhat smaller than during the rainy season, indicating greater stability. [5]; [7]; [8]; [9]

When comparing the two seasons, the pH variation range generally does not show significant differences, but there are variations at specific locations. Some points, such as B3, B6, and B7, have lower pH during the dry season compared to the rainy season. Notably, the dry season shows higher pH stability due to less influence from rainwater and water dilution. In the rainy season, rainwater may alter the characteristics of the water environment, leading to larger pH fluctuations. On the other hand, during the dry season, evaporation and reduced water flow can increase the concentration of acidic or alkaline substances in the water, leading to pH fluctuations at certain points. [7]; [8]; [9]

In general, the pH values at the surveyed locations range from neutral to slightly acidic. The pH fluctuations during the rainy season are greater due to the influence of flow and rainfall, while the dry season tends to be more stable. However, some locations still show low pH values, possibly due to the accumulation of pollutants or the impact of organic decomposition processes. To obtain a more accurate assessment, continued monitoring and further research on the factors affecting pH, particularly at points with low values, are needed. [5]; [7]

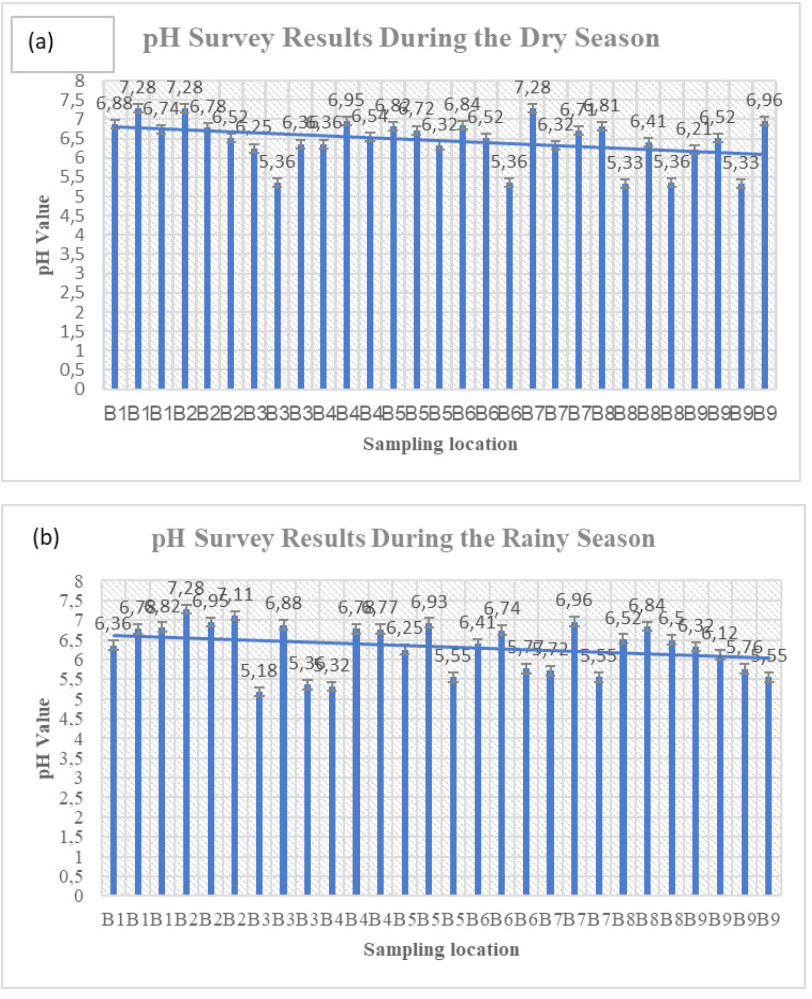
The fluctuation of total organic carbon (TOC) between the two seasons demonstrates a clear difference in accumulation dynamics and distribution in the sediment environment. During the rainy season, TOC concentrations exhibit strong variability across the monitoring sites, with some locations recording sharp spikes, reaching a maximum of 2.36% (B5 and B7). In contrast, during the dry season, TOC also tends to increase with sampling location; however, the degree of fluctuation is lower, and there is less seasonal variation between sampling points during the 2022–2024 period.

Regarding the spatial distribution trend of TOC, both seasons show an increase in TOC concentrations along the flow path, clearly reflected by the trendline. However, in the dry season, this trend is more stable, indicating a more uniform accumulation of organic matter compared to the rainy season, when hydrodynamic factors strongly influence the distribution of organic material. [7]

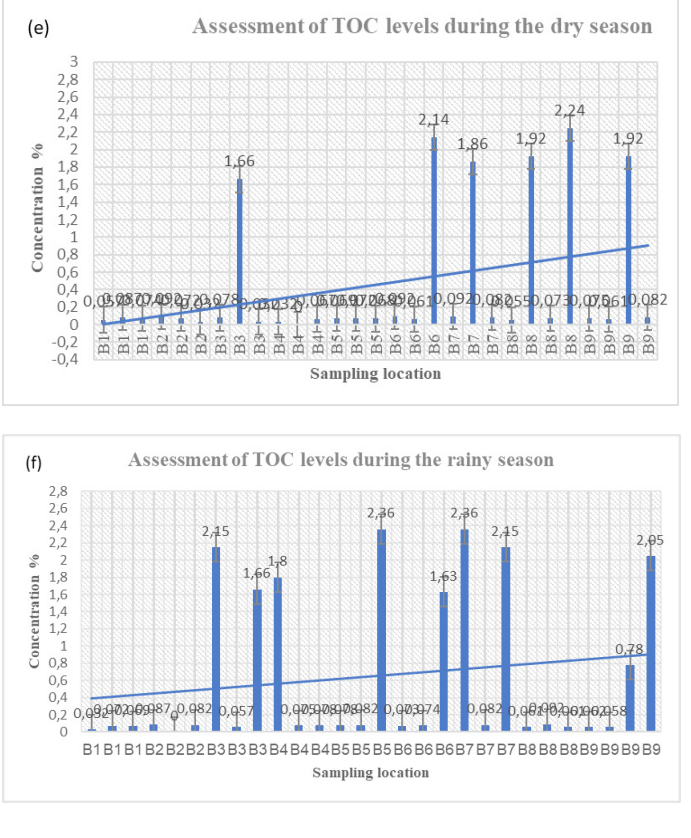
In terms of average values, during the rainy season, many locations have high TOC

Table 1: Sediment Sampling Locations

No.	Location	Code	VN 2000 Coordinates	
			X (m)	Y (m)
1	Ben Nghe	B1	1189604	606003
2	Kenh Te	B2	1189604	606003
3	Phu Xuan	B3	1183917	608181
4	Muong Chuoi	B4	1190231	605662
5	Can Giuoc river	B5	1184661	595261
6	Ba Buom creek	B6	1190975	604053
7	Cay Kho	B7	1180485	601280
8	Cau Kinh creek	B8	1166885	612214
9	Drainage Outlet of Hiep Phuoc Industrial Park	B9	1183510	608462



▲ *Figure 2. Spatial distribution of pH index during the dry season (a) and the rainy season (b)*



▲ *Figure 3. Spatial distribution of TOC concentrations in the dry season (e) and rainy season (f).*

concentrations, with some points exceeding the 2% threshold, such as B3 (2.15%), B5 (2.36%), B6 (2.36%), and B7 (2.15%), reflecting uneven accumulation of organic material. Meanwhile, the dry season records high TOC values but fewer extreme points. This may be related to the impact of surface flow and flooding during the rainy season, altering the processes of transport, deposition, or washout of organic compounds in various areas of the hydrological system. [1]; [2]; [5]; [7]

The effect of seasonal factors on TOC is clearly reflected in the fluctuation of organic content concentration. During the rainy season, strong flows may disturb sediments, causing suspended matter and re-deposition of organic material in low-lying areas, leading to uneven distribution of TOC. Conversely, in the dry season, due to less influence from strong flows, organic matter tends to accumulate more consistently in sediments, contributing to a more uniform distribution trend.

The results show that TOC concentrations in sediments tend to increase with sampling location in both seasons. However, during the rainy season, the fluctuations are stronger, with some points exhibiting sharp increases in TOC values, while the dry season shows a more stable increase. This difference may stem from the influence of hydrodynamic processes during the rainy season and the organic accumulation mechanism in the dry season, affecting TOC distribution in the riverbank sediment ecosystem. [5]; [7]

4. CONCLUSION

The research results indicate that the total organic carbon (TOC) content in sediments varies between the two seasons, with higher TOC values during the rainy season compared to the dry season. This may be due to increased flow and the transportation of organic matter from upstream. Additionally, the pH index fluctuates seasonally, with pH values during the rainy season tending to be lower at some sampling sites, possibly due to dilution and the influence of other environmental factors. The variations in TOC and pH at the sampling locations reflect the impact of tidal sluice gates in accumulating and dispersing organic pollution within the Saigon river basin.

The current study primarily focuses on TOC and pH indices, without fully assessing other factors such as heavy metals, persistent organic pollutants (POPs), or nutrients that may affect sediment environmental quality. Moreover, the sample collection period was limited to a specific timeframe, not fully reflecting the long-term fluctuations of the river ecosystem. The study's scope is also confined to a few sampling points in the tidal sluice system and has not been extended to cover the entire basin for a more comprehensive overview.

In the future, the research could be expanded to assess the impact of other environmental factors, such as metals, nutrients, microorganisms, and more complex organic pollutants. Additionally, the use of remote sensing technology and hydrological modeling to predict the distribution and accumulation of pollution in the context of climate change is an important direction. Furthermore, studying the mechanisms of pollution spread based on the operation of tidal sluice systems could help clarify the role of water control structures in managing sediment environmental quality.

Based on the research results, environmental managers and businesses could consider the following measures: controlling organic waste sources by tightening the management of emissions from industrial, agricultural, and residential activities to reduce organic pollution in river sediments; improving the operation of tidal sluice gates by developing flow control procedures to limit pollution accumulation at tidal discharge points; continuously monitoring the environment with automated monitoring systems to track sediment environmental quality in real time, helping to detect early signs of pollution; and developing pollution treatment technologies such as biological traps, adsorbent materials, or sediment restoration techniques to minimize negative impacts on river ecosystems. These solutions will contribute to more effective management of sediment environmental quality in the Saigon river area, protect ecosystems, and reduce adverse effects on socio-economic activities.

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