EFFECT OF THE COVID-19 ON SAIGON RIVER WATER QUALITY AND RESIDENT'S AWARENESS IN HO CHI MINH CITY

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ABSTRACT

The COVID-19 pandemic has resulted in significant changes to the surface water and lifestyle habits of residents in Ho Chi Minh city, Vietnam. The objective of this study was to evaluate the impact of COVID-19 on the Saigon River water and the environmental awareness of Ho Chi Minh city residents. Samples were collected from 12 locations along the Saigon River during three stages of the COVID-19 outbreak: before lockdown, during lockdown, and after restrictions were lifted. The analysis showed that the physicochemical parameters (excluding DO) and heavy metals (Zn, Cd, Pb, Ni, Cr, Fe) in the Saigon River water decreased by more than 80.0% during the lockdown, meeting the requirements of QCVN08:2023/BTNMT (level B), but increased again after the restrictions were lifted, reaching pre-lockdown levels. Simultaneously, a survey was conducted to assess the knowledge and environmental awareness of Ho Chi Minh city residents regarding the impact of COVID-19. A total of 630 valid responses were collected. The results revealed that over 60% of the participants identified waste, domestic, and industrial wastewater as the main sources of water pollution in the Saigon River. Hence, it is crucial to enhance residents' awareness to foster behaviors that can minimize water pollution and improve the water quality of the river.

ẢNH HƯỞNG CỦA DỊCH COVID-19 ĐỐI VỚI CHẤT LƯỢNG NƯỚC SÔNG SÀI GÒN VÀ NHẬN THỨC CỦA NGƯỜI DÂN THÀNH PHỐ HỒ CHÍ MINH

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TỪ KHÓA

COVID-19
Sông Sài Gòn
Đóng cửa
Kim loại nặng
Khảo sát nhận thức

TÓM TẮT

Đại dịch COVID-19 gây thay đổi đáng kể về nước mặt và thói quen sinh hoạt của người dân Thành phố Hồ Chí Minh, Việt Nam. Mục tiêu nghiên cứu là đánh giá tác động của COVID-19 đến nước sông Sài Gòn và nhận thức môi trường của người dân Thành phố Hồ Chí Minh. Mẫu nước được thu thập từ 12 địa điểm dọc sông Sài Gòn trong ba giai đoạn dịch COVID-19: trước phong tỏa, trong thời gian phong tỏa, và sau khi hạn chế được nới lỏng. Phân tích cho thấy các tham số hóa lý (ngoại trừ DO) và kim loại nặng (Zn, Cd, Pb, Ni, Cr, Fe) trong nước sông Sài Gòn giảm hơn 80,0% trong thời gian phong tỏa, phù hợp với QCVN08:2023/BTNMT (mức B), nhưng tăng trở lại sau khi hạn chế được nới lỏng, đạt lại mức trước khi phong tỏa. Đồng thời, một khảo sát được tiến hành để đánh giá kiến thức và nhận thức môi trường của người dân Thành phố Hồ Chí Minh về tác động của COVID-19. Tổng 630 phản hồi hợp lệ được thu thập. Kết quả cho thấy hơn 60% người tham gia xác định rác thải, nước thải sinh hoạt và công nghiệp là nguồn chính gây ô nhiễm nước sông Sài Gòn. Vì vậy, việc nâng cao nhận thức của người dân để thúc đẩy những hành vi có thể giảm thiểu ô nhiễm và cải thiện chất lượng nước sông.

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1. Introduction

The Saigon River, located in southern Vietnam, originates from Phum Daung in southeastern Cambodia [1]. It then traverses Ho Chi Minh City (HCMC) before eventually flowing into the East Sea of Vietnam. The Saigon River is an important water source for HCMC and a recipient of waste generated from agricultural, industrial, and residential zones within the city [2]. However, the accelerated economic and industrial growth over the last decade has led to the degradation of the river, primarily due to elevated levels of heavy metals and nutrients [3] - [5].

Some previous studies have shown that human-generated waste is the primary cause of heavy metal pollution in aquatic systems, closely linked with organic matter [6]. During the onset of the COVID-19 pandemic, a temporary lockdown was enforced in HCMC, Vietnam, aimed at curtailing disease transmission [7]. This led to a temporary cessation of activities that contribute to water pollution in the Saigon River, such as waterborne transportation and industrial and domestic discharges [8]. This unique circumstance provided an opportunity to assess the influence of human activities on the aquatic ecosystem of the Saigon River.

Several studies have reported the positive impact of the COVID-19 pandemic on the surface water quality of the Damodar River (India) [9], Yamuna River (China) [10], and Yamuna River (India) [11]. However, most of these studies have focused on determining the concentrations of physicochemical parameters and heavy metals without integrating surveys on residents' environmental awareness in the study areas.

Despite the prevalence of diverse media coverage on the COVID-19 pandemic, the exploration and dissemination of information concerning public perceptions and behaviors towards the environment amid the pandemic remained relatively limited [12]. Therefore, this study was conducted with the objective of evaluating the water quality of the Saigon River in HCMC during three distinct periods: before the implementation of the lockdown measures, the lockdown phase, and the subsequent reopening, all influenced by the COVID-19 pandemic. Concurrently, the study investigated public awareness levels regarding the water environment of the Saigon River within the HCMC region, in light of the pandemic's impact.

2. Materials and methods

2.1. Study area

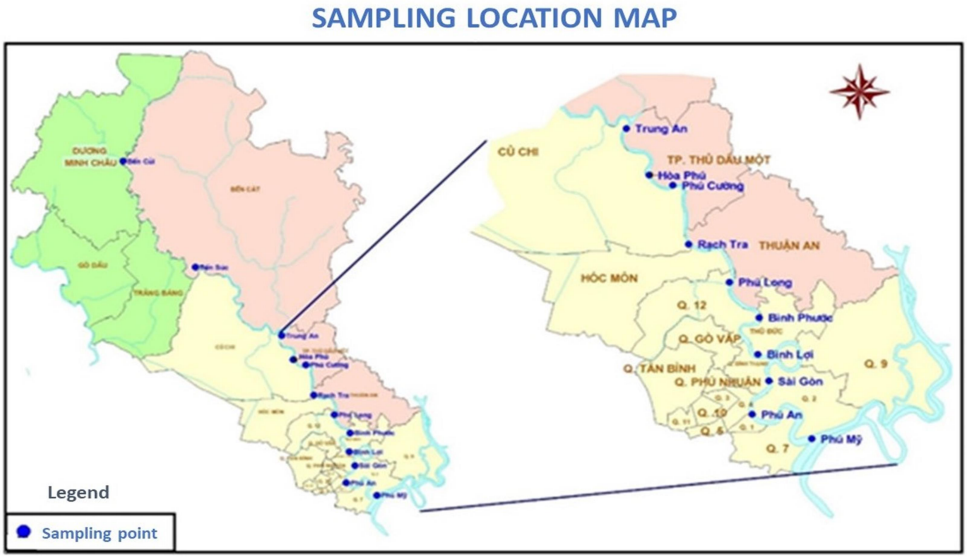

Figure 1. *Study area and sampling location on the Saigon River, Vietnam*

2.2. Sampling strategies and analysis

2.2.1. Surface water sample

Surface water samples were collected from the Saigon River at a depth of 10 centimeters using 2-liter polyethylene bottles. This sampling process was carried out at 12 different locations along the course of the river as illustrated in Figure 1. Sampling locations were selected based on field surveys, boundary maps of the Saigon River area, and were chosen to be representative of the study area. The collection occurred during three distinct periods: before (5/2021), during (9/2021), post (12/2021) lockdown. After collection, the samples were immediately stored in a refrigerated environment and then transported to the laboratory for further analysis.

During the field operations, dissolved oxygen (DO) levels and pH were conducted by using Hach HQ40d. Turbidity was also measured using a handheld turbidimeter (Hach 2100Q). Upon arrival at the laboratory, a portion of the water sample was filtered on the day of collection. In the case of unfiltered water samples, the determination of biochemical oxygen demand (BOD) was conducted using a manometer known as Hach BODTrak II. Total suspended solids (TSS) was determined by using the gravimetric method as stipulated by the APHA [13] guidelines.

For the filtered water samples, an inductively coupled plasma emission spectrometer (ICP-OES, Spectro Analytical Instrument GmbH, 47533 Kleve Germany) was used in the laboratory premises, located at the Institute for Environmental Science, Engineering and Management - Industrial University of HCMC, Vietnam to measure the concentrations of six different metals, namely zinc (Zn), cadmium (Cd), lead (Pb), nickel (Ni), chromium (Cr), and iron (Fe) (liquid state).

Sampling and analysis process of surface water samples in the field and laboratory was conducted in accordance with Circular 10/2021/TT-BTNMT on technical regulations for environmental monitoring and the management of environmental quality monitoring information and data.

2.2.2. Survey method

The primary objective of this study is to evaluate the extent of public awareness of river water contamination resulting from the influence of COVID-19 in HCMC. An online survey was designed using the Google Forms platform. The survey was then widely circulated to the public through various social networking applications, including Facebook, Zalo, WhatsApp, and Instagram. The survey was distributed over a period of one month (from June 1 to July 7, 2022).

The questionnaire was developed to assess the environmental awareness of the residents, after reviewing previous studies that utilized similar survey forms [14], [15].

2.2.3. Data analysis

The collected data were processed using SPSS 26.0 software to calculate the mean score of the observed variables in the sample set, which are measured on a Likert scale. The data of observed variables of each group were tested. The one-way ANOVA with a significant level of 0.0001 was used to compare physicochemical parameters and heavy metals within surface water. These analyses were performed on the JMP Pro 16.0 statistical software. For the graphical representation of data, Sigmaplot 14.0 software was used to create the necessary charts and visualizations.

3. Result and discussion

3.1. Assessment of the impact of the COVID-19 epidemic on the water of the Saigon River

Prior to the implementation of the COVID-19 closure order, nearly all measured physicochemical parameters exceeded the permissible limits outlined in Vietnam's national technical regulation on surface water quality, QCVN08:2023/BTNMT – level B, with the exception of pH, which fell within the range of 6 – 8.5 (Figure 2). In the lockdown phase, the concentrations of various water quality parameters decreased compared to the previous phase, consistently maintaining levels within the prescribed regulatory thresholds, except for turbidity.

Notably, the concentration of PO_4^{3-} experienced the most significant reduction during both the lockdown and after unlock phases, declining by 80.65% and 52.76%, respectively. However, following the after unlock phase, the physicochemical parameters of the Saigon River's water once again escalated beyond the allowable standards (Figure 2). Similarly, the effects of the COVID-19 pandemic on river water quality have been observed in various regions around the world. For instance, in the Bagmati River in Nepal [16], Yamuna River in Delhi [11]. These findings align with other published studies emphasizing the positive influence of COVID-19 on regional water quality [17], [18].

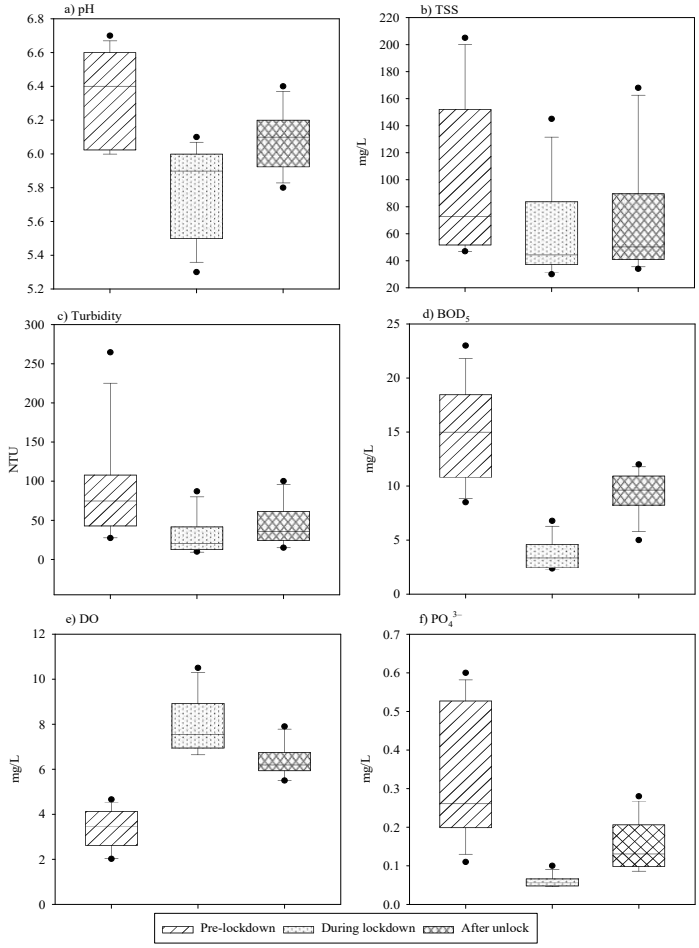

Figure 2. *Physicochemical parameters of Saigon river water in three phases of COVID-19 epidemic*

In the context of the Saigon River, the concentrations of heavy metals before the closure period exceeded the prescribed threshold QCVN08:2023/BTNMT (Figure 3). During the lockdown phase, Zn and Pb exhibited the most significant declines, with reductions of 84.34% and 75.74% respectively during the lockdown and after unlock phases, primarily attributed to reduced industrial wastewater discharge. Similarly, Pb concentrations decreased by 85.17% and 71.29% respectively during these periods. However, after the reopening phase, the resurgence of industrial wastewater contributed to an increase in heavy metal concentrations in the Saigon River's water. Statistical analysis revealed significant differences ($p<0.0001$) in heavy metal concentrations across the three phases of the COVID-19 pandemic (Figure 3).

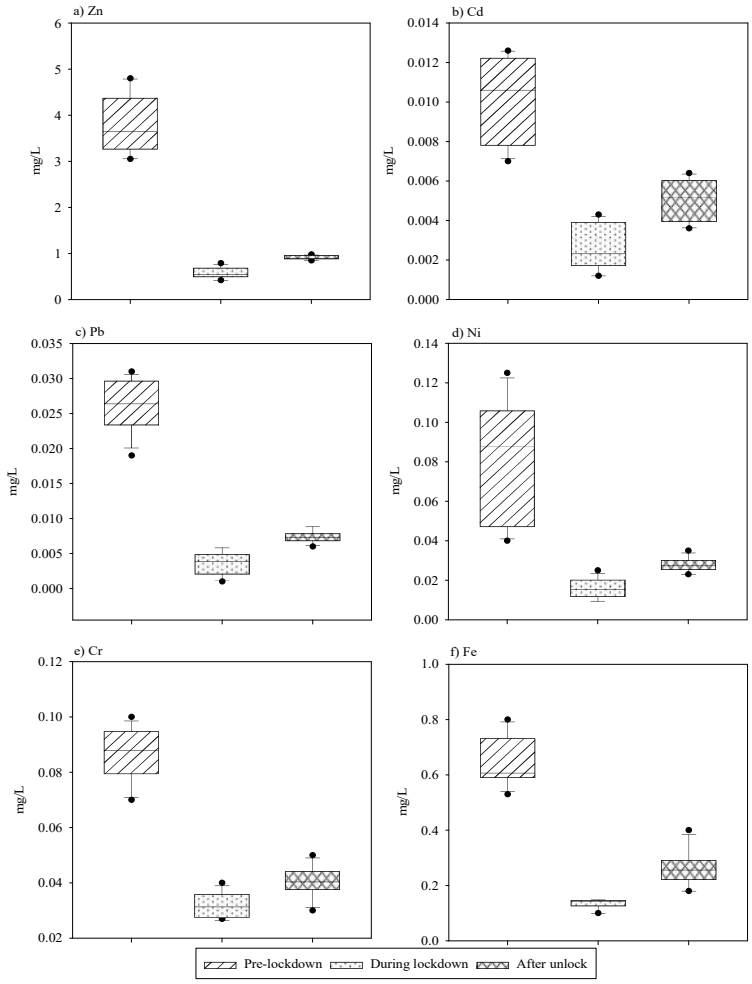

Figure 3. *Heavy metal concentrations of Saigon river water in three phases of COVID-19 epidemic*

These patterns of improved water quality during closure periods and deteriorations upon reopening are not unique to the Saigon River; similar trends have been observed in other rivers like the Damodar River in India [19] and the Gomti River by Khan, et al. [20]. The temporary reduction of anthropogenic activities, including industrial processes and traffic, during the closure period appears to contribute to improved water quality, emphasizing the vital role of human activities in shaping the environmental conditions of rivers.

The influence of human activities on water quality is undeniable, and the understanding and awareness of local residents play a critical role in determining the environmental health of the Saigon River in HCMC. To address this issue comprehensively, the study conducted a survey to evaluate the awareness and comprehension of the local population regarding their environment, with specific emphasis on the implications of the COVID-19 pandemic.

3.2. Survey results on the level of people's understanding and awareness about the impact of COVID-19 on the water environment

The results of the survey conducted among the residents of HCMC demonstrate a widespread perception that the COVID-19 pandemic has had favorable effects on the environment. Notably, these effects are primarily attributed to a reduction in the influx of industrial wastewater and

waste discharge into rivers (Figure 4). The findings of this study echo those of a previous research effort that aimed to increase public understanding of this important issue [21]. This underscores a notable interest in and commitment to enhancing awareness and educating the community about the pivotal role of the environment in both disease transmission and environmental contamination.

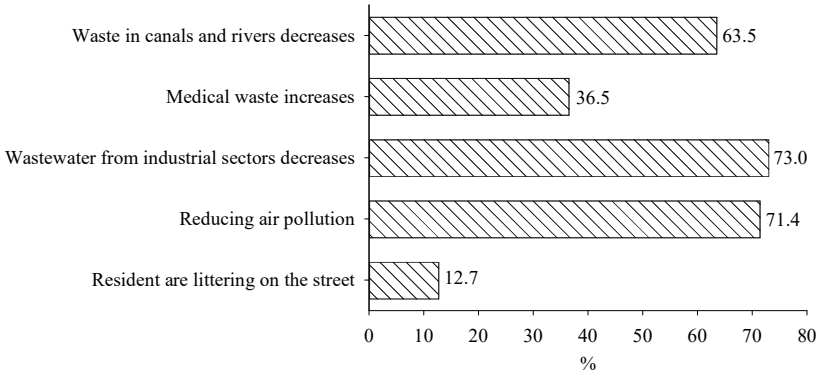

Figure 4. *Impact of COVID-19 on the environment in the living area of HCMC's residents*

The survey results underscore a notable level of awareness among the residents of HCMC regarding the adverse impacts of human activities on the Saigon River, particularly those related to discharge behaviors from both individuals and local organizations (Figure 5). This heightened awareness reflects the community's sensitivity and understanding of the importance of protecting and preserving the integrity of the water environment, particularly the Saigon River.

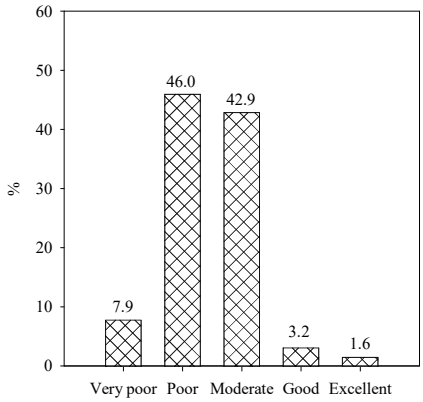

Figure 5. *People's opinions on the level of human impact on the water environment*

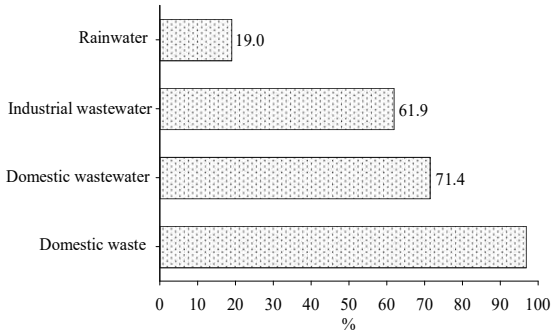

Figure 6. *People's feedback on the main source of water pollution in the Saigon River*

Garbage, domestic wastewater, and industrial effluents were identified as the main sources of pollution in the Saigon River, with these factors accounting for over 60% of responses (Figure 6). These findings suggest that there is a collective acknowledgement of the negative impacts on the Saigon River, but there is still a need for more robust measures and interventions to effectively curtail these detrimental effects.

The significance of raising people's environmental awareness is paramount, as individuals actively shape present and future actions that influence the environment, both within and beyond organizations and society as a whole [22]. As a result, the analysis of environmental perception is emerging as a vital tool for managing water quality and establishing appropriate regulations, especially in the face of challenges posed by dwindling water resources due to pollution [23].

4. Conclusion

The assessment results of the Saigon River's water quality revealed a noticeable improvement during the lockdown period, as human discharge activities were temporarily suspended. The physicochemical indexes and heavy metals have met the standards QCVN08:2023/BTNMT-level B-National technical regulation on surface water quality. The positive trend was not sustained, and the river's pollution levels saw a resurgence following the reopening phase. Survey results revealed that public awareness played a pivotal role in shaping behavioral adjustments aimed at curbing and preventing water pollution in the Saigon River. The deterioration of the river's water quality upon reopening signified the need for more robust and stringent environmental management strategies. At the same time, it is necessary to carry out local awareness campaigns to enhance residents' and organizations' understanding of the impacts of discharging waste into the Saigon River. Through concrete actions and heightened public consciousness, the influx of waste into the Saigon River can be mitigated, thus fostering a sustainable and ecologically-friendly environment. This endeavor holds the promise of safeguarding human health post-COVID-19 and establishing a resilient "green" ecosystem.

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