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Assessing water quality index for Chau Pha Lake in Vietnam

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ABSTRACT

Chau Pha Lake is one of the large reservoirs providing water for domestic, irrigation and production of people in Phu My town, Ba Ria Vung Tau province. This study was conducted to analyze the parameters of pH, temperature, DO, BOD₅, COD, N-NH₄⁺, P-PO₄³⁻, TSS, turbidity, total Coliform on 16 samples in 2020 and the water quality index calculation WQI. The analysis results show that the water quality of Chau Pha lake in the rainy season is quite good, all parameters reach the limit value A₂ according to QCVN 08:2015/BTNMT; however, in the dry season, the values of parameters DO, BOD₅, P-PO₄³⁻, TSS exceed the limit value A₂ but not significantly; WQI values fluctuate at a fairly high level from 71 to 92, which is correlated with turbidity, COD, and BOD₅ parameters. Thus, the average WQI of the lake reaches 85.4 points, corresponding to level 2 (green) - water used for domestic water supply purposes but needs appropriate treatment measures.

Keywords: *Chau Pha lake, public water, water quality, water quality index, supply, WQI*

1. Introduction

Water is a particularly important natural resource, an essential component of life and the environment. Water resources are under heavy pressure in the world and Vietnam in particular due to climate change, population growth rate, and the development of socio-economic activities. Surface water quality deterioration has become a serious concern

worldwide due to increased pollution and climate change. Such deterioration threatens the use of water resources, especially the drinking water supply, and economic development. Improving the water supply remains a challenge, especially in Vietnam. Poor water quality has been linked to public health concerns, mainly through the transmission of water-borne diseases. Therefore, many countries have implemented water quality protection measures and monitoring regimens. Furthermore, to better understand water resource conditions, it is critical to assess water quality, especially the major contributors to its spatial and temporal variations. (John et al., 2014).

Today, with the development of socio-economic, Ba Ria - Vung Tau also falls into the general situation of the whole country lack of clean water, so the Ba Ria - Vung Tau province has come up with a solution to build a water reservoir to serve for living activities and economic. Ho Chau Pha is one of the province's large reservoirs that are significant in daily life, irrigation and production. But at present, domestic wastewater, livestock wastewater, agricultural wastewater, and production wastewater are discharged into the lake and greatly affect the quality of lake water from research results Phan Cong Soai (2019).

The water quality Index (WQI) is a mathematical tool of converting large amounts of water quality data into a single value that represents the water environment and reflects the overall water quality level. However, it is impossible to identify the temporal and spatial variation of water quality, which is crucial for the comprehensive evaluation and management of water quality, even though the WQI method can provide reasonable accuracy of the water quality of a single sample. This is a simple method which helps to reduce a large set of data to a single value which can be further applied to determine the general water quality status (Saeedi et al., 2009). In Viet Nam, WQI has been applied to several rivers, lakes such as rivers and canals in Ho Chi Minh city (Le Trinh, 2008), Hau river in Can Tho city (Ton That Lang, 2009), Thi Tinh river in Binh Duong province (Thuy Chau To, 2015), the upper part of Dong Nai river (Pham Hung, 2017), Hanoi lake (Nguyen Thi Thu Ha, 2021).

This study will provide an effective method for rapid, quantitative, and sustainable water quality management in Chau Pha lake. These results reflect the current status of the lake's water source and help the authorities to take timely measures to prevent and deal with the pollution problem.

2. Materials and methods

2.1. Sample collection and analysis

Eight points (abbreviated to VT1, VT2, VT3, VT4, VT5, VT6, VT7, and VT8) were selected for monthly sampling along the lake in wet season (May – October) and dry season (November – April). Parameters like surface water temperature, pH, SS and DO

were measured by the water quality checker WQC 22A (TOA, Japan). The water samples were collected in separate polyvinyl propylene bottles (1L), glass bottles (500ml) and by dipping completely into the water to avoid mixing of air bubbles. The water sample in 1L bottle was used for the analysis of parameters like BOD₅, COD, N-NH₄, P-PO₄, turbidity, while the sample in second bottle (500 ml) was used for total Coliform analysis. The sampling depths were 50 cm and 100 cm. All samples were kept at 40C prior to analysis. Values used for each parameter are the mean value of the three sites under this investigation.



Figure 1. Water sampling location in the lake

TABLE 1. Method of analyzing parameters

Parameter	BOD ₅	COD	N-NH ₄ ⁺	P-PO ₄ ³⁻	Turbidity	Total Coliform
Methods	SMEWW 5210 B	SMEWW 5520 D	TCVN 5988:1995	TCVN 6202:2008	TCVN 6184: 2008	TCVN 6187-2: 1996

2.2. Application of the WQI

This study is an attempt to evaluate the historical changes in water quality of Chau Pha Lake. WQI for this purpose was calculated from ten water quality parameters have been selected which are: pH, temperature, DO, BOD₅, COD, N-NH₄⁺, P-PO₄³⁻, TSS, turbidity, total Coliform using the following formula:

$$WQI = \frac{WQI_{pH}}{100} \left[\frac{1}{5} \sum_{a=1}^5 WQI_a \times \frac{1}{2} \sum_{b=1}^2 WQI_b \times WQI_c \right]^{1/3}$$

Where

- BP_i : The lower limit concentration of the observed parameter value specified in the table corresponding to level i .
- BP_{i+1} : The upper limit concentration of the observed parameter value is specified in the table corresponding to the level $i+1$.
- q_i : The WQI value at level i given in the table corresponds to the BP_i value.
- q_{i+1} : WQI value at $i+1$ level given in table corresponds to BP_{i+1} value.
- C_p : The value of the observed parameter is included in the calculation.

WQI receives the value between 1 (the worst water quality) and 100 (the best water quality). Chau Pha lake water quality was divided into 5 classes as presented in Table 2 (Al-Bahrani, 2012).

According to this classification, a water source is good for public water supply when its WQIs belong to Class I and II.

TABLE 2. Water quality classification and interpretation based on WQI

Class/Level	WQI	Interpretation	Interpretation
I	91 - 100	Excellent	Blue
II	76 - 90	Good	Green
III	51 - 75	Medium	yellow
IV	26 - 50	Poor	Orange
V	10 - 25	Bad	Red
VI	<10	Very bad	Brown

3. Results and discussion

3.1. Water quality analysis results in dry season 2020

The results of water quality analysis results in dry season (Fig 2) showed that:

The values of pH from all the sampling sites in Chau Pha lake ranged from 6,5 to 6,7; The range of ammonium levels was between 0.07 and 0.19 mg/L; the total coliform values ranged between 93 and 1100 MPN/100 mL; the chemical oxygen demand values varied from 5 to 12 mg/L; These parameters were within the allowable range of QCVN 08-MT: 2015/BTNMT.

The TSS values were between 19 and 31 mg/L, most of samples was within the allowable range of QCVN 08-MT: 2015/BTNMT, without sampling site VT2

The Dissolved oxygen values varied from 4,2 to 6,4 mg/L, the low values of the dissolved oxygen at sampling site VT4, and VT6 can be attributed to organic waste, and mainly the untreated sewage from the industrial activities. A decrease in oxygen levels resulted from the pressure and discharge of high amounts of organic matter in the water. The reduction in dissolved oxygen along Chau Pha lake indicates that the deoxygenation rate caused by the biological decomposition of organic matter is higher

than the re-oxygenation rate from the atmosphere.

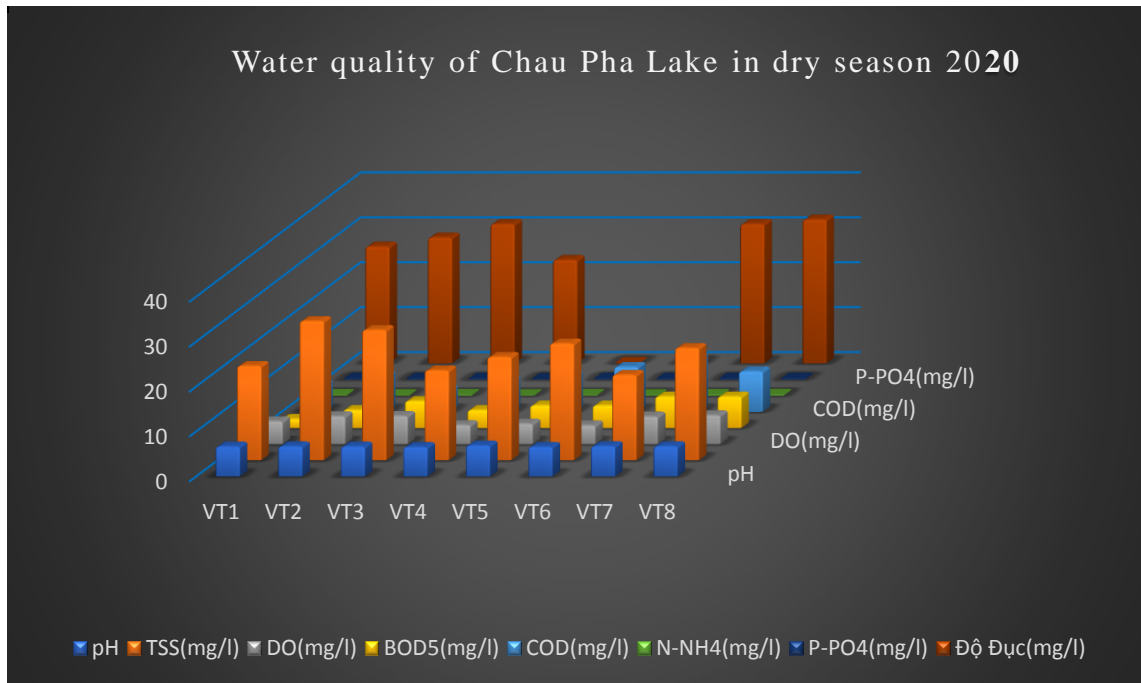


Figure 2. Water quality of Chau Pha Lake in dry season 2020

The phosphate levels ranged between 0.07 and 0.22 mg/L, there was significant difference among the sampling sites. Domestic wastewater, mainly those containing detergents, industrial effluents, and fertilizer run-off, contributes to elevated phosphates levels in surface waters. High concentrations of phosphates can indicate the presence of pollutants that are primarily responsible for atrophic (people's activities) conditions. The highest concentrations were noted in VT3, VT8 (0,22 mg/L), while the lowest levels were indicated in VT4.

The BOD values varied from 2.0 to 7.0 mg/L, the highest concentrations were noted in VT7 and VT8, while the lowest levels were indicated in VT1. The high BOD concentrations in this study can be attributed to high levels of organic contamination from the aquaculture farms, leaky sewer pipes and tanks, agricultural run-off, and nonpoint source pollution that support micro-bacteria growth.

3.2. Water quality analysis results in wet season 2020

The results of water quality analysis results in wet season (Fig 3) showed that large amounts of freshwater are dilute the organic matter during the rainy season, thus leading to a decrease at all parameters: the BOD₅ values varied from 1.0 to 3.0 mg/L; the TSS values were between 6 and 26 mg/L; the Dissolved oxygen values varied from 5,2 to 6,4 mg/L; the phosphate levels ranged between 0.01 and 0.03 mg/L; the range of ammonium levels was between 0.05 and 0.19 mg/L; the total coliform values ranged between 7 and 460 MPN/100mL. These parameters were within the allowable range of QCVN 08-MT: 2015/BTNMT.

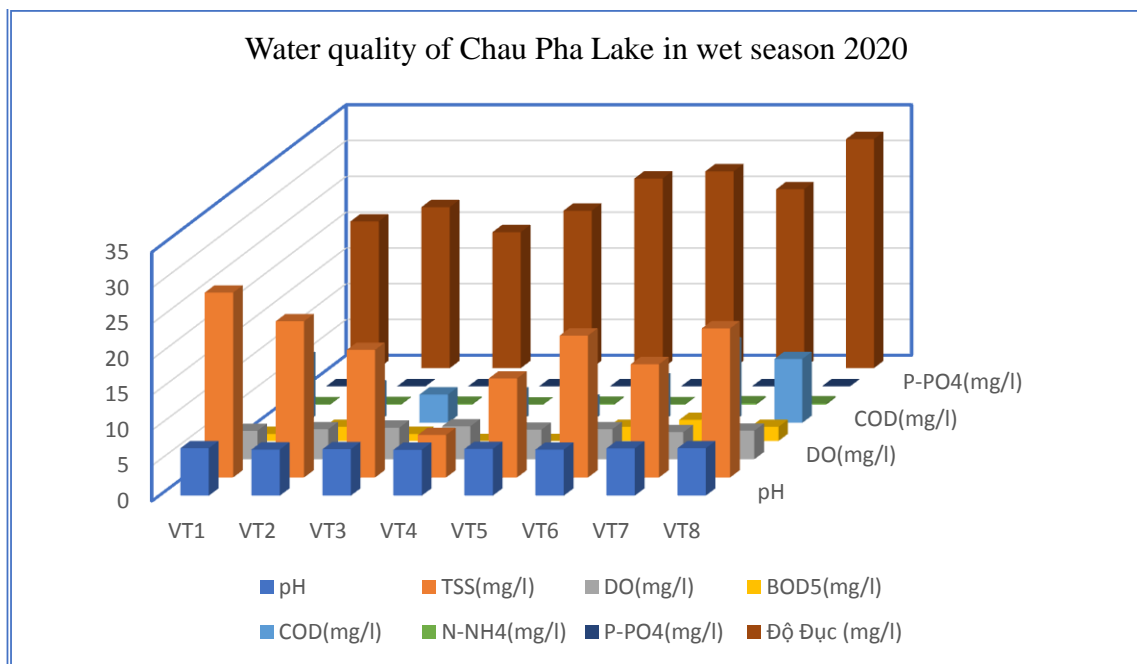


Figure 3. Water quality of Chau Pha Lake in wet season 2020

3.3. Calculation of water quality index (WQI) of the lake

TABLE 3. Calculation of water quality index (WQI) of the lake in wet season and dry season

Samples	WQI DO	WQI COD	WQI pH	WQI BOD5	WQI TSS	WQI N-NH ₄	WQI PO ₄ ³⁻	WQI Turbidity	WQI Coliform	WQI Total	Time
VT1	50	100	100	100	85	100	100	74	100	89	wet season
VT2	52	100	100	100	95	100	100	69	100	90	
VT3	54	100	100	100	100	93	100	77	100	92	
VT4	58	100	100	100	100	100	100	70	100	92	
VT5	52	100	100	100	100	98	100	59	100	89	
VT6	53	100	100	100	100	100	100	56	100	89	
VT7	47	95	100	100	100	78	100	63	100	88	
VT8	50	100	100	100	98	83	100	49	100	86	
VT1	63	100	100	100	98	90	75	60	100	88	dry season
VT2	83	100	100	100	74	100	75	55	100	84	
VT3	78	100	100	75	78	83	70	49	100	80	
VT4	53	100	100	100	100	100	100	68	100	91	
VT5	57	100	100	88	93	93	83	1	100	73	
VT6	53	100	100	88	85	98	80	1	100	71	
VT7	75	90	100	72	100	80	73	49	100	84	
VT8	45	100	100	72	88	78	70	49	100	79	

The Water Quality Index (WQI) is a single value expression that summarizes numerous parameters and provides a measure of water quality. Water quality indices (WQIs) were calculated for the samples using the concentration of 9 parameters such as pH, DO, COD, BOD₅, TSS, N-NH₄⁺, P-PO₄³⁻, turbidity, total Coliform. The river water quality classification was indicated in Table 2. Based on the seasonal WQI values (wet season; dry season) at the sampling stations. The WQI of the samples ranged from 86 to 92 in wet season, and from 71 to 91 in dry season. The color in the map is corresponding to the WQI scale as shown in Table 1. According to the calculated value of the WQI, 87,5% of the experimented samples show excellent and good and 12,5% of the samples fall under good quality type water for drinking purposes (table 2). More over the overall status of the quality of water around the Chau Pha lake has been shown in Table 3 which might be helpful to have the proper monitoring program for maintaining sustainable water environ and sound mining operation in the area. According to the investigation results of the source of pollution of Chau Pha Lake from Phan Cong Soai (2019), domestic wastewater, livestock wastewater, agricultural wastewater, and production wastewater were the cause affecting the lake water quality.

3.4. Correlation analysis

TABLE 4. Correlation coefficient between WQI and water quality parameters

Parameters	COD mg/L	BOD ₅ mg/L	TSS mg/L	N-NH ₄ ⁺ mg/L	Turbidity NTU	PO ₄ ³⁻ mg/L	Coliform MPN/100ml	WQI Total
COD mg/L	1							
BOD ₅ mg/L	0.71	1.00						
TSS mg/L	0.43	0.49	1					
N-NH ₄ ⁺ mg/L	0.46	0.59	0.15	1				
Turbidity NTU	0.28	0.35	0.08	0.44	1			
PO ₄ ³⁻ mg/L	-0.01	0.24	0.19	0.29	0.23	1		
Coliform MPN/100ml	0.04	0.54	0.30	0.04	-0.08	0.06	1	
WQI Total	-0.65	-0.57	-0.42	-0.59	-0.84	-0.38	0.006	1

In bold correlation is significant at the 0.01 level (2-tailed)

The results of the ranking correlation matrix analysis for different water quality parameters (Table 4) show that the COD showed a significant positive correlation with BOD5 (0.71); The BOD showed a significant positive correlation ammonium (0.59). From correlation coefficient values between WQI and water quality parameters, it is evident that COD,

Turbidity, BOD₅ and N-NH₄⁺ were the most affecting factors for the computed WQI values of Chau Pha Lake in the study period. WQI total showed a significant negative correlation with COD (-0.65), BOD₅ (-0.57), N-NH₄⁺ (-0.59), Turbidity (-0.84).

4. Conclusion

The WQI values of Chau Pha lake water ranged from 71 to 92; in which, most of the water samples fell in excellent and good water quality (class I and II), and medium water quality (class III, WQI ranges from 71 to 73) only 12,5%. Accordingly, the Chau Pha lake water quality was suitable for public water supply. It is, therefore, necessary to have solutions to maintain water quality.

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