

# Journal of Energy Technology & Environment www.nipes.org



## **Evaluating Surface Water Quality in Cai Nuoc River, Ca Mau Province,** Vietnam

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#### **Article information**

Article History Received 26 January 2024 Revised 20 February 2025 Accepted 27 February 2025 Available online 13 March 2025

Keywords:

Water quality, eutrophication index, WQI index, principal component analysis, Cai Nuoc River.



https://doi.org/10.5281/zenodo.15020707

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#### Abstract

This study aims to evaluate surface water quality in Cai Nuoc River, Ca Mau province using a water quality index and principal component analysis. Surface water quality is assessed using National Technical Regulation on surface water quality (QCVN 08-MT:2015/BTNMT, Column B1), water quality index (WQI), eutrophication index (EI) with the support of principal component analysis (PCA). Nine water quality parameters of pH, DO, TSS, COD, BOD,  $N-NH_4^+$ ,  $P-PO_4^{3-}$ ,  $N-NO_3^-$  and colliform were used for the evaluation and index calculations. The results presented that surface water quality in Cai Nuoc River was polluted by low DO and high N- $NH_{4^{+}}$  and  $P-PO_{4^{3^{-}}}$ . The WQI index classified water quality from average to very good (WQI= 73-94), relatively suitable for the survival and development of aquatic organisms. Meanwhile, the EI index showed the water bodies was in the stages of the poor to super eutrophication, mainly due to aquaculture and seafood processing activities. PCA determined three potential sources responsible for 100% of water quality fluctuations. The problems of organic and nutrients pollution in the study areas should be urgently solved to preserve diversity of aquatic organisms.

#### **1. Introduction**

Water is one of the most important and valuable resources on earth [1]. However, surface water quality has been affected by factors from natural processes and anthropogenic activities [2]. Therefore, water quality on rivers tends to decline in both quality and quantity, especially in coastal provinces. Ca Mau is a province with three sides adjacent to the sea, with a density of 1.34 km/km<sup>2</sup> and a total length of about 7,000 km (accounting for about 3.02% of the natural land area). However, the province's river system cannot supplement fresh water from the upstream of the Mekong River like other provinces in the Mekong Delta region. In recent years, Cai Nuoc River in Ca Mau province has been facing many environmental challenges, especially surface water environment. Because the water quality is affected by agricultural, industrial, aquaculture and civil activities. Therefore, regular monitoring and supervision of water quality is an urgent issue and needs great attention.

Not only in Vietnam but in many countries around the world, most water quality monitoring is carried out using traditional methods, through measuring physical and chemical parameters and comparing with surface water quality standards [3,4]. WQI is a popular tool for assessing surface water quality, it uses synthetic techniques that allow the analysis of large data sets of water quality varying in space and time to create a unique value, indicating the water quality in that basin [5,6].

On the other hand, the eutrophication index is applied to determine the influencing factors causing water eutrophication [7-9]. Meanwhile, the principal component analysis method is used to identify influencing criteria and potential sources of pollution on surface water quality, from which representative criteria can be identified for assessment of water quality [10,11]. This is one of the first studies that evaluate surface water quality in Cai Nuoc River, Ca Mau province using EI, WQI and PCA at the same time. The results could provide useful information about the state of water quality for surface water quality monitoring and management.

## 2. Materials and methods

## 2.1 Surface water quality collection

Surface water quality monitoring data was collected from the Department of Natural Resources and Environment of Ca Mau province in 2022 [12]. Surface water quality in Cai Nuoc River was assessed through nine parameters including pH, dissolved oxygen (DO), total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonium (N– $NH_4^+$ ), orthophosphate (P– $PO_4^{3-}$ ), nitrate (N– $NO_3^-$ ) and coliform. Samples were collected at four monitoring locations and labeled as CN1 (Cai Nuoc River Junction), CN2 (Thi Tuong A Hamlet, Hung My Commune), CN3 (Dai Loi company, Lo Xe River, Phu Hung commune) and CN4 (Nha Phan market) (Figure 1). Surface water quality was monitored with a frequency of three times per year in August, October and December.



Figure 1. Demonstrations of the sampling locations

#### 2.2 Surface water quality evaluation

Surface water quality of Cai Nuoc river, Cai Nuoc district, Ca Mau province was assessed according to national technical standards on surface water quality (QCVN 08-MT:2015/BTNMT, Column B1) [13]. Measurement methods and allowable limits of water quality indicators are presented in Table 1.

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No.	Parameters	Unit	Analytical methods	QCVN, B1
1	pH	-	TCVN 6492:2011	5.5 - 9
2	DO	mg/L	TCVN 7325:2016	$\geq 4$
3	TSS	mg/L	TCVN 6491:1999	50
4	COD	mg/L	SMEWW 5220.C:2017	30
5	BOD <sub>5</sub>	mg/L	TCVN 6001-1:2008	15
6	$N-NH_4^+$	mg/L	SMEWW 4500NH <sub>3</sub> .B&F:2017	0.9
7	$P - PO_4^{3-}$	mg/L	SMEWW 4500P.B&E:2017	0.3
8	N–NO <sub>3</sub> -	mg/L	TCVN 6638:2000	10
9	Coliform	MPN/100mL	TCVN 6187-2:2020	7500

Table 1. Water quality parameters and analytical methods

To evaluate the overall water quality in the Cai Nuoc River, the water quality index (WQI) was calculated according to Decision No. 1460/QD-TCMT dated November 12, 2019 of Vietnam Environment Administration [14]. In this study, the index was calculated using eight parameters, including pH, DO, COD, BOD, N–NH<sub>4</sub><sup>+</sup>, P–PO<sub>4</sub><sup>3-</sup>, N–NO<sub>3</sub><sup>-</sup> and coliform [14]. The WQI index was calculated according to Equation 1 and was classified as surface water quality as shown in Table 2.

In which, WQI<sub>I</sub> is the WQI value is calculated for the pH parameter; WQI<sub>IV</sub> is the WQI calculated for DO, COD, BOD,  $N-NH_4^+$ ,  $P-PO_4^{3-}$ ,  $N-NO_3^-$ ; WQI<sub>V</sub> is WQI calculated for coliform.

#### Table 2. Classification of surface water quality using WQI

Values of WQI	Water quality
91 - 100	Excellent
76 - 90	Good
51 – 75	Moderate
26 - 50	Poor
10 – 25	Very poor
< 10	Heavily polluted

The eutrophication index (EI) is used to simplify the quality of water with different nutrient concentrations in space and time. Eutrophication in water does not occur when EI<1 and occurs when  $EI \ge 1$  [8]. Besides, the eutrophication index is divided into five assessment levels to clarify the eutrophication of the basin based on the three indices of COD, DIN and DIP which were presented in Table 3. The equation to calculate the eutrophication index was presented according to Equation 2 and widely applied by many researchers to assess eutrophication status in basins [11, 15]:

In which, COD is chemical oxygen demand (mg/L); DIN is dissolved nitrogen species (mg/L); DIP is dissolved phosphorus (mg/L);  $S_C$  is the mean product of COD, DIN, DIP.

Table 3	: Classif	fication	of surfa	ice water	quality	using	Eutro	ohication	Index
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Values of EI	Water quality
EI < 0.5	Oligotrophic
0.5 < EI < 0.75	Mesotrophic
0.75 < EI< 1	Moderately eutrophic
1 < EI < 3	Eutrophic
EI ≥ 3	Hypereutrophic

Principal component analysis (PCA) was used to identify potential sources and main indicators affecting surface water quality in the study area. The main component is evaluated through the Eigenvalus index, the hidden source is determined to be meaningful and contribute significantly when the Eigenvalus coefficient > 1. In which the Eigenvalues coefficient > 1 is considered the main source of impact and the Eigenvalues < 1 are secondary sources [10]. Liu et al. (2003) [16] classified main indicators affecting water quality through weighted correlation coefficients. The weighted correlation coefficient is divided into three levels, from 0.3 - 0.5 is considered weak, 0.5 - 0.75 is medium and > 0.75 is high. Principal component analysis was performed using the copyrighted software Primer V5.2.9.

#### 3. Results and discussion

#### 3.1 Evaluating surface water quality using national technical regulation

The pH value in water at monitoring locations on Cai Nuoc River ranged from 6.3 to 7.48 (Figure 2). Specifically, pH in water was highest in August at the position CN4 and lowest in December at the position CN2. The pH values in water at the monitoring locations were within the allowable limit of QCVN 08-MT:2015/BTNMT, column B1 (5.5 - 9) [13]. Compared to other studies, the pH value in this study also fluctuated similarly to previous studies in the Mekong Delta. For example, according to research by Hong and Giao (2022) [17], measured in Phung Hiep district, Hau Giang province, the pH value in water ranged from 6.71 to 7.42. On the other hand, the research by Giao and Minh (2021) [18] showed that the pH value on the Tien River ranged from 6.7 to 7.4. Thereby, research results showed that surface water in Cai Nuoc River was mainly salt water and brackish water, so the pH was slightly alkaline and the monitoring locations were neutral, suitable for aquatic organisms.



Figure 2. Fluctuations of pH at monitoring locations on Cai Nuoc River

The dissolved oxygen (DO) presented in Figure 3 showing that surface water quality at the monitoring locations over the months fluctuated between 1.15 and 5.61 mg/L. In August, it can be seen that DO values all reached the allowable limit of QCVN 08-MT:2015/BTNMT, column B1 ( $\geq$  4mg/L), while in October and December DO values at most locations were lower than the allowable limit of the standards [13]. This could prove that the water quality in the study area was slight organic pollution [19]. The causes affecting DO concentration in water mainly may come from agricultural activities, aquaculture and high domestic wastewater leading to a decrease in DO in water. Living organisms depend on dissolved oxygen. Depending on the living environment, organisms use different forms of oxygen to maintain metabolism, growth and development. Therefore, low DO concentrations could affect the development of aquatic organisms and water ecosystems [20]. In general, dissolved oxygen at the monitoring locations fluctuated between space

and time but it was not significant. In addition, DO values in this study also fluctuated similarly to previous studies [21,22].



Figure 3. Fluctuations of DO at monitoring locations on Cai Nuoc River

Total suspended solids (TSS) in water bodies in the study area ranged from 10 to 42 mg/L (Figure 4). In which, the position CN1 in August recorded the lowest TSS value and the position CN2 in October recorded the highest TSS value. It can be seen that the TSS values measured in August were lower than those measured in October and December. However, the values were low and within the allowable limit of QCVN 08-MT:2015/ BTNMT, column B1 (50 mg/L) [13]. The TSS in water is mainly produced from silt and mineral colloids and depends on the level of water disturbance and the amount of water flowing into canals and rivers [23]. Besides, erosion and rainwater runoff are also the causes of TSS in water. Comparing with reference values from the previous studies, it can be seen that the TSS in Cai Nuoc River is lower than that in other water bodies in the Mekong Delta. Specifically, in Hau River the TSS concentration ranged from 45 to 59 mg/L [6].



Figure 4. Fluctuations of TSS at monitoring locations on Cai Nuoc River

Chemical oxygen demand (COD) at surface water quality monitoring locations in Cai Nuoc River was presented in Figure 5. At the location CN1, COD concentration in water ranged from 18 to 24.8 mg/L, and at the location CN2, the COD concentration in water ranged from 18 to 24.8 mg/L, at the location CN3 fluctuated between 20 - 23 mg/L, at the position CN4 ranged from 21.73 to 24 mg/L. In general, COD concentrations in the study area range from 16 to 24.8 mg/L, lower than the allowable threshold of QCVN 08-MT:2015/BTNMT column B1 (30 mg/L) [13]. Monitoring results showed that the COD concentration in water in Cai Nuoc River is similar to other studies, specifically in Hau Giang COD ranged from  $18.5\pm4.93$  to  $21.25\pm7.13$  [17], research in An Giang province COD values ranged from 14.0 to 21.7 mg/L [24]. Meanwhile, the average COD value in

Soc Trang ranges from  $10.19\pm1.59$  mg/L to  $72.15\pm13.65$  mg/L [25] significantly higher than that in the study area. In general, at all monitoring locations of COD values in Cai Nuoc River, there are fluctuations in water quality over space and time but are not significant.



Figure 5. COD fluctuations at monitoring locations on Cai Nuoc River

Biochemical oxygen demand (BOD) in surface water over months of monitoring in the study area ranged from 1.15 to 13.6 mg/L. In particular, the BOD in August fluctuated between 11.1 - 13.6 mg/L, in October the BOD value was in the range of 12 - 13 mg/L and the BOD value measured was in the range of 1.15 - 11 mg/L in December (Figure 6). Research results showed that BOD at the monitoring locations in Cai Nuoc River fluctuated between space and time but it was not significant. Compared with some studies, it can be seen that the BOD in Cai Nuoc River was relatively lower than that in some other water bodies [26,27]. BOD in Cai Nuoc River was within the allowable limit according to QCVN 08-MT:2015/BTNMT, column B1 (15mg/L) [13]. In general, in the study area there were still no signs of organic pollution.



Figure 6. Fluctuations of BOD at monitoring locations on Cai Nuoc River

Ammonium (N-NH<sub>4</sub><sup>+</sup>) concentration in surface water in the study area over the months ranged from 0.27 to 5.7 mg/L (Figure 7). N-NH<sub>4</sub><sup>+</sup> at the position CN1 fluctuates between 0.3 - 0.42 mg/L. It can be seen that N-NH<sub>4</sub><sup>+</sup> at this location had little variation over the monitoring time (August, October and December). For the position CN2, N-NH<sub>4</sub><sup>+</sup> values ranged from 0.31 to 0.35 mg/L. Meanwhile, at the location CN3, N-NH<sub>4</sub><sup>+</sup> concentration in Cai Nuoc River had large fluctuations in the monitoring months with the values ranging from 0.87 to 5.7 mg/L. In October, N-NH<sub>4</sub><sup>+</sup> exceeded the allowable threshold and had a relatively large fluctuation. Finally, at the position CN4, N-NH<sub>4</sub><sup>+</sup> value was similar to those of the positions CN1 and CN2. N-NH<sub>4</sub><sup>+</sup> value in this study fluctuated more than that in previous studies. N-NH<sub>4</sub><sup>+</sup> concentrations in water bodies in Soc Trang and Bac Lieu provinces were  $0.1\pm0.00 - 2.3\pm1.60$  mg/L and  $0.66\pm0.71 - 1.55\pm0.86$  mg/L, respectively [21], in Ca Mau's water bodies ranged from  $0.07\pm0.05$  to  $0.17\pm0.09$  mg/L [28]. According to research by Tam et al. (2022) [29], source of nutrient pollution in water originating from wastes in daily life and industrial activities. From the research results, it showed that N-NH<sub>4</sub><sup>+</sup> at almost all monitoring

locations were within the allowable limit of QCVN 08-MT:2015/BTNMT (column B1) [13], except for location CN3. High N-NH<sub>4</sub><sup>+</sup> in surface water has the potential to cause eutrophication of water sources and affect the environment.



Figure 7. Fluctuations of N–NH4<sup>+</sup> at monitoring locations on Cai Nuoc River

Figure 8 presented the fluctuations in orthophosphate (P–PO<sub>4</sub><sup>3-</sup>) concentration in water bodies at the monitoring locations in three periods on the Cai Nuoc River. The concentration of P–PO<sub>4</sub><sup>3-</sup> in August at the locations ranged from 0.03 to 0.43 mg/L. In particular, at location CN3, the concentration of P–PO<sub>4</sub><sup>3-</sup> was significantly higher than that in the remaining areas and was 4.43 times higher than the allowable standard of QCVN 08-MT:2015/BTNMT, column B1 (0.3 mg/L) [13]. In October, P–PO<sub>4</sub><sup>3-</sup> concentrations at all monitoring locations were at non-detection range, except for the location CN3, which exceeded 1.87 times the allowed standard (0.56 mg/L). Similarly, in December, the P–PO<sub>4</sub><sup>3-</sup> concentration at the location CN3 had a value of 0.72 mg/L, 2.4 times higher than the standard. Meanwhile, at three locations CN1, CN2 and CN4, the measured P–PO<sub>4</sub><sup>3-</sup> values were lower than the detection limit. Phosphate in river water is not toxic to humans, animals or fish and is a limiting factor in eutrophication [30]. Similarly, previous studies reported that P–PO<sub>4</sub><sup>3-</sup> in water bodies in Soc Trang province ranged from 0.17±0.18 to 0.36±0.49 mg/L[25], in Bac Lieu province ranged from 0.22±0.13 to 0.3±0.09 [23].



Figure 8. Fluctuations of P–PO4<sup>3-</sup> at monitoring locations on the Cai Nuoc River

Nitrate (N-NO<sub>3</sub><sup>-</sup>) in surface water in August at the locations CN1, CN2 and CN4 had value of about 0.2 mg/L. Meanwhile, in October and December, N-NO<sub>3</sub><sup>-</sup> values were at the non-detection range. For the location CN3, the N-NO<sub>3</sub><sup>-</sup> concentration in three months ranged from 1.5 to 1.8 mg/L. It can be seen that in October, the N-NO<sub>3</sub><sup>-</sup> concentration was higher than that in the remaining months. According to Giao (2022) [21], in the coastal provinces of Soc Trang and Bac Lieu, N-NO<sub>3</sub><sup>-</sup> ranged from 0.01 to 1.93 mg/L, while in the study of Chuong et al. (2024) [22], the N-NO<sub>3</sub><sup>-</sup> value in water bodies of Thoi Binh district ranged from 0.095 to 1.234 mg/L. It can be seen that in this study, the

 $N-NO_3^-$  value was assessed to have higher fluctuations than that in previous studies. However, nitrate concentrations in the water body of the Cai Nuoc River were lower than the standard limit and it could not harm the growth of aquatic plants.



Figure 9. Fluctuations of N–NO3<sup>-</sup> at monitoring locations on Cai Nuoc River

Coliform density in surface water in the study area ranged from 1,300 to 2,000 MPN/100mL (Figure 10). For the average value of the assessed coliform population, there was no large variation between months at the 4 monitoring locations. From the results, it showed that the coliform density was within the allowable range of QCVN 08-MT:2015/BTNMT, column B1 (7,500 MPN/100mL) [13]. Coliform is a group of bacteria that often appears in waste from warm-blooded animals and humans, leading to the appearance of pathogens due to the presence of this type of microorganism in water [31]. Coliform density in this study had a relatively low value compared to previous studies. In Bac Lieu water body, coliform density ranged from 1,100 to 9,500 MPN/100mL [26], in Tien River coliform ranged from 2,621 to 11,968 MPN/100mL [18]. However, the appearance of coliform in surface water shows that the water source having signs of mild microbiological pollution. The research results showed that coliform density in Cai Nuoc River had little variation over space and time.



Figure 10. Coliform fluctuations at monitoring locations on Cai Nuoc River

In summary, surface water quality in Cai Nuoc River was polluted by DO,  $N-NH_4^+$  and  $P-PO_4^{3-}$ . This result was also consistent with the previous studies in the Mekong Delta showing signs of organic and nutrient pollution [18,26]. Water quality in the study area was fluctuated depending on the sampling locations, especially at the location CN3 where is heavily influenced by seafood

production and processing activities. The parameters including pH, TSS, COD, BOD, N-NO<sub>3</sub><sup>-</sup> and coliform were still within the allowable limits of QCVN 08-MT:2015/BTNMT, column B1 [13].

## 3.2 Evaluating surface water quality using WQI



Figure 11. Surface water quality by water quality index

The results of calculating the water quality index (WQI) at Cai Nuoc River are shown in Figure 11. The average value of WQI in the study area ranged from 73 to 94, classifying water quality from average to very good level. In particular, water quality at three out of four locations (CN1, CN2 and CN4) was classified as good to very good (WQI= 88-94). Meanwhile, water quality at the location CN3 was classified from average to good (WQI= 71-75). Water quality at the location CN3 was assessed to be worse than the remaining locations in the study area. This can be explained by the fact that the location CN3 was located at a company specializing in the production and processing of frozen seafood. As can be seen that the quality of surface water in Cai Nuoc River could only be used for irrigation, domestic water and other purposes, but appropriate treatment measures are still needed. Khanh et al. (2022) [6] reported poor water quality (WQI= 26-50) in Chau Phu district, An Giang province. Thuan (2022) [32] presented water quality of Hau Giang province ranged from poor to very good (WQI= 23-96). The overall surface water quality in the study area was relatively better than those in other studies.

## 3.3 Eutrophication of surface water

The results of eutrophication index at Cai Nuoc River were presented in Table 4. The values of eutrophication index at Cai Nuoc River ranged from 0 to 89.2. In August, at locations CN1 and CN2, the EI values in the water environment were 0.37 and 0.33, respectively, showing that the water condition at these two locations was in a poor state of nutrients (EI < 0.5). At location CN3, the water was super eutrophic (EI =  $68.4 \ge 3$ ). At the location CN4, the EI value was 0.54 classifying water quality at mesotrophic level ( $0.5 \le EI < 0.75$ ). Meanwhile, in October and December, eutrophication index was assessed to be similar. Specifically, at the locations CN1, CN2 and CN4, the eutrophication index was assessed as poor in nutrients (EI=0). As for location CN3, the water condition was classified as super eutrophic since the EI value was 89.2 (October) and 41.1 (December). From the analysis results, it showed that the average level of eutrophication in CN3

had a higher EI value than that in the other locations in the study area. The excess amount of nutrients in this water area was the cause of reduced water quality in the area, which was consistent with the observed N-NH<sub>4</sub><sup>+</sup> and P-PO<sub>4</sub><sup>3-</sup> concentrations. Regarding the status and level of eutrophication in the Cai Nuoc river section, the main cause could be the development of agricultural and aquaculture activities, especially in intensive and super-intensive shrimp farming models. These sources could release great amount of nutrients into the water environment, causing eutrophication [7,33]. Eutrophication in surface water not only causes deterioration of water quality but also contributes to the degradation of sediments, habitats and biological communities [34].

Table 4. Results of cut opineation rever in Cat Nuce River								
Month	CN1	CN2	CN3	CN4				
August	0.37	0.33	68.4	0.54				
October	0	0	89.2	0				
December	0	0	41.1	0				

#### Table 4. Results of eutrophication level in Cai Nuoc River

#### 3.4 Identifying the main causes affecting water quality

Principal component analysis (PCA) results showed that the surface water in Cai Nuoc River was influenced by three main potential sources (Table 3). The main factors comprising PC1, PC2, PC3 explained water quality fluctuations, contributing 53.5%, 29.3% and 17.2%, respectively. Eigenvalue coefficients are used to determine the importance of each major component in influencing water quality fluctuations. In this study, the eigenvalues of the 3 PCs were greater than 1, which is considered the main potential source. The analysis results indicated that PC1 had weak correlation with the indicators of pH, DO, N–NH<sub>4</sub><sup>+</sup>, P–PO<sub>4</sub><sup>3-</sup> and N–NO<sub>3</sub><sup>-</sup>. Previous study presented that PC1 often explained surface water quality affected by nutrients, as well as by hydrological conditions, domestic sources and production and aquaculture activities [3]. PC2 had the contribution of BOD at a weak correlation level and at a moderate correlation level with TSS and coliform. Besides, the Eigenvalue value in PC2 was 2.64 and explained 29.3% of the variation in water quality. It can be seen that the presence of TSS comes from surface runoff, river bank erosion and farming activities [3]; Meanwhile, coliform in water originates from the feces of warm-blooded animals [35]. At PC3, pH and COD were evaluated at a medium correlation level, while at the DO and BOD were at weak relationship. In short, pH, TSS, DO, COD, BOD, N-NH4<sup>+</sup>, P-PO4<sup>3-</sup> N-NO3<sup>-</sup> and coliform were the main parameters influencing surface water quality. Previous studies also reported that these indicators also responsible for water quality shifting in the Mekong Delta [11,18].

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Parameters	PC1	PC2	PC3
рН	-0.326	-0.157	0.523
TSS	0.156	-0.577	-0.044
DO	-0.392	-0.042	0.405
COD	-0.273	0.148	-0.614
BOD <sub>5</sub>	0.150	0.493	0.402
$N-NH_4^+$	-0.454	-0.003	-0.080
$P - PO_4^{3-}$	-0.454	-0.011	-0.077
N–NO3 <sup>-</sup>	-0.454	-0.011	-0.077
Coliform	0.037	-0.612	0.057
Eigenvalues	4.81	2.64	1.55
%Var.	53.5	29.3	17.2
Cum.%Var.	53.5	82.8	100

Table 5.	Kev	variables	influen	cing on	surface	water	quality	in	Cai N	Nuo
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#### 4. Conclusion

The results showed that surface water quality in Cai Nuoc River was polluted by low DO and high  $N-NH_4^+$  and  $P-PO_4^{3-}$ ). WQI classified water quality from average to very good (WQI= 73-94), relatively suitable for the survival and development of organisms. The EI indicated surface water from poor to super eutrophication, mainly concentrated in aquaculture and seafood processing areas. PCA results identified PC1, PC2, PC3 responsible for water quality variation by 53.5%, 29.3% and 17.2%, respectively. The indicators including pH, TSS, DO, COD, BOD,  $N-NH_4^+$ ,  $P-PO_4^{3-}$ ,  $N-NO_3^-$  and coliform should be future monitored. The current findings provide scientific information regarding state of surface water quality in the study area for water use choice and surface water management.

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