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Seasonal Variation and Key Parameters Influencing Surface Water Quality in Xa No Canal Segment Belonging to Vi Thanh District, Hau Giang Province, Vietnam

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Abstract

The study was conducted to assess the surface water quality on Xa No canal in Vi Thanh district, Hau Giang province. Surface water quality samples were collected at 3 locations with a frequency of 4 times per year including March, May, August and October 2020 from the Department of Natural Resources and Environment of Hau Giang province. The results showed that the temperature, pH and NO_3^--N in the study area is still within the allowable limits of QCVN 08-MT:2015/BTNMT, Column A1. Surface water in the study area was contaminated with organic (low DO, TSS, BOD, high COD), nutrients (NH_4^+-N and PO_4^{3-}-P exceeded permissible limits), heavy metals (Fe) and coliform. Water quality has obvious seasonal variation in which DO in August and TSS, BOD, COD, NO_2^--N in May were significantly higher than those in other months. NH_4^+-N and PO_4^{3-}-P in October were higher than those in March, May and August. Meanwhile, iron and coliform in March were significantly lower than those in other months. The results showed that the WQI (25 to 52) classified the water quality was from bad to moderate in which water quality in October was better than that in the other months. Surface water quality at Xa No canal was influenced by five potential polluting sources which caused 92.4% of water quality variation. All monitoring parameters (pH, temperature, TSS, DO, BOD, COD, NH_4^+-N, NO_2^--N, NO_3^--N, PO_4^{3-}-P, Fe and coliforms had impact on water quality and need to be continuously monitored. However, NO_2^--N, BOD can be considered to reduce because it can be predicted from other indicators such as DO, COD and NH_4^+-N. Environmental management agencies need to find solutions to improve water quality, especially organic matters and microorganisms.

1. Introduction

Xa No canal was dug by the French in the dry season from 1901 to July 1903, when it was completed. Xa No canal with a surface width of 60 m, a bottom width of 40 m, a depth of 2.5 - 9 m, connects the Hau River (from Vam canal to Can Tho canal) to Cai Lon river (Cai Tu canal) [1]. The flow rate of Xa No canal is 9.27 m^3/s. The average flow velocity is 0.16 m/s [1]. In addition to solving drainage for about 40,000 hectares of agricultural production in the region, Xa No canal is also a very important canal for rice trade in Hau Giang region [1]. To promote the effect of Xa No canal, the French continued to dig horizontal branch canals into the fields, every 500 meters is a small canal, 1,000 meters is a large canal. From there, there are places such as One Thousand, Seven Thousand, Seven Thousand and Half, Ten Thousand. in Chau Thanh A district, Hau Giang province [1]. In addition, along the main canal branch, there are many small interlaced canals. The section of Xa No canal through Vi Thanh town includes canal branches such as Canal Ba Nha, Canal 59, Kenh Muong Lo, Rach Cai Nhut, Kenh Tac, and Kenh Cai Sinh. Xa No canal - Hau Giang province is one of the arterial waterways in circulation and trade between provinces, neighboring localities and the region [2]. Like other rivers in the province, Xa No canal is the main source of water supply for daily life in urban and rural areas, especially people in rural areas, areas without a network of clean water supply and low-income people [1]. In addition to the main canal, the canal also has many interconnected small branches to serve cultivation, husbandry and aquaculture [1,2]. However, the canal is the place to receive wastewater from waste sources on the canal such as boats and ships. In addition, the canal also receives wastewater from activities of industrial parks and factories along both sides of the canal areas. This study was conducted to evaluate seasonal variation and key water parameters influencing surface water quality in Xa No canal. The results of the current study could provide useful information for better surface water quality management in the study area.

2. Materials and methods

Surface water samples were respectively determined in March (end of dry season), May (onset of rainy season), August (end of rainy season) and October (onset of dry season) at three sampling sites including XN1-XN3.

Table 1. The sampling sites in the study area

No.	Code	Brief description
1	XN1	Xang Xa No canal, near Vi Thanh water plant
2	XN2	Xang Xa No Canal, 50m from Vi Thanh Sugar Enterprise
3	XN3	Xa No canal, Cai Tu bridge - Tan Tien commune

Three water samples were collected in accordance with the guide of TCVN 6663-6:2018 (ISO 5667-6:2014) – Guidance on sampling of rivers and streams. A total of 12 parameters were analyzed to assess water quality such as pH, temperature, TSS (mg/L), DO (mg/L), BOD (mg/L), COD (mg/L), NH_4^+-N (mg/L), NO_2^--N (mg/L), NO_3^--N (mg/L), PO_4^{3-}-P (mg/L), Fe (mg/L) and coliforms (MPN/100mL). pH, temperature and DO parameters were measured in-situ by pH meter (HANNA HI 8224, Rumani) and DO meter (Milwaukee SM 600, Rumani). The remaining water quality indicators were properly preserved and analyzed at the laboratory of the Provincial Center for Natural Resources and Environment Monitoring Hau Giang province by Standard methods [3].

Table 2. Limited value of surface water quality parameters

Paramater	Units	Limit values	
		QCVN*A1	QCVN*A2
pH	-	6-8.5	6-8.5
Temp.	^{0}C	-	-
TSS	mg/L	20	30
DO	mg/L	≥6	≥5
BOD	mg/L	4	6
COD	mg/L	10	15
NH_4^+-N	mg/L	0.3	0.3

NO_2^--N	mg/L	0.05	0.05
NO_3^--N	mg/L	2	5
PO_4^{3-}-P	mg/L	0.1	0.2
Coliforms	MPN/100mL	2500	5000
Fe	mg/L	0.5	1

**National technical regulation on surface water quality (QCVN: 08-MT: 2015/BTNMT) [4]. A1 means water quality used for domestic purposes (after normal treatment has been applied), conservation of aquatic plants and animals and other purposes; A2 is used for domestic purposes but treatment technology must be applied.*

The WQI index is calculated according to the guidance in Decision No. 1460/QD-TCMT on the promulgation of the technical guidelines for the calculation and publication of the Vietnam Water Quality Index (WQI) [5]. The Water Quality Index (WQI) is a composite index that is calculated from defined water quality parameters through a mathematical formula. WQI is a quantitative description of water quality and is expressed on a scale. WQI parameters are calculated according to the Equation (1):

$$WQI = \frac{WQI_{pH}}{100} \times \left[\frac{1}{k}\sum_{i=1}^{k} WQI_{IV} \times \frac{1}{l}\sum_{i=1}^{l} WQI_{V}\right]^{1/2} \quad \text{(Eq. 1)}$$

Where: WQI_{pH}: Calculated WQI value for pH parameter; WQI_{II}: Calculated WQI value for the parameter; $WQII_{I}$: WQI calculated value for parameters: DO, BOD, COD, NH_4^+-N, NO_2^--N, NO_3^--N, PO_4^{3-}-P WQI_{II}: The calculated WQI value for the coliform parameter. The scale of water quality is presented in Table 3.

Table 3. Scale of water quality index assessment

WQI	**Water quality**	Water quality level	**Color**
91 - 100	Very good	Good for domestic water supply purposes	Blue
76 - 90	Good	Use for domestic water supply purposes but need appropriate treatment measures	Green
51 - 75	Moderate	Used for irrigation and other similar purposes	Yellow
26 - 50	Poor	Used for navigation and other similar purposes	Orange
10 - 25	Very poor	Heavily polluted water, needing treatment measures in the future	Red
<10	Extremely poor	Toxic water, need to take measures to overcome and treat	Brown

In this study, the main factor analysis (PCA-Principal Component Analysis) is widely applied in multivariate analysis used to extract important information from the initial data set [6,7]. PCA reduces the original data variables that did not make a significant contribution to the data variability while creating a new group of variables called the principal or principal (PC) variables. These PCs are unrelated to each other and appear in descending order of importance. The important value to consider the main components is the eigenvalue coefficient, the larger the coefficient, the greater the contribution that major component contributes to explaining the variability of the original data set. The pivot method used in PCA is Varimax, each initial data variable will be assigned a factor and each factor will represent a small group of original variables [7]. The correlation between the main component and the initial data variables is indicated by the loading correlation coefficients [7]. PCA was conducted using Primer 5.2 software for Windows (PRIMER-E Ltd, Plymouth, UK). Based on PCA classification, water environment monitoring criteria will be proposed

3. Results and discussion

3.1 Evaluating surface water quality using national technical standards

Water temperature ranged from 27.5^{o}C to 31.1^{o}C (average 29.1^{o}C). This temperature is within the general range of the Mekong Delta region [8-10]. Temperatures in March, May, August and September are 27.9 ^{o}C, 31.1 ^{o}C, 29.2 ^{o}C, 28.3 ^{o}C, respectively (Figure 1). Water temperature did not differ much between months and sampling locations. This temperature range is still within the tolerance limit of aquatic organisms [11,12].

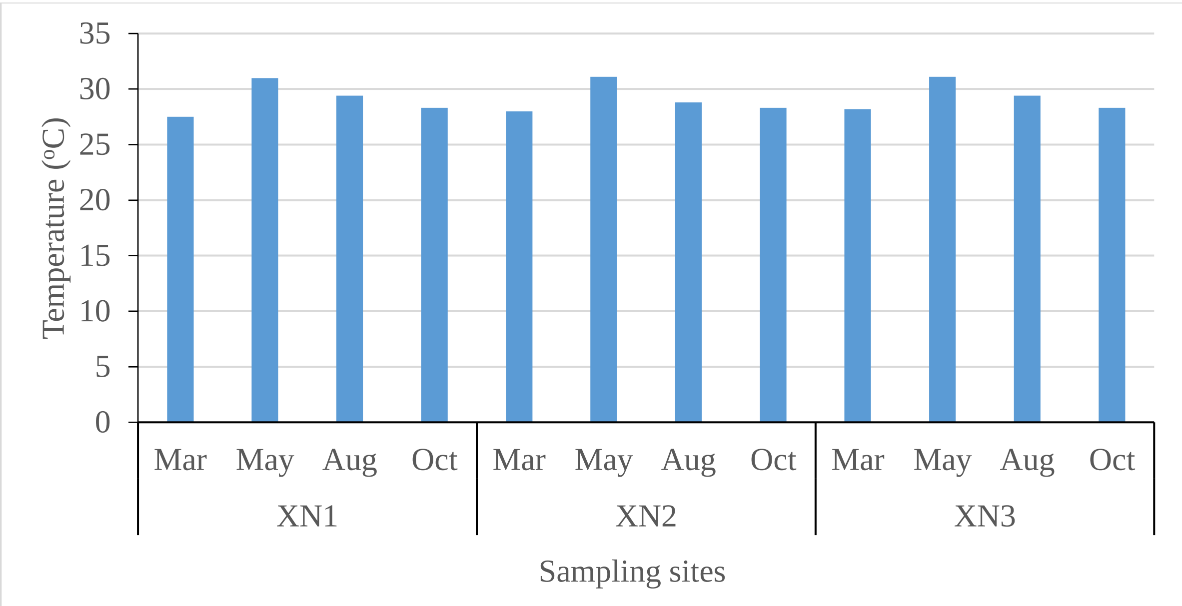

Figure 1. Temperature in the study area

Water pH values ranged from 6.7 to 7.1 (mean 6.9). Temperatures in March, May, August and September are 7.0, 6.8, 6.8, 7.0, respectively (Figure 2). The results of this study are consistent with the pH values of some previous studies. Previous studies showed that pH in canals in An Giang province ranged from 6.9-7.1 [8], in main rivers and tributaries of Hau river in 2016 ranged from 6.3-8.0 [9] and Hau river in An Giang section. Hau Giang ranges from 6.7-7.12 [13]. The pH value did not differ much between the months and the sampling sites. In general, the pH value in the studies has similarity that the pH has little variation in space and time and is within the allowable range of QCVN 08-MT:2015/BTNMT [4]. pH does not highly fluctuate and this is the common condition in tropical region [6].

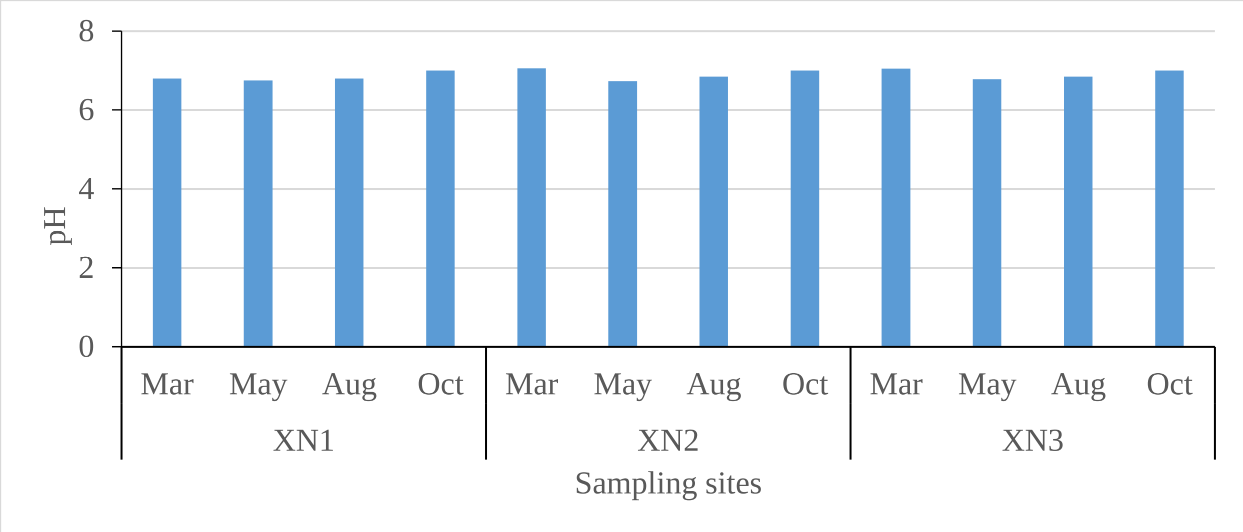

Figure 2. pH in the study area

The concentration of suspended solids (TSS) in water ranged from 20.0 mg/L to 70.0 mg/L (mean 53.8 mg/L). TSS in Hau river ranges from 41.2±33.7 mg/L to 89.57±31.31 mg/L [9], in canals of An Giang province from 25.0 ± 11.5 mg/L to 93.7 ± 28.3 mg/L [8]. In general, TSS in water bodies often exceeds the allowable limit of QCVN 08-MT:2015/BTNMT [4]. TSS content between locations fluctuates greatly. The suspended solids concentrations in the months of March, May, August and September were 56.7 mg/L, 70.0 mg/L, 39.7 mg/L, and 48.7 mg/L, respectively (Figure 3). The suspended solids content in May was significantly higher than in other months. Previous research also showed that TSS has seasonal variation, usually TSS in the rainy season is higher than in the dry season [2,10]. TSS increases the cost of water treatment, affecting aquatic life [11]. TSS is also a carrier that helps transport other pollutants such as pathogenic microorganisms, pesticides, antibiotics to different places in the water body, increasing the possibility of exposure to unfavorable environment for humans and organisms [2,10].

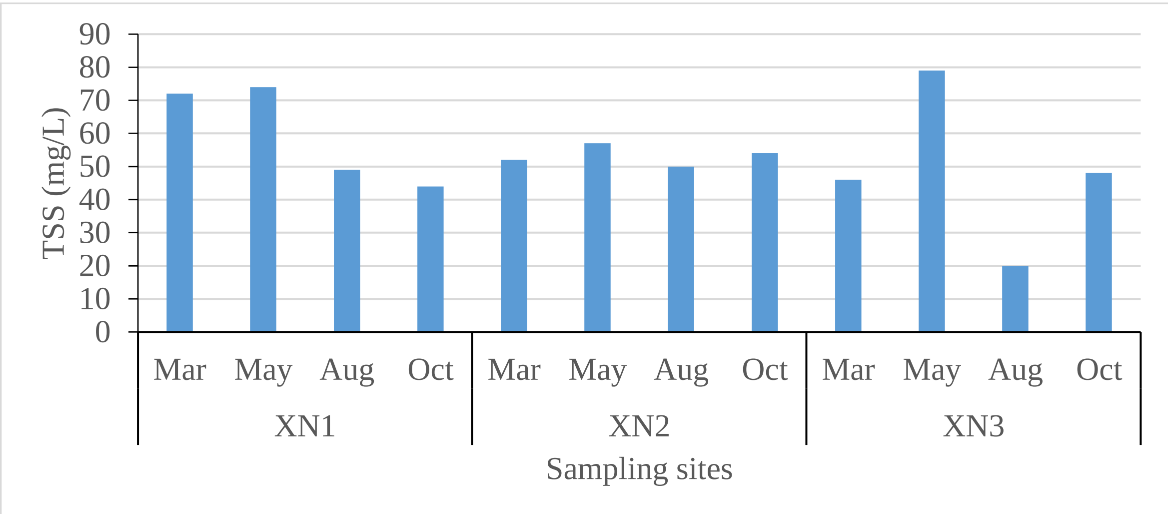

Figure 3. TSS in the study area

Dissolved oxygen content in water ranged from 2.6 mg/L to 4.1 mg/L (mean 3.3 mg/L). The average DO concentration in the upstream water bodies of An Giang ranges from 4.0-5.2 mg/L [8], the Hau river is 4.8±1.1- 5.5±0.7 mg/L [9.13]. The DO content between sites fluctuates greatly. DO in the months of March, May, August and September were 3.7 mg/L, 2.6 mg/L, 4.0 mg/L, 2.9 mg/L, respectively (Figure 4). DO in August is significantly higher than other months. On the Hau River, the mean DO in the months of March, June, and September was 5.5±1, 5.6±0.3, and 6.1±0.6 mg/L, respectively, showing that September was higher than the remaining months [13]. DO at all sampling locations are lower than the allowable value of Vietnamese standards. All living things depend on the amount of oxygen, depending on the environment, the organisms will use different forms of oxygen. For the aquatic environment, dissolved oxygen (DO) is a very important factor, in order to maintain metabolism, growth and development [11,14].

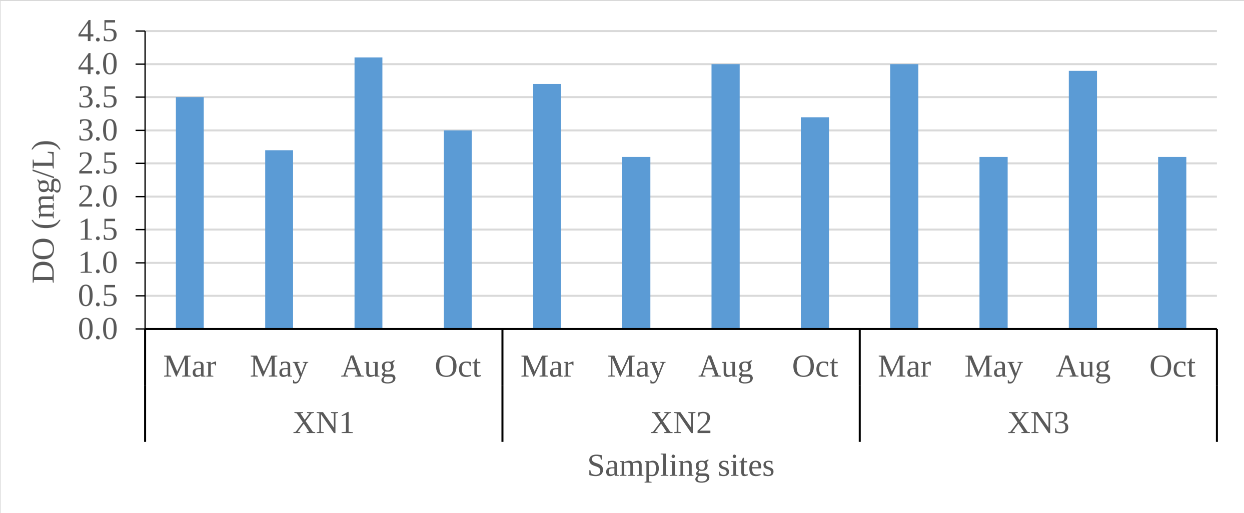

Figure 4. DO in the study area

The biochemical oxygen demand in water ranges from 6.7 mg/L to 17.0 mg/L (mean 10.3 mg/L). The biochemical oxygen demand between sites fluctuates greatly. BOD in the months of March, May, August and September were 9.3 mg/L, 13.3 mg/L, 8.0 mg/L, 10.7 mg/L, respectively (Figure 5). The biochemical oxygen demand in May is significantly higher than in other months. BOD in months and years tended to increase, ranging from 5.1±4.2 mg/L to 10.5±3.9 mg/L. BOD values in the months of March, June, and September were 6.1±1.6 mg/L, 5.1±2.2 mg/L and 8.9±2.6 mg/L, respectively, indicating that the BOD was significantly higher in the rainy season compared to the rainy season. dry [13]. The seasonal variation of organic compounds in which the rainy season is higher than the dry season is also noted by previous studies [8]. The biochemical oxygen demand at all sampling sites is higher than the allowable value of Vietnamese standards. High BOD is a common problem of water bodies in the Mekong Delta [8-10]. River water with a BOD content exceeding QCVN 08-MT:2015/BTNMT [4] poses many risks when used as feed water because organic compounds can combine with chlorine during the disinfection phase to produce harmful chemicals. compounds hazardous to health when exposed to the community through the use of water [15].

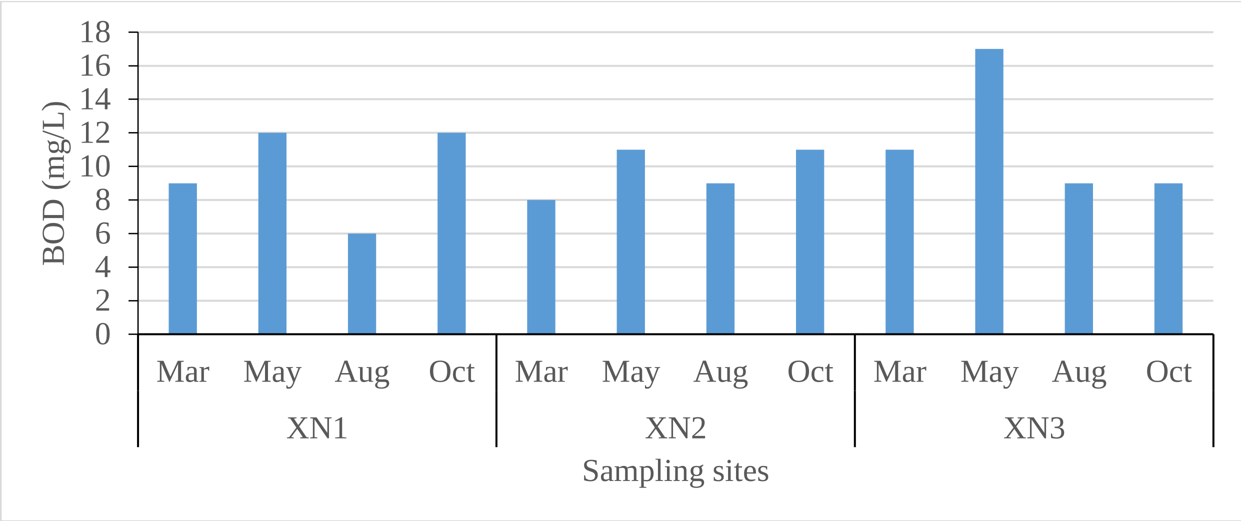

Figure 5. BOD in the study area

The chemical oxygen demand in water ranges from 10.0 mg/L to 30.0 mg/L (mean 18.5 mg/L). The chemical oxygen demand between sites fluctuates greatly. Chemical oxygen demand in the months of March, May, August and September is 14.3 mg/L, 26.3 mg/L, 14.0 mg/L, 19.3 mg/L, respectively (Figure 6). Chemical oxygen demand in May is significantly higher than in other months. COD in Tien River ranged from 10.75 mg/L -15.5 mg/L, the lowest was 7 mg/L in March and the highest 20 mg/L in November [16]. Thus, COD has seasonal variation similar to the results of this study. COD at all positions exceeded the allowable limit of QCVN 08-MT:2015/BTNMT [4], column A1 (10 mg/L). High chemical oxygen demand will reduce the DO concentration of water, which is harmful to aquatic organisms and the aquatic ecosystem in general. Production wastewater, domestic wastewater is the cause of high BOD and COD values of the water environment, COD was used as indicator of organic waste concentration in water [17].

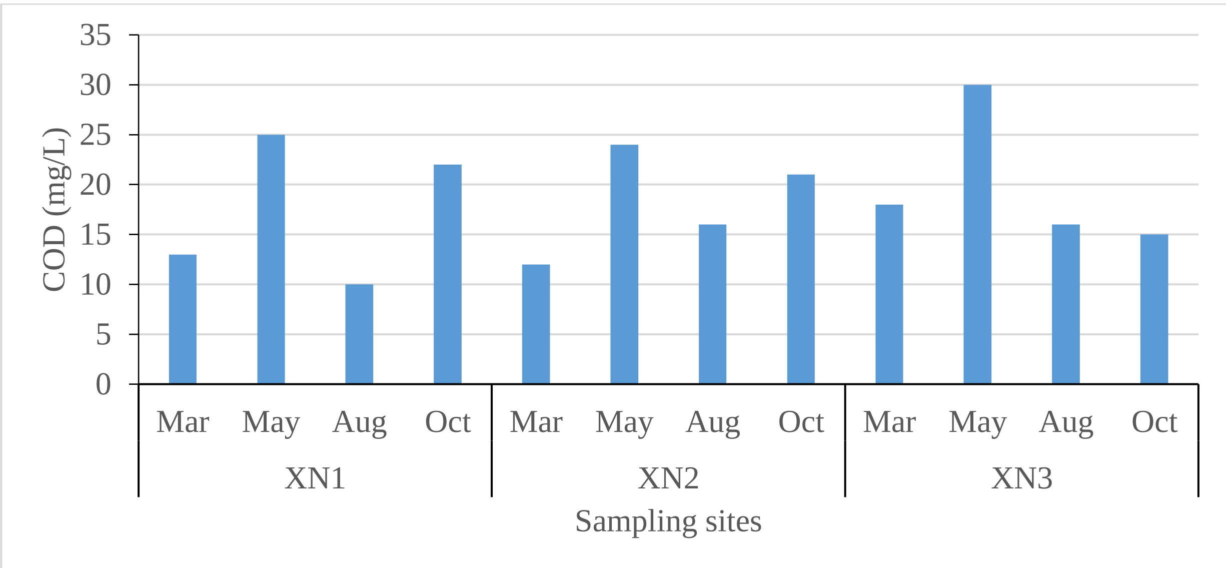

Figure 6. COD in the study area

NH_4^+-N in water ranged from 0.08 mg/L to 0.55 mg/L (mean 0.21 mg/L). NH_4^+-N between positions fluctuates greatly. NH_4^+-N in the months of March, May, August and September were 0.09 mg/L, 0.22 mg/L, 0.12 mg/L, and 0.40 mg/L, respectively (Figure 7). NH_4^+-N in October was significantly higher than in other months. The value of NH_4^+-N specified in QCVN 08-

MT:2015/BTNMT in column A1, A2 is 0.3 mg/l for domestic water supply and 0.9 mg/L for column B1, B2 for domestic use. used for irrigation, irrigation and navigation purposes [2]. NH_4^+-N at positions XN2(May, Oct), XN3(Oct) are all higher than the allowable values of Vietnamese standards. The concentration of NH_4^+-N in the water should not exceed 5 mg/L, if it is more than 5 mg/L, the water is in very dirty condition. In freshwater environments, an increase in pH to 8 increases the toxicity of ammonia in water compared to a lower pH [11].

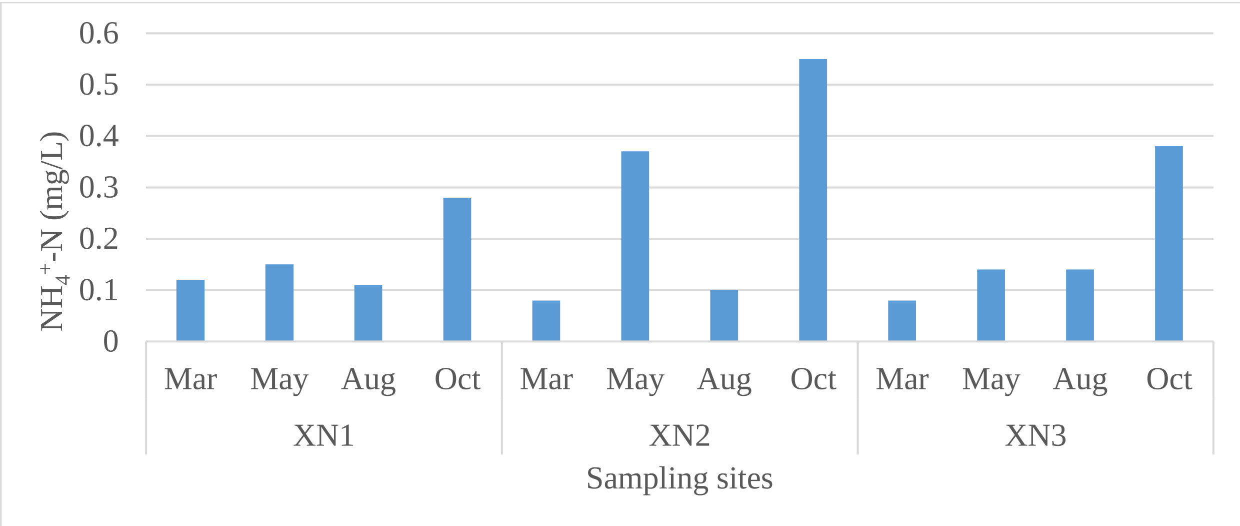

Figure 7. NH_4^+-N in the study area

Nitrite (NO_2^--N) in water ranged from 0.02 mg/L to 0.14 mg/L (mean 0.05 mg/L). Nitrite between positions fluctuates greatly. Nitrite in the months of March, May, August and September were 0.05 mg/L, 0.10 mg/L, 0.03 mg/L, and 0.03 mg/L, respectively (Figure 8). Nitrite in May is significantly higher than other months. Nitrite nitrogen compounds in the water bodies of Hau Giang province have an average concentration of 0.04±0.017 mg/L [13]. Nitrite present in water is an intermediate product in the nitrogen cycle. Nitrite is very toxic to fish and aquatic animals. Nitrite needs to be strictly controlled for wastewater and drinking water. Nitrite at some sampling locations exceeds the allowable limit of Vietnamese standards.

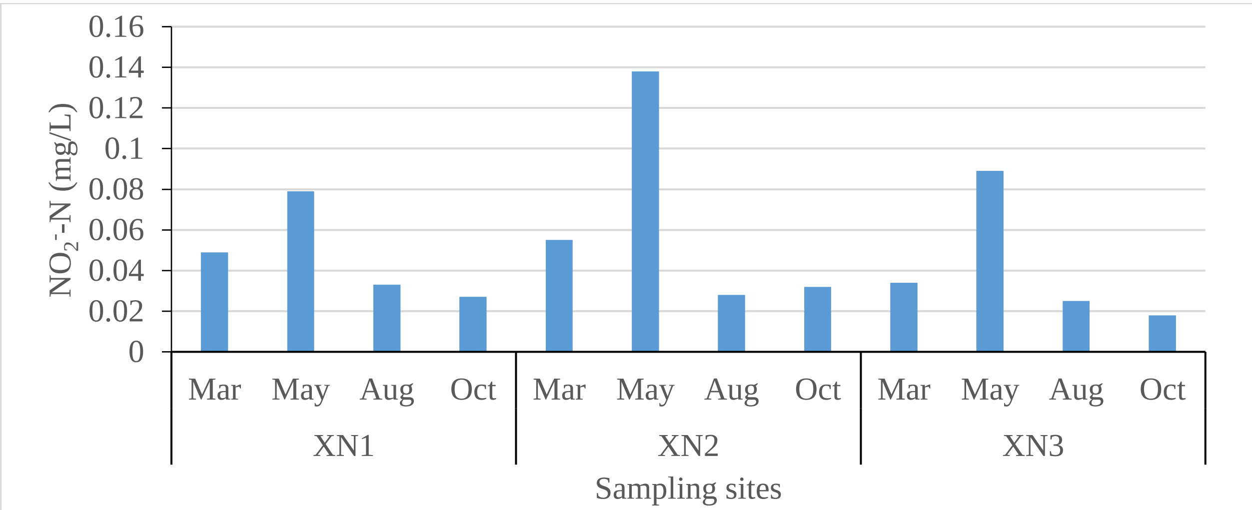

Figure 8. NO_2^--N in the study area

Nitrate (NO_3^--N) in water ranged from 0.27 mg/L to 0.44 mg/L (mean 0.36 mg/L). Nitrate between sites fluctuates greatly. Nitrate in the months of March, May, August and September were

0.41 mg/L, 0.35 mg/L, 0.37 mg/L, and 0.30 mg/L, respectively (Figure 9). Nitrate between months did not differ. Nitrate (NO_3^--N) is a product of the nitrification process, nitrate is not toxic to shrimp and fish, but can cause phytoplankton bloom, causing water quality changes that are not beneficial to farmed shrimp and fish. If the nitrogen in the water is mainly in the form of nitrate, the oxidation is over. The concentration of NO_3^--N specified in QCVN 08-MT:2015/BTNMT column A1 (2 mg/L) [4] is good for domestic water supply and other purposes; limit column A2 (5 mg/L) of water quality used for domestic water supply purposes must apply appropriate treatment technology. Nitrate at the sampling site is lower than the allowable value of Vietnamese standards. The results of this study are consistent with previous studies that nitrate is always within the allowable limit of Vietnamese standards [8-10].

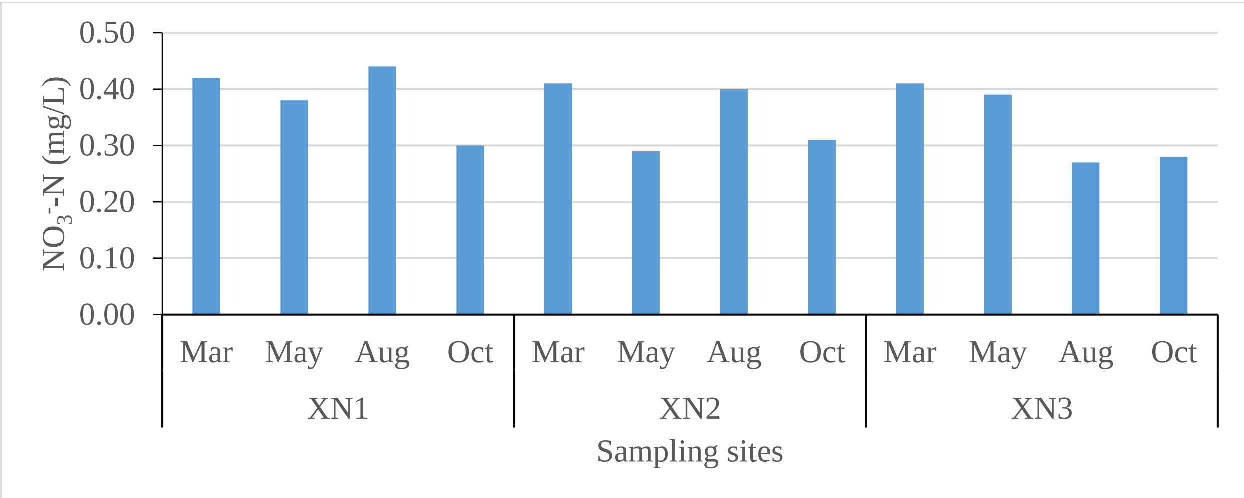

Figure 9. NO_3^--N in the study area

Orthophosphate (PO_4^{3-}-P) in water ranged from 0.11 mg/L to 0.36 mg/L (mean 0.18 mg/L). Orthophosphate between sites fluctuates greatly. PO_4^{3-}-P in the months of March, May, August and September were 0.12 mg/L, 0.12 mg/L, 0.17 mg/L, 0.33 mg/L, respectively (Figure 10). PO_4^{3-}-P in October was significantly higher than in other months. PO_4^{3-}-P values in infield canals and Hau river of An Giang province ranged from 0.02 to 0.47 mg/L [8], in Hau river in An Giang-Hau Giang section 0.04-0.11 mg/L [13]]. PO_4^{3-}-P in surface water environment in the Mekong Delta has exceeded QCVN 08-MT:2015/BTNMT, column A1 [4]. Therefore, PO_4^{3-}-P can be a problem for water environment in water bodies [9,13,16]. According to the national technical regulation on surface water quality, the concentration of PO_4^{3-}-P in columns A1, A2, B1, B2 is 0.1, respectively; 0.2; 0.3; 0.5 mg/L corresponds to different uses [2]. PO_4^{3-}-P at the sampling site are all higher than the allowable value of Vietnamese standards. The origin of phosphorus may be from fertilizers, detergents due to farming, livestock and industrial activities [18]. Thus, the canal is at risk of eutrophication because the phosphorus content exceeds the allowable limit of Vietnamese standards.

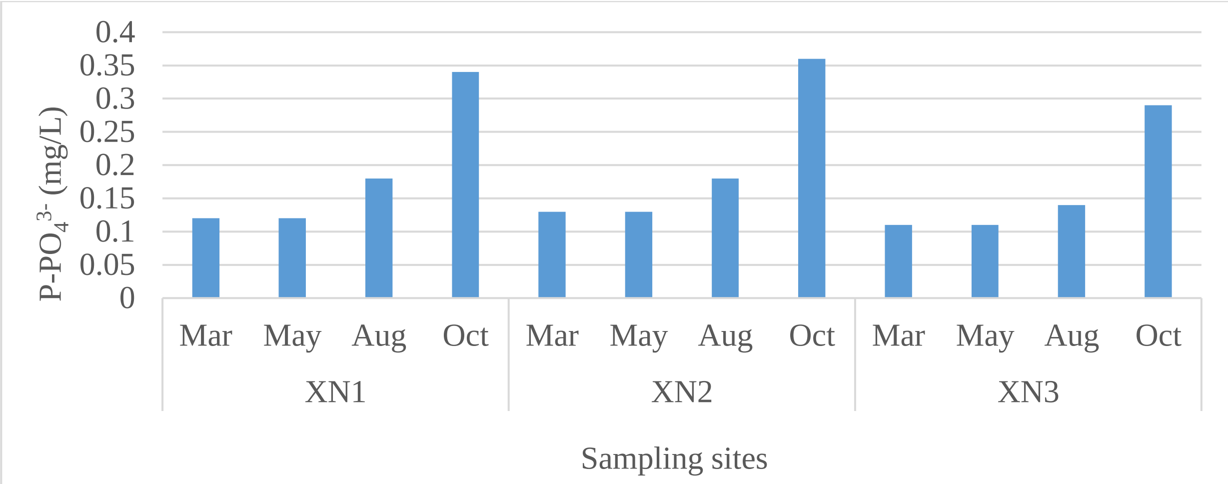

Figure 10. PO_4^{3-}-P in the study area

Iron (Fe) in water ranged from 0.10 mg/L to 1.70 mg/L (mean 1.18 mg/L). Iron between positions fluctuates greatly. Iron in the months of March, May, August and September was 0.73 mg/L, 1.37 mg/L, 1.43 mg/L, 1.20 mg/L, respectively (Figure 11). Iron in March is significantly lower than in other months. Previous research showed that Fe in water bodies of Hau Giang province ranged from 0.3±0.1 mg/L-2.3±1.9 mg/L (mean 1.2±0.6 mg/L) and exceeded QCVN 08-MT:2015/BTNMT, column A because Hau Giang is an alkaline soil, so the iron content in the water environment is high [13]. The presence of iron degrades water quality, incurs treatment costs and poses health risks to humans and the environment [13]. Iron at the sampling location is higher than the allowable value of Vietnamese standards.

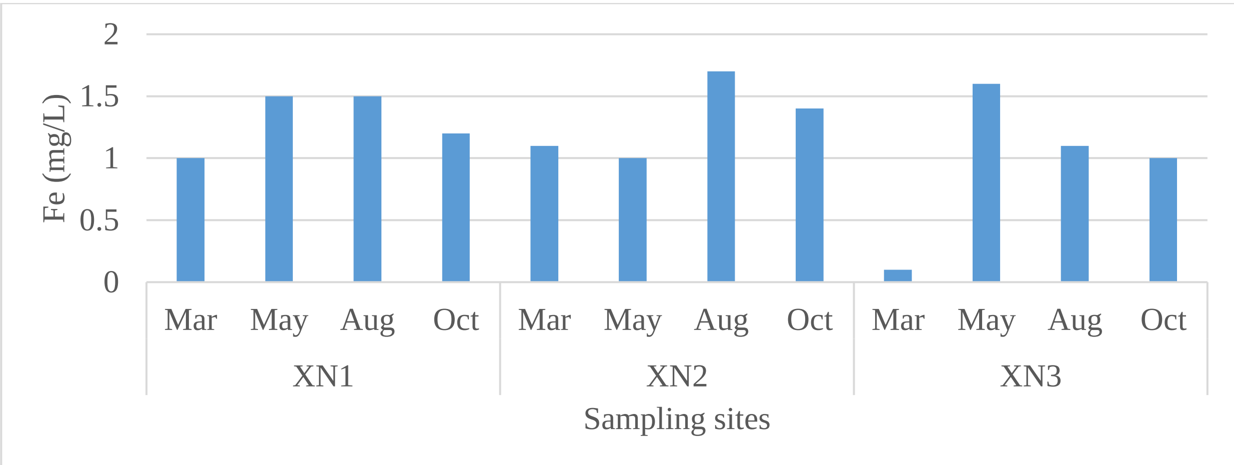

Figure 11. Fe in the study area

Coliform is a group of microorganisms used to indicate the possibility of the presence of pathogenic microorganisms. Coliforms in water in the study area ranged from 9300 MPN/100 mL to 24000 MPN/100 mL (mean 15125 MPN/100 mL). Coliforms in the months of March, May, August and September were 13100 MPN/100 mL, 14650 MPN/100 mL, 17600 MPN/100 mL, 15150 MPN/100 mL, respectively (Figure 12). Coliforms in March were significantly lower than in other months. Previous studies have shown that water bodies in the Mekong Delta have a coliform density that is always higher than the allowable value of Vietnamese standards [8,9,13,16]. The sources of coliform contamination are from human and animal wastes, especially the fecal materials [19,20].

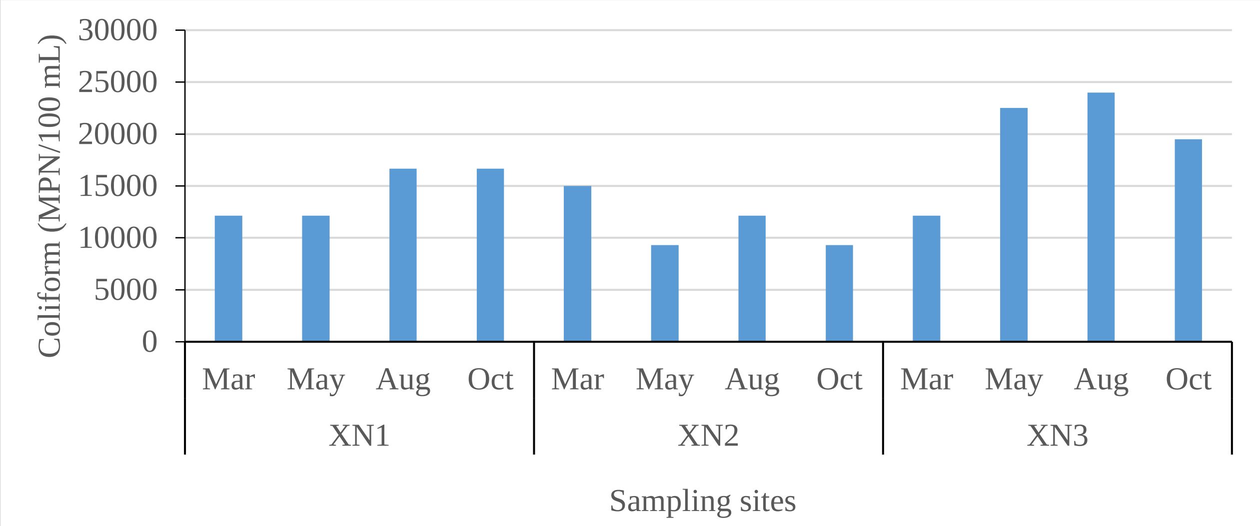

Figure 12. Coliform in the study area

3.2 Evaluating overall water quality using WQI

The overall water quality at the study site is presented in Table 4. The results showed that the WQI value ranged from 25 to 52, the average value at 33. The water quality was graded from bad to moderate. The WQI values in the months of March, May, August, and October are 28, 32, 29, 41 respectively. The WQI value shows that the water quality in October was better than that in other months. The results of the WQI showed that water quality at all monitoring positions in the year reached the orange threshold; except that position XN1 (October) reached the yellow threshold and position XN3 (May) reached the red threshold. In general, the surface water quality at the monitoring locations in this area was from very poor to moderate as seen in Table 4. The main reason for low WQI value was high coliforms parameter.

Table 4. Water quality by WQI

Site	Sampling period	WQI	Color	Classified
XN1	Mar	29	Orange	Poor
	May	26	Orange	Poor
	Aug	29	Orange	Poor
	Oct	35	Orange	Poor
XN2	Mar	27	Orange	Poor
	May	44	Orange	Poor
	Aug	29	Orange	Poor
	Oct	52	Yellow	Moderate
XN3	Mar	29	Orange	Poor
	May	25	Red	Very poor
	Aug	29	Orange	Poor
	Oct	37	Orange	Poor

3.3 Key variables influencing surface water quality in the study area

Surface water quality at Xa No canal is affected by five main components as shown in Table 5. Main components PC1, PC2, PC3, PC4, PC5 explain 37.0%, 24.2%, 12.3%, 10.3 respectively. % and 8.6% variation in water quality. PC1 has an influence on temperature, pH, DO, TSS, NO_2^--N, BOD and COD. PC2 affects NO_3^--N, N, NH_4^+-N, PO_4^{3-}-P. PC3 affects TSS and coliform. PC4 affects pH, PO_4^{3-}-P, BOD and Fe. PC5 affects pH, TSS, NO_2^--N, NO_3^--N, BOD. All monitoring indicators have an impact on water quality and need to be continuously monitored. However, NO_2^--N, BOD can be considered to reduce because it can be predicted from other indicators such as DO, COD and NH_4^+-N.

Table 5. Key variables influencing on surface water quality in the study area

Parameter	PC1	PC2	PC3	PC4	PC5
Temp	**0.402**	0.096	-0.258	-0.046	-0.244
pH	**-0.306**	-0.254	0.171	**0.332**	**0.319**
DO	**-0.364**	0.285	-0.062	-0.046	-0.054
TSS	**0.319**	0.174	**0.390**	-0.129	**0.370**
NO_2^--N	**0.390**	0.124	0.162	0.113	**-0.374**
NO_3^--N	-0.057	**0.488**	0.270	-0.101	**0.366**
NH_4^+-N	0.087	**-0.517**	0.206	-0.172	-0.192
PO_4^{3-}-P	-0.118	**-0.505**	0.081	**-0.300**	0.198
BOD	**0.365**	-0.112	-0.041	**0.326**	**0.427**
COD	**0.413**	-0.157	-0.025	0.208	0.180
Coliform	-0.021	-0.011	**-0.741**	0.134	0.277
Fe	0.171	0.014	-0.220	**-0.747**	0.240
Egien. V	4.44	2.90	1.48	1.23	1.03
Var (%)	37.0	24.2	12.3	10.3	8.6
C.Var(%)	37.0	61.2	73.5	83.8	92.4

4.0 Conclusion

Research results show that the temperature, pH and NO_3^--N in the study area are still within the allowable limits of QCVN 08-MT:2015/BTNMT. DO is lower than the allowable limit. DO in August is significantly higher than other months. TSS, BOD, COD all exceeded the allowable limit. Particularly, NO_2^--N at some locations has also exceeded the allowable limit. The concentrations of TSS, BOD, COD, NO_2^--N indicators in May were significantly higher than in other months. NH_4^+-N at positions XN2 (May, Oct), XN3 (Oct) are all higher than the allowable values of Vietnamese standards. Similarly, PO_4^{3-}-P at all sampling locations exceeded the allowable limit. NH_4^+-N and PO_4^{3-}-P in October were significantly higher than in other months. Iron and coliform at the sampling site were both higher than the allowable values of Vietnamese standards. Iron and coliform in March were significantly lower than in other months. The results showed that the WQI value ranged from 25 to 52, classifying the water quality was from bad to moderate. Overall water quality in October was better than that in other months. Surface water quality in Xa No canal is affected by five main components that explain 37.0%, 24.2%, 12.3%, 10.3% and 8.6% of water quality variation, respectively. All monitoring indicators have an impact on water quality and need to be continuously monitored. However, indicators of NO_2^--N, BOD can be considered to reduce because it can be predicted from other indicators such as DO, COD and NH_4^+-N. The results provide scientific information on water quality fluctuations and key influencing indicators. Further studies need to determine the causes and contributions of sources of pollution to surface water quality in the study area.

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Nomenclature

Abbreviations	Full description
pH	The potential of hydrogen
Temp.	Temperature
TSS	Total suspended solids
DO	Dissolved oxygen
BOD	Biological oxygen demand
COD	Chemical oxygen demand
NH_4^+-N	Ammonium
NO_2^--N	Nitrite
NO_3^--N	Nitrate
PO_4^{3-}-P	Orthophosphate
Coliforms	Density of coliforms
Fe	Iron
WQI	Water Quality Index

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