NIPES

Journal of Science and Technology Research

Journal homepage: www.nipesjournals.org.ng

Seasonal Variation of Surface Water Quality in the Water Bodies in the Plain of Reeds, a Vietnamese Mekong Delta Area

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Article Info

Received 20 March 2021
Revised 03 April 2021
Accepted 07 April 2021
Available online 04 June 2021

***Keywords*:**
surface water quality, organic pollution, suspended solids, coliforms, Vietnamese standards, Plain of Reeds.

https://doi.org/10.37933/nipes/3.2.2021.5

https://nipesjournals.org.ng

Abstract

This study was conducted to evaluate surface water quality in rivers and canals in the Plain of Reeds, Dong Thap province for the year 2020 using national technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT) and water quality index (WQI). Surface water quality parameters of turbidity, pH, temperature, dissolved oxygen (DO), suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrite ($N\text{-}NO_2^-$), nitrate ($N\text{-}NO_3^-$), ammonium ($N\text{-}NH_4^+$), orthophosphate ($P\text{-}PO_4^{3-}$), coliform, and E. coli. The results showed that BOD, COD, coliform and E. coli at most of the monitoring locations exceeded QCVN 08-MT: 2015/BTNMT, column A2 pointing out that surface water quality was being seriously impaired. Temperature, pH, DO, and E. coli were not significantly different between the seasons. TSS, BOD, COD, $N\text{-}NH_4^+$, $N\text{-}NO_3^-$, $P\text{-}PO_4^{3-}$, and coliform were high in the rainy season while $N\text{-}NO_2^-$ was high in the dry season. WQI values ranging from 24 to 64 indicated the poor water quality in densely populated, industrial areas along Tien and Hau rivers. Further studies should focus on specific water polluting sources for sustainable surface water quality management.

1. Introduction

Water is a very important resource for human life and development. However, the imbalance between water resources and water demand has caused water scarcity and become one of the most pressing problems in the world. The main sources of water pollution are manifested in man-made (industrial, agricultural or domestic) activities or natural processes (precipitation, erosion); all of these contribute to the changes in the natural state of the water, by direct discharge into the freshwater of various types of pollutants [1-3]. Rivers play a crucial role in transforming industrial and urban wastewater treatment methods. Municipal and industrial wastewater discharges constitute a constant source of pollution, while surface runoff can be a seasonal phenomenon, severely affected by the weathering process. Seasonal variations of debris, runoff and groundwater pumped in and out have a strong impact on the discharge of river water and, thereafter, on the concentration of pollution in the river water [4].

The flow discharge on the Vietnamese Mekong River divides into two distinct seasons. Flood season with the largest discharge of 38,000-40,000 m^3/s, causing flooding about 1.2–1.9 million ha with depths from 0.5 to 4.5 m. The minimum discharge in dry season is 2,000-2,400 m^3/s, making it difficult for water supply during Winter-Spring and Summer-Autumn [5-6]. According to the

research by Ogston et al. (2017) [7], the construction of hydroelectric dams upstream makes the Vietnamese Mekong Delta from annual sedimentation to shrinking the area due to erosion, especially in the coastal area. Besides, according to the research by Brunier et al., (2014) [8], the floodplain area of the Vietnamese Mekong Delta including the Dong Thap Muoi and Tu Giac Long Xuyen sub-regions are less affected by tides and saline intrusion than the coastal areas which is influenced by hydroelectric dam systems on the upper Mekong River, climate change and internal socio-economic development. The operation of hydropower dams is expected to change the water level in the river by 26-70% in the dry season and 0.8-5.9% in the rainy season [9] and could reduce the amount of sediment by 40% by the period 2050-2060 [10]. In addition, the change of surface water resources in the floodplain of the Vietnamese Mekong Delta is also affected by local socio-economic development [11], especially the use of water for agricultural activities in flooded areas will have direct effects on the central and coastal regions of the Vietnamese Mekong Delta [12-13]. The Vietnamese Mekong Delta is at risk of facing a lack of surface water resources, especially in the context that the normal flow of the Mekong River may be altered due to increased water use by the upstream nation and the effects of climate change [14]. Therefore, the ability to provide surface water (especially for agricultural and aquaculture activities) for the entire Vietnamese Mekong Delta at present and in the future is a matter of concern.

Dong Thap is located in the headwaters of the Mekong River. The surface water source is relatively plentiful. The fresh water source is not salty all year round. However, the deep lowland area in the center of Dong Thap, at the end of the dry season and the beginning of the rainy season, is also affected by acid sulfate water. The Tien River has an average flow of 11,500 m^3/s, the largest of 41,504 m^3/s, the smallest 2,000 m^3/s. In addition to the Tien River and Hau River, there are two small river branches that affect the surface water in the North of the province, namely So Ha River and So Thuong River originating from Cambodia and flowing into Tien and Hong Ngu Rivers. Dong Thap province also has a natural system of rivers and canals that supply and drain the fields to the Tien and Hau rivers, in which in the North there are Ba Rang, Doc Vang Thuong, Doc Vang Ha, Cao Lanh rivers, Can Lo; In the South, there are Cai Tau Ha, Cai Tau Thuong, Sa Dec and Lap Vo-Lai Vung rivers [6]. Due to the influence of natural features, the rivers and canals in Dong Thap are strongly influenced by the flood regime in the rainy season, which leads to the difficulty of draining water during the flood period for urban areas in the province. Meanwhile, in the dry months, river water is most often polluted, especially in-field canals. This study evaluates the seasonal variation of surface water quality in Dong Thap province using the monitoring data of the year 2020. The sources of water pollution were also discussed. The results of this study could provide useful information for water quality management.

2. Methodology

Surface water quality data were collected from the Department of Natural Resources and Environment of Dong Thap province in 2020 at 58 locations, denoted from NM1 to NM58 (Figure 1). Water quality parameters including pH, temperature, DO, TSS, BOD, COD, $N\text{-}NO_2^-$, $N\text{-}NO_3^-$, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, coliform, E. coli were used to evaluate water quality by comparing with national technical regulation on surface water quality (QCVN 08- MT: 2015/BTNMT). All the parameters were determined using standard methods [15]. The allowable limits of water quality parameters according to QCVN 08- MT: 2015/BTNMT were presented in Table 1. Seasonal variation of water quality indicators was assessed using one factor variance analysis (ANOVA), followed by Ducan test at 5% significance level using SPSS software.

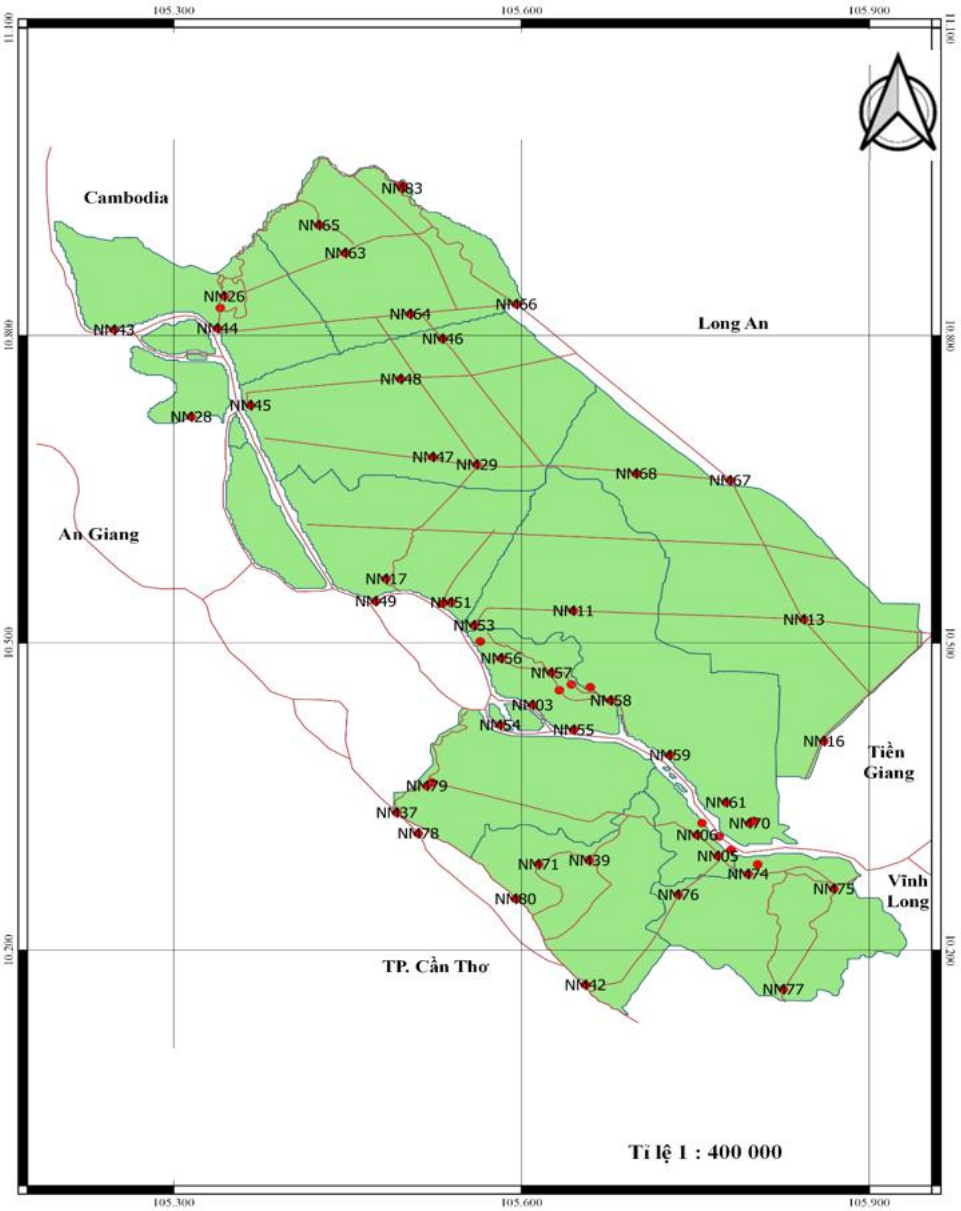

Figure 1. Diagram of the sampling sites

Table 1. Limited value of surface water quality parameters

No.	Parameters	Unit	Limit values, Column A2
1	pH		6 – 8.5
2	BOD	mg/l	6
3	COD	mg/l	15
4	DO	mg/l	≥ 5
5	$N\text{-}NH_4^+$	mg/l	0.3
6	TSS	mg/l	30
7	$N\text{-}NO_2^-$	mg/l	0.05
8	$N\text{-}NO_3^-$	mg/l	5
9	$P\text{-}PO_4^{3-}$	mg/l	0.2
11	Coliform	MPN or CFU/100 mL	5000
12	E. coli	MPN or CFU/100 mL	50

Surface water quality was also assessed using the water quality index (WQI). The WQI was calculated using the Equation (1) according to the guidance of Decision No. 1460/QĐ-TCMT dated November 12, 2020 of the Vietnam Environment Administration (2019) [16].

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

In which, WQI_I: Calculation result for group I parameter, pH parameter; WQI_{IV}: Calculation results for parameters group IV (group of organic and nutrient parameters), including: BOD, COD, DO, N-NH_4^+, N-NO_3^-, N-NO_2^-, N-PO_4^{3-}; WQI_V: Calculation results for parameters of group V (microbiological parameter group), including: Coliform, E. coli.

Table 2. 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

3. Results and discussion

3.1 Temperature and pH

Water temperature in the sampling areas fluctuated from 27.1 to 32^{o}C, average 29.29 ± 1.16^{o}C. The temperature had slight variation and the difference was statistically significant between the observed months (significance level 5%), of which, in February, May, August and November, the temperature is 29.96 ± 1.05^{o}C, 30.59 ± 0.98^{o}C, 29.56 ± 0.73^{o}C, 31.08 ± 1.09^{o}C, respectively (Figure 2a). The data showed that the temperature in November was higher than that of February, May and August. Previous studies have shown that the water temperature was relatively stable. Giao and Dan (2020) [17] reported that the water temperature in Bung Binh Thien during the dry season (January 2019) ranged from 28.07 ± 0.06 ^{o}C to 30.33 ± 1.36 ^{o}C. Similar to the previous study by Ly and Giao (2018) [18], the average water temperature of canals and rivers in An Giang province in the period 2009 - 2016 fluctuated in the range of 29 - 30 °C, the average was 29,7 ± 0,7°C. In addition, the research by Lien et al. (2016) [5] showed that there was no difference in water temperature between main river and tributary river of Hau river in rainy and dry seasons. In general, temperature fluctuation in the water bodies was small and consistent with the region's temperature because water has a regulating function, especially in large and deep canals or rivers [19]. Suitable temperature for aquatic species growing from 25-32^{o}C [20]; Therefore, the water temperature in rivers and canals in Dong Thap province is suitable for the growth of aquatic organisms.

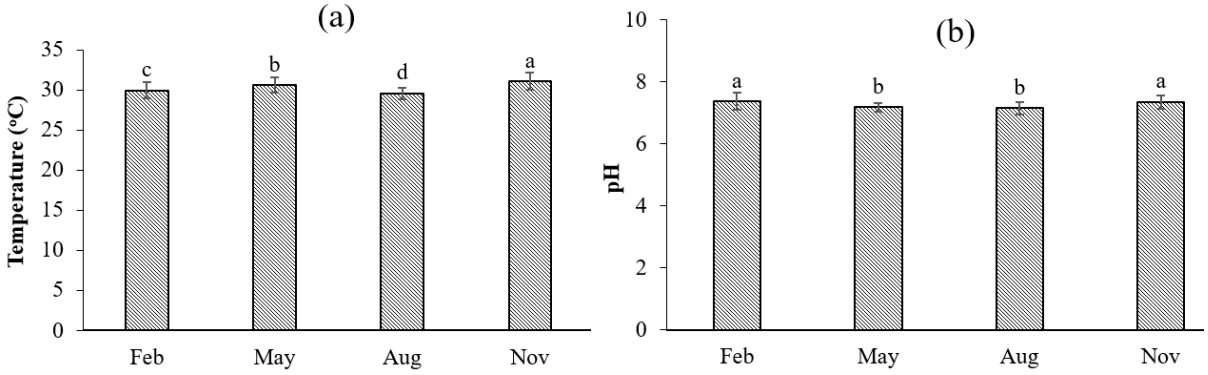

Figure 2. Seasonal variation of temperature and pH

The average pH values between the monitoring months had a statistically significant difference ($p<0.05$) between May and August compared to February and November. pH values between months varied from 7.15 ± 0.20 to 7.36 ± 0.27 (Figure 2b), this was consistent with the study of Giao (2020), the pH value in Bung Binh Thien in 2019 fluctuated in the range of 7.55 ± 0.03 to 7.85 ± 0.01. In the study of Ly and Giao (2018) [18] on surface water quality in inland canals of An Giang province during 2009 to 2016, pH values ranged from 6.7 to 7.1 with the mean value of 7.0 ± 0.2. pH in water in the main and tributary rivers of Hau river in 2016 ranged from 6.3 to 8.0, averaged at 7.10 [5]. It can be seen that pH value has slight variation over time and was within the allowable range of QCVN 08-MT: 2015/BTNMT.

3.2 Total suspended solids and oxygen demand

Dissolved concentrations (DO) in the water bodies in February, May, August, November were 5.07 ± 0.63 mg/L, 5.13 ± 0.12 mg/L, 5.16 ± 0.15 mg/L and 5.18 ± 0.33 mg/L, respectively and there was no statistically significant difference between the monitoring months ($p>0.05$) (Figure 2a). DO values all met the limit of QCVN 08-MT: 2015/BTNMT column A2 (5 mg/L). According to some previous studies, the average DO in Can Tho water bodies ranged from 3.5 to 5.8 mg/L [22]. DO in An Giang's water bodies in the period of 2009-2016 ranged from 4.0 to 5.2 mg/L [18]. DO in the upstream of Tien River did not have any difference between months, the highest was recorded in September (5.85 ± 0.42 mg/L) and the lowest in April (5.55 ± 1, 11mg/L) [4]. DO in water depends on water turbulence (exchange between water and air), photosynthesis, and transportation. The data of DO in this study revealed water quality is being improved because DO in the water is gradually approaching the threshold specified in column A1 of QCVN 08-MT: 2015/BTNMT. The BOD concentration across the monitoring positions ranged from 12.75 ± 0.5 to 18 ± 0.82 mg/L and reached the average value at 15.30 ± 1.29 mg/L. BOD value fluctuated slightly over the months of observation in the range from 14.05 ± 1.41 mg/L to 15.52 ± 1.67 mg/L (Figure 3b). The statistical analysis showed that there was a significant difference ($p <0.05$) between August compared to February, May and November, but there was no difference between February, May, and November ($p>0.05$). Former study showed that BOD in the Can Tho River ranged from 5.5 to 31.6 mg/L in the period of 2010-2014, in which BOD in the dry season was higher than that in the rainy season; BOD in rivers and canals in Soc Trang province ranged from 2.2 to 22.4 mg/L [23]. As can be seen that BOD is the main concern in the water bodies in the Vietnamese Mekong Delta. The results of the study showed that BOD in surface water environment in Dong Thap province exceeded the permitted limit of QCVN 08MT: 2015/BTNMT, column A2. High BOD indicates the abundant presence of organic matters in the water bodies which could lead to low dissolved oxygen due to decomposition of organic matters. Lack of DO could result in water pollution and make water unsuitable for certain type of aquatic lives.

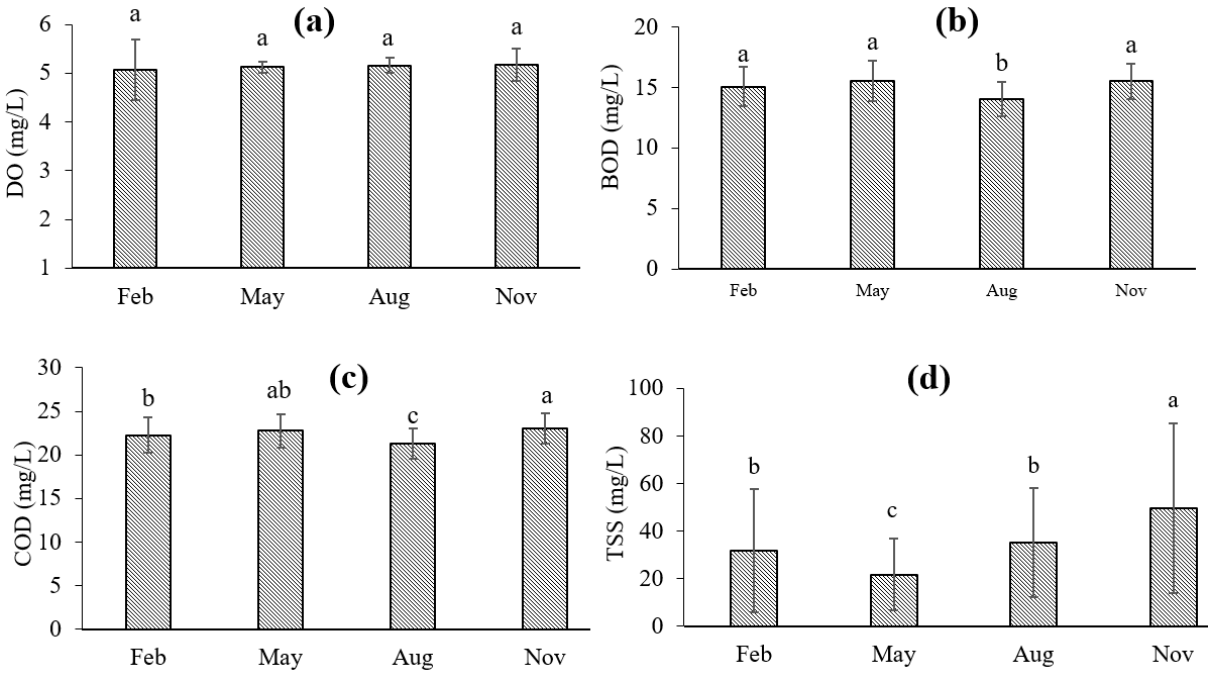

Figure 3. Seasonal variations of suspended solids and oxygen demand

The mean values of COD in February, May, August and November were 22.28 ± 2.01 mg/L, 22.78 ± 1.94 mg/L, and 21.26 ± 1.74 mg/L, and 23.03 ± 1.77 mg/L, respectively. The results of statistical analysis showed that COD in November was statistically significant difference ($p<0.05$) with the other months (Figure 3c). COD in surface water quality of Can Tho river in the period of 2010-2014 ranged from 8.5 to 44.7 mg/L [22]. According to the research by Lien et al. (2016) [5], COD in the water bodies in the main and tributary rivers of the Hau river was in the range of 2.56 – 35.84 mg/L. The current study found that COD exceeded the permitted limit of QCVN 08MT: 2015/BTNMT, column A2. The result showed that the water quality was polluted with organic matters, and the water quality at the locations is suitable for irrigation or navigation purposes, but for domestic water supply. Concentration of suspended solids at the sampling locations fluctuated sharply from 19 ± 12.96 mg/L to 80.5 ± 35.16 mg/L, reaching the average value at 34.6 ± 22.3 mg/L, the highest value was 2.7 times higher than that of column A2 of QCVN 08-MT: 2015/BTNMT and 1.6 times higher than that of column B1 at the NM13 position (80.5 ± 35.16 mg/L) (Figure 3d). Suspended solids have seasonal fluctuations, the lowest value in May was 21.71 ± 15.11 mg/L and the highest in November was 49.57 ± 33.58 mg/L. There was a significant difference in statistical analysis ($p <0.05$) between May and November (Figure 3d). Former studies reported that mean TSS concentrations at the sampling site of the Hau River ranged from 28.88 ± 7.31 to 90.11 ± 28.18 mg/L, the highest value was recorded in September (90.11 ± 28.18 mg/L) [4]. Ly and Giao (2018) [18] found the highest TSS concentration in Chau Phu (107.8 mg/L) in the rainy season and the lowest was recorded in the Hau River (28.4 mg/L) in the dry season. Besides, the other research also showed that TSS in Tien River was the highest in September 2011 [24]. TSS concentrations increase strongly in the rainy season due to the strong flow of water, floods coming from upstream bring a lot of silt plus leaching material, the presence of TSS with high concentrations can increase treatment costs and can also make the aquatic environment incapable of being suitable for the life of the organisms.

3.3 Nitrogen compounds

The evolution of $N\text{-}NH_4^+$ over the observing months tended to increase slightly and ranged from 0.36 ± 0.061 mg/L to 0.40 ± 0.074 mg/L, the difference was statistically significant between months

($p < 0.05$) (Figure 4a). According to the study on surface water quality of Tien River flowing through Tan Chau, An Giang province, $N\text{-}NH_4^+$ value was the lowest in April 2018 (0.3 mg/L), the highest in January 2018 (8.3 mg/L). The concentration of $N\text{-}NH_4^+$ from June (2017) to September (2018) all exceeded the allowable value of QCVN08-MT: 2015/BTNM, column A2. The presence of high concentrations of $N\text{-}NH_4^+$ can lead to eutrophication that affects water quality, the natural cleaning process of water sources. With neutral pH, nitrogen exists in the form of $N\text{-}NH_4^+$ and in the presence of DO will quickly convert to $N\text{-}NO_3^-$ and both $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ are absorbed by organisms, so it does not cause a serious impact on aquatic organisms. The results of nitrite measurement were presented in Figure 4b. The concentration of $N\text{-}NO_2^-$ in February (0.459 mg/L) and May (0.455 mg/L) were higher than that of QCVN 08-MT: 2015/BTNMT, column A2 (0.05 mg/L) by 9.18 times and 9.1 times higher, respectively. However, the concentration of $N\text{-}NO_2^-$ in the water bodies in August and November were within the permitted limits. The concentration of $N\text{-}NO_2^-$ was statistically significant difference ($p<0.05$) between February, May and August and November. This showed that concentration of nitrite in water bodies in Dong Thap in the rainy season was very higher than that in the dry season. Former study also found that $N\text{-}NO_2^-$ concentration in the rainy season was higher than that in the dry season [25]. $N\text{-}NO_2^-$ is capable of toxicity to aquatic organisms at a concentration of 0.1 mg/L [19]. High concentration of $N\text{-}NO_2^-$ can be influenced by agriculture, high concentrations of organic fertilizers and pesticides, so the water quality in the surveyed areas is suitable for agricultural purposes, navigation and other similar purposes.

The concentration of $N\text{-}NO_3^-$ at sampling locations ranged from 0.99 ± 0.64mg/L to 2.7 ± 2.31 mg/L, with the highest value at the position NM79 of 2.7 ± 2, 31mg / L and lowest at NM03 position was 0.99 ± 0.64 mg/L, reaching the average value at 1.77 ± 1.07 mg/L (Figure 4c). $N\text{-}NO_3^-$ concentrations tended to increase in August and November, ranging from 1.14 ± 0.39 mg/L to 3.00 ± 0.83 mg/L, with the highest value in November (3.00 ± 0.83 mg/L) and the lowest value in May (1.14 ± 0.39 mg/L). The results of statistical analysis showed that there was a significant difference ($p<0.05$) of $N\text{-}NO_3^-$ concentration between May and August, November, but there was no difference between May and February ($p>0.05$) (Figure 4c). The concentration of $N\text{-}NO_3^-$ increased in August and November showing that runoff water plays important role in $N\text{-}NO_3^-$ concentration. This result was also consistent with the study of Giao (2020) [26], the lowest average $N\text{-}NO_3^-$ concentration in March (0.02 ± 0.04 mg/L) and the highest in December (0.48 ± 0.27 mg/L). In addition, Ha (2019) [4] reported the average $N\text{-}NO_3^-$ concentration in the upstream of Tien River over the past 12 months of observation from 2009 to 2018 ranged from 0.04 ± 0.02 to 0.12 ± 0.04 mg/L, all of which did not exceed the permitted limit of QCVN 08-MT: 2015/BTNMT, column A1 (2 mg/L). The concentration of $N\text{-}NO_3^-$ suitable for aquaculture is from 0.2 to 10 mg/L [28]. The concentration of $N\text{-}NO_3^-$ in the water bodies in the study area is still in the acceptable range.

The concentration of $P\text{-}PO_4^{3-}$ in February, May, August and November were 0.24 ± 0.18 mg/L, 0.21 ± 0.12 mg/L, 0.18 ± 0.11, 0.30 ± 0.30 mg/L, respectively. The difference was statistically significant ($p < 0.05$) of $P\text{-}PO_4^{3-}$ concentrations between November and May, August; however, there was no difference of $P\text{-}PO_4^{3-}$ concentrations between November and February ($p>0.05$) (Figure 4d). The highest $P\text{-}PO_4^{3-}$ concentration was found in November (0.30 ± 0.30 mg/L) possibly due to the rain of floodwater pouring from upstream and dissolving nutrients accumulated in the soil. According to the analysis results of Lien et al. (2016) [5], the concentration of $P\text{-}PO_4^{3-}$ in Hau river fluctuated in the range of 0.017-0.415 mg/L. $P\text{-}PO_4^{3-}$ concentration in in-field canals of An Giang province in the period 2009 - 2016 ranged from 0.02 mg/L to 0.47 mg/L, the averaged at 0.16 ± 0.12 mg/L [18]. $P\text{-}PO_4^{3-}$ concentration in Hau river belonging to An Giang - Hau Giang section was 0.04-0.11 mg/L [16]. According to Boyd and Green (2002) [28], dissolved phosphorus in natural surface water exists from 0.005 to 0.02 mg/L, $P\text{-}PO_4^{3-}$concentration in the water body greater than 0.02 mg/L is considered to be nutrient rich. Thus, $P\text{-}PO_4^{3-}$ concentration in the study area can cause

eutrophication. The high $P\text{-}PO_4^{3-}$ concentration can be attributed to agricultural activities and domestic wastewater from the surrounding area.

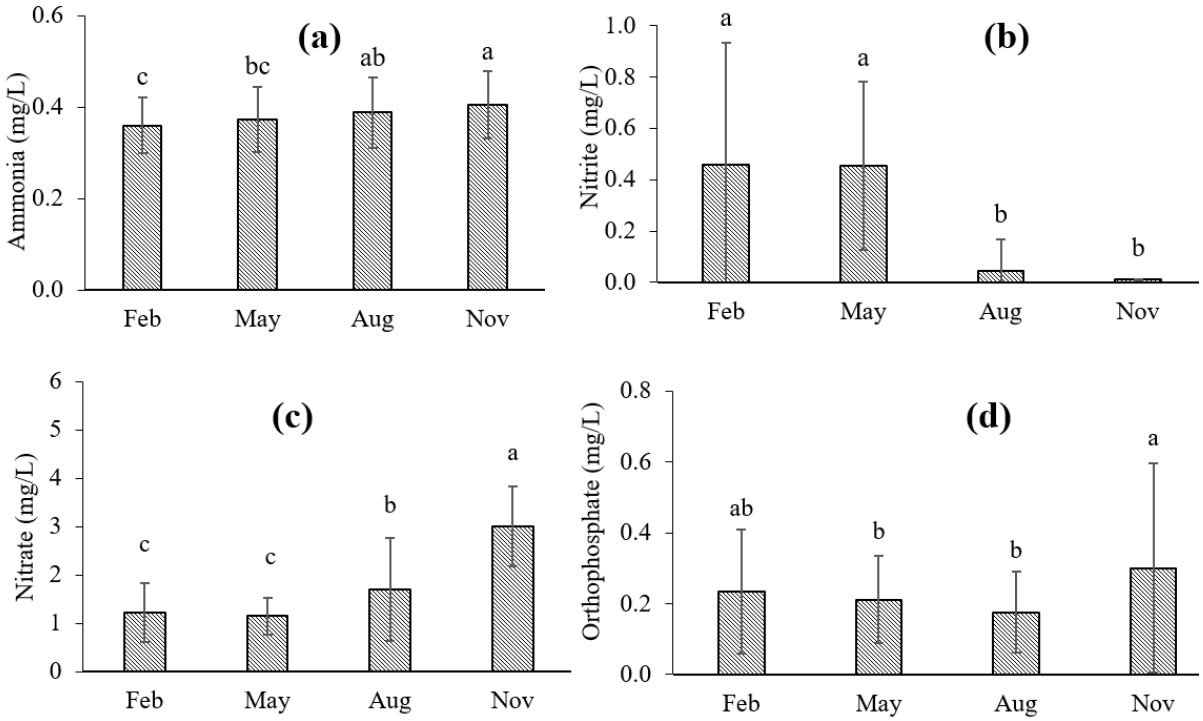

Figure 4. Seasonal variation of nitrogen compounds

3.4 Coliform and E. coli

The average density of coliforms in February, May, August and November were 4599.31 ± 3019.32, 6451.55 ± 7912.07, 8327.41 ± 7685.89, 7000 ± 4778.53 MPN/100 mL, respectively (Figure 5b). Similar to the study of Ly and Giao (2018) [18], it was shown that coliforms in surface water of An Giang province in the period 2009-2016 exceeded the permitted limit by 2.14-7.04 times compared to QCVN 08-MT: 2015/BTNMT. In the study of Giau et al. (2019) [20], it was reported that the density of coliforms in Can Tho river in the period 2010 - 2014 ranged from 3,448 to 27,327 MPN/100 mL. The density of coliforms in the rivers and canals of Dong Thap in the rainy season was higher than that in the dry season. The presence with high concentrations of coliforms indicated that the water is polluted by organic matters derived from human and animal wastes (Ly and Giao, 2018) [18].

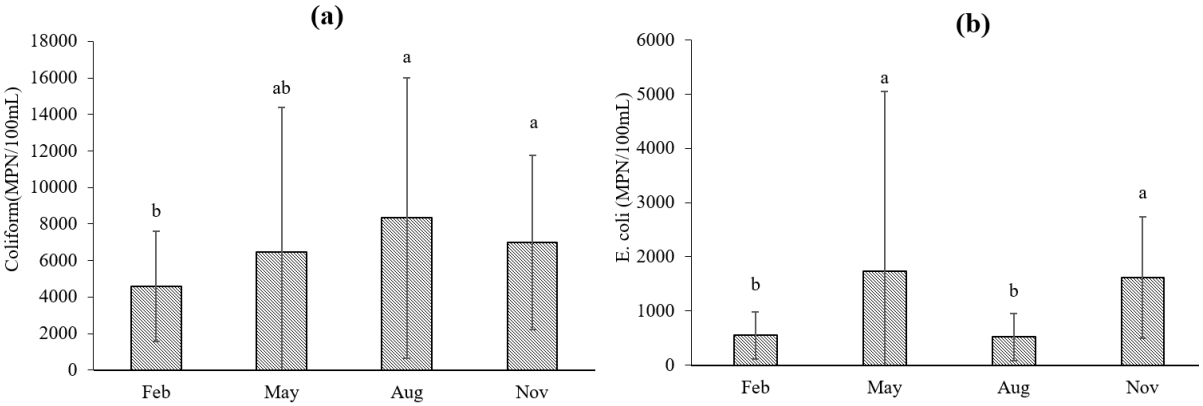

Figure 5. Seasonal variation of microbes

Based on Figure 5b, it was showed that E. coli at almost all surveyed locations exceeded the allowable limit of QCVN 08-MT: 2015/BTNMT, column A2 from 8.12 to 134.15 times. The mean densities of E. coli in February, May, August, November were 548.10 ± 430.41, 1728.97 ± 3320.80, 520.26 ± 438.64, 1615.17 ± 1124.19 MPN/100mL, respectively (Figure 5b). The fluctuations of E. coli in the months were was statistically significantly different ($p<0.05$). The density of E.coli in the rainy season was higher than that in the dry season. The surface water in the water bodies in the Dong Thap province was seriously polluted.

3.5 Evaluating water quality using WQI index

The calculation result of water quality index (WQI) for 58 locations along Tien river, Hau river, in-field canals in Dong Thap province is shown in Figure 6.

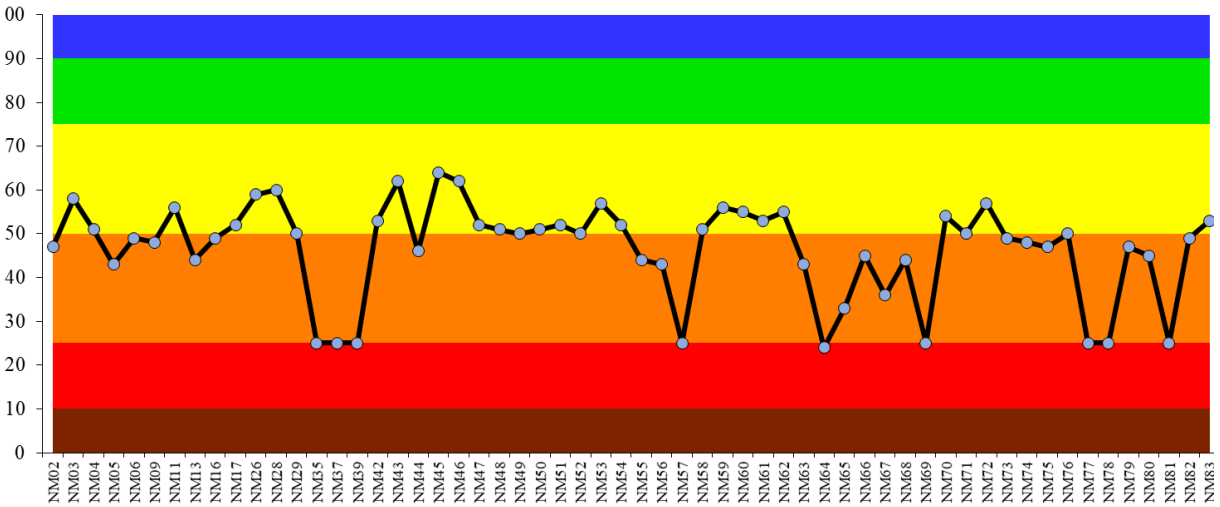

Figure 6. Water quality index in the study area

Figure 6 showed that the water quality index ranged from 24 (NM64) to 64 (NM45). According to the water quality rating scale of the Vietnam Environment Administration (Table 2), the water quality at all study sites was from moderate pollution to heavy pollution. The water quality index at NM64 (24) was the lowest, possibly because domestic wastes and livestock wastes discharged directly into the river, so the concentration of microorganisms at the location was high, specifically the density of coliform (11,050 MPN/100 mL) was 2.21 times and E. coli (1117.5 MPN/100 mL) was 22.35 times higher than that of column A2 of QCVN08-MT: 2015/BTNMT (Figure 5). In general, compared with the water quality rating scale of the Vietnam Environment Administration (Table 2), the water quality of all monitoring sites is only used for irrigation and navigation purposes. In the coming time, there should be measures to treat and manage water quality in Dong Thap province to serve the purpose of supplying water for domestic use.

4. Conclusion

The surface water quality in the plain of reeds was studied. The results showed that temperature and pH are consistent with the quality of surface water used for daily life and aquatic life. Surface water quality at the monitoring locations along Tien River, Hau River and inland canals in Dong Thap province in the year 2020 was polluted by TSS, BOD, COD, N-NH_4^+, N-NO_2^-, coliform, E. coli since the concentrations of these parameters exceeded the limits of QCVN 08-MT: 2015/BTNMT, column A2. Temperature, pH, DO, and E. coli were not significantly different between the seasons. TSS, BOD, COD, N-NH_4^+, N-NO_3^-, P-PO_4^{3-}, and coliform were high in the rainy season while N-NO_2^- was high in the dry season. The results of the calculation of the water quality index (WQI = 24-64) showed that the water quality in Dong Thap province was classified from moderate to poor.

Water quality was polluted could be due to the influence of the hydrological regime, agricultural cultivation, industry and people's daily life activities. Future study should investigate the water polluting sources and the appropriate treatment could be applied.

References

[1] Chounlamany, V., Tanchuling, M.A., and Inoue, T., 2017. Spatial and temporal variation of water quality of a segment of Marikina River using multivariate statistical methods. Water Science and Technology 66.6: 1510-1522.
[2] Gebreyohannes, F., Gebrekidan, A., Hadera, A., Estifanos, S., 2015. Investigations of Physico-Chemical Parameters and its Pollution Implications of Elala River, Mekelle, Tigray, Ethiopia. Momona Ethiopian Journal of Science (MEJS), V7(2):240-57.
[3] Giao, N.T., Nhien, H.T.H., 2020. Phytoplankton-Water Quality Relationship in water bodies in the Mekong Delta, Viet Nam. Journal of Applied Environmental Research, 42(2):1-12.
[4] Chau Thi Hong Ha, 2019. Evaluation of frequency and monitoring indicators of surface water in An Giang province in the period of 2009 - 2018. Graduation thesis from Can Tho University.
[5] Lien, N.T.K., Huy, L.Q., Oanh, D.T.H., Phu, T.Q., Ut, V.N. Water quality in mainstream and tributaries of Hau River. Can Tho University Journal of Science, 2016, 43, 68-79. (In Vietnamese).
[6] Department of Environment and Natural Resources, Dong Thap province. Environmental Monitoring Report of Dong Thap Province in 2020.
[7] Ogston, A.S.; Alison, M.A.; Mullarney, J.C. Nittouer Sediment and hydro-dynamics of the Mekong Delta: From tidal river to continental shelf. Cont. Shelf Res. 2017, 147, 1–6.
[8] Brunier, G.; Edward, J.A.; Marc, G.; Mireille, P.; Philippe, D. Recent Morphological Changes in the Mekong and Bassac River Channels, Mekong Delta: The Marked Impact of River-Bed Mining and Implications for Delta Destabilisation. Geomorphology 2014, 224, 177–191.
[9] Dang, T.D.; Cochrane, T.A.; Arias, M.E.; Tri, V.P.D. Future Hydrological Alterations in the Mekong Delta under the Impact of Water Resources Development, Land Subsidence and Sea Level Rise. J. Hydrol. Reg. Stud. 2015, 15, 119–133.
[10] Manh, N.V.; Dung, N.V.; Hung, N.N.; Kummu, M.; Merz, B.; Apel, H. Future Sediment Dynamics in the Mekong Delta Floodplains: Impacts of Hydropower Development, Climate Change and Sea Level Rise. Glob. Planet. Change 2015, 127, 22–33.
[11] Kakonen, M. Mekong Delta at the Crossroads: More Control or Adaptation. Swedish Acad. Sci. 2008, 37, 205–217.
[12] Turner, S.; Pangarre, G.; Mather, R.J. Water Governace: A Situational Analysis of Cambodia, Lao PDR and Vietnam. In Proceedings of the Mekong region water dialogues; IUCC: Gland, Switzerland, 2009; Vol. 2, p. 59.
[13] Truong, T.V River Basin Management Challenges and Solutions. Vietnam National Committee on Large Dams & Water Resources 2015, 1–12.
[14] Ministry of Natural Resources and Environment (MONRE). National State of Environment -Surface Water Quality, 2012.
[15] American Public Health Association, 1998. Standard Methods for the Examination of Water and Wastewater, 20th edition, Washington DC, USA 1998.
[16] Vietnam Environment Administration, 2019. Decision No. 1460/QD-TCMT dated 12 November 2020 promulgating technical guidance for calculating water quality index..
[17] Nguyen Thanh Giao and Truong Hoang Dan. Interrelation of Phytoplankton and Water Quality at Bung Binh Thien Reservoir, An Giang Province, Vietnam. Indonesian Journal of Environmental Management and Sustainability, 2020, 4 (4): 110-115.
[18] Ly, N.H.T., and Giao, N.T. (2018). Surface water quality in canals in An Giang province, Viet Nam, from 2009 to 2016, Journal of Vietnamese Environment 10(2), 113-119.
[19] Le Huy Ba, 2007. Soil ecology. Ho Chi Minh City National University Publishing House, 320 pages.
[20] Ministry of Fisheries, 2004. Water quality management in aquaculture. 17 pages.
[21] Ministry of Environment and Natural Resources (MONRE). QCVN 08-MT: 2015/BTNMT National technical regulation on surface water quality, 2015.
[22] Vo Thi Ngoc Giau, Phan Thi Bich Tuyen and Nguyen Hieu Trung, 2020. Assessment of changes in surface water quality in Can Tho river for the period 2010-2014 by calculation method of water quality index (WQI). Science Journal of Can Tho University. 55 (Issue number: Environment and Climate Change) (2): 105-113.
[23] Tuan, D.D.A., Thu, B.A., and Trung, N.H. 2019. Assessing quality of surface water for urban water supply source for Soc Trang City. Tạp chí Đại học Cần Thơ, No 4A (2019):61-70. (In Vietnamese).

[24] Ut, V.N., Loan, N.B., Giang, H.T., Oanh, D.T.H., Lien, N.T.K., Quoc, N.B., Ngoan, N.V., Hoa, A.V., Tu, P.T.C., 2013. Study on measures to limit the growth of Limnoperna fortunei living on Cipangopaludina lecithoides in Cho Lach district, Ben Tre. Final report on ministerial-level projects, 100 pages.
[25] Dang Van Ty, Nguyen Hoang Huy, Chau Thi Da, Vu Ngoc Ut and Tran Van Viet, 2018. Assessment of water quality variation in Bung Binh Thien, An Giang province. Science Journal of Can Tho University. 54 (3B): 125-131.
[26] Giao, N. T. (2020). Evaluating current water quality monitoring system on Hau river, mekong delta, Vietnam using multivariate statistical techniques. Applied Environmental Research, 42(1), 14–25.
[27] Boyd, CE., 1998. Water quality for pond aquaculture. Research and development series No. 43 August 1998 international center for aquaculture and aquatic environments Alabama agricultural experiment station Auburn University.
[28] Boyd, C.E. and Green, B.W., 2002. Water quality monitoring in shrimp farming areas: an example from Honduras, Shrimp Farming and the Environment. The World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment; Auburn: USA.