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Assessing Surface Water Quality in In-Field Water Bodies in Ben Tre Province, Vietnam

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Abstract

Water is essential for all life. The study was conducted to assess surface water quality in in-field water bodies of Ben Tre province in 2020. Surface water samples were taken in the dry and rainy seasons at nine representative sites (VT1 to VT9). Temperature, pH, turbidity, salinity, dissolved oxygen (DO), suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen (COD), ammonium (N-NH_4^+), nitrate (N-NO_3^-), orthophosphate (P-PO_4^{3-}), iron (Fe) and Coliform were used for water quality assessment by comparing with the national technical regulation on surface water quality QCVN 08-MT:2015/BTNMT, column B1. The results showed that surface water was polluted by TSS, BOD, and Fe. The highest salinity was at 7.9‰ in the dry season. TSS and BOD were high in the rainy season while DO and Fe were high in the dry season. Temperature, pH, COD, N-NH_4^+, N-NO_3^-, P-PO_4^{3-} and Coliform were within the limits of QCVN 08-MT:2015/BTNMT, column B1. However, the risk of eutrophication is still exist due to the presence of nutrients. The more pollution of water source in the dry season could limit the water use. Sources of water pollution could be from agricultural production and human activities. Future study should focus on investigating concrete water pollution sources and appropriate measures should be taken to improve the current water quality problems.

1. Introduction

Ben Tre is one of the provinces in the Mekong Delta region, with a natural area of 2360.2 km^2. This is a locality with the strength of a dense network of rivers, connecting with four large rivers flowing through the territory and out to the sea estuaries, creating open trade, bustling exchange and trading [1]. With favourable natural conditions such as the sea border, mild climate, fertile alluvium, Ben Tre has many policies to promote the development of agriculture and aquaculture in order to bring great economic resources to the locality as well as stabilizing the livelihoods of the people. Along with the strong development of the agriculture and fishery industries, along with the problems of saline intrusion, drought, and salinity in recent years, which have taken place continuously over the years, are having a great impact on the soil environment [2-3]. The water and air environment in the area, the livelihoods of people in Ben Tre are also affected. In-field canals and aquaculture areas show signs of pollution [1]. Along with other pollution risks, surface water quality is also severely affected. In addition to impacts from natural processes such as hydrology, weather conditions, climate change, etc., surface water quality is also affected by human factors such as excessive use of fertilizers, pesticides, aquaculture, domestic activities, industrial activities [2,4]. Some studies show that surface water quality tends to decrease gradually and one of the areas of surface water with high risk of pollution is the area of the irrigation system [2,4]. Evaluation and monitoring of surface water quality is needed [2]. This study used water quality parameters including pH, temperature, salinity, turbidity, dissolved oxygen, total suspended solids, biochemical oxygen demand, chemical oxygen demand, ammonium, nitrate, orthophosphate, iron, and Coliform to assess the quality of surface water in Ben Tre province in 2020. This study aims to provide scientific information on surface water quality for the study area.

2. Methodology

The study collected water samples at 9 monitoring points, which are denoted VT1, VT2, VT3, VT4, VT5, VT6, VT7, VT8 and VT9, respectively, representing the areas in the field canals of Ben Tre province (Table 1). The frequencies of water samplings were 4 times in March, June, August and October of 2020. The collected surface water quality samples were used for the analysis of temperature, pH, turbidity, salinity, dissolved oxygen (DO), total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD), ammonium ($N-NH_4^+$), nitrate ($N-NO_3^-$), orthophosphate ($P-PO_4^{3-}$), iron (Fe), Coliform. pH, temperature (^oC), DO, salinity (‰), turbidity were measured at the field while TSS, BOD, COD, $N-NH_4^+$, $N-NO_3^-$, $P-PO_4^{3-}$, Fe, and Coliform were analyzed according to standard methods [5]. Table 2 presents the methods for water sample analysis.

Table 1. Sites of the water sampling locations

No.	Sites	Code	Coordinates	
			Longitude	Latitude
1	Binh Phu commune	VT1	106^0 20’40,1’’	10^0 14’04,6’’
2	Phu An Hoa commune	VT2	106^0 23’06,1’’	10^0 18’06,4’’
3	Vinh Thanh commune	VT3	106^0 13’01,8’’	10^0 11’52,6’’
4	Tan Phu Tay commune	VT4	106^0 17’36,6’’	10^0 12’11,6’’
5	Luong Quoi commune	VT5	106^0 28’38,0’’	10^0 12’04,7’’
6	Tan Thuy commune	VT6	106^0 38’21,0’’	10^0 01’07,0’’
7	Chau Hung commune	VT7	106^0 30’25,8’’	10^0 14’41,5’’
8	Quoi Dien commune	VT8	106^0 29’00,8’’	09^0 59’00’’
9	Cam Son commune	VT9	106^0 20’51,4’’	10^0 01’21,5’’

Table 2. Methods of analysis of surface water quality indicators

No.	Parameters	Unit	Analytical methods
1	pH	-	Handy Lab 100
2	Temperature (T)	^0C	Physics 300
3	Salinity (S)	‰	WTW Cond 3310
4	Turbidity (Turb.)	NTU	2100PHACH
5	Dissolved oxygen (DO)	mg/L	Multi 3620 IDS
6	Total suspended solids (TSS)	mg/L	SMEWW 2450D:2017
7	Biological Oxygen Demand (BOD)	mg/L	SMEWW 5210B:2017
8	Chemical Oxygen Demand (COD)	mg/L	SMEWW 5220C:2017
9	Ammonium ($N-NH_4^+$)	mg/L	SMEWW 4500 NH3 B&F:2017
10	Nitrate ($N-NO_3^-$)	mg/L	SMEWW 4500-NO_3^- E:2017
11	Orthophosphate ($P-PO_4^{3-}$)	mg/L	SMEWW 4500P(E):2017
12	Iron (Fe)	mg/L	SMEWW 3111B: 2017
13	Coliform	MPN/100ml	TCVN 6187-2 :1996

3. Results and discussion

The pH value at the monitoring sites fluctuates around 6.84-7.3 (Figure 1). The average pH value in the rainy season and the dry season is 7.03 and 7.19, respectively, showing that the water quality in the study area has a neutral pH and there is no significant difference between the two seasons. At point VT6 has the highest pH value of 7.59 in the dry season and point VT5 has the highest pH value of 7.21 in the rainy season. Previous research showed that the pH in canals of main rivers and tributaries of Hau River in 2016 ranged from 6.3-8.0 [6]. The pH in the Can Tho area ranges from 7.00-7.80 with an average of 7.40 [4]. In Dong Thap's water bodies, the pH values ranged from 7.15 ± 0.20 to 7.36 ± 0.27 [7]. The pH does not highly fluctuate and this is the common condition in tropical region [8,9]. The pH at the monitoring points is within the allowable limit of QCVN 08-MT:2015/BTNMT, column B1 (5.5-9) [10].

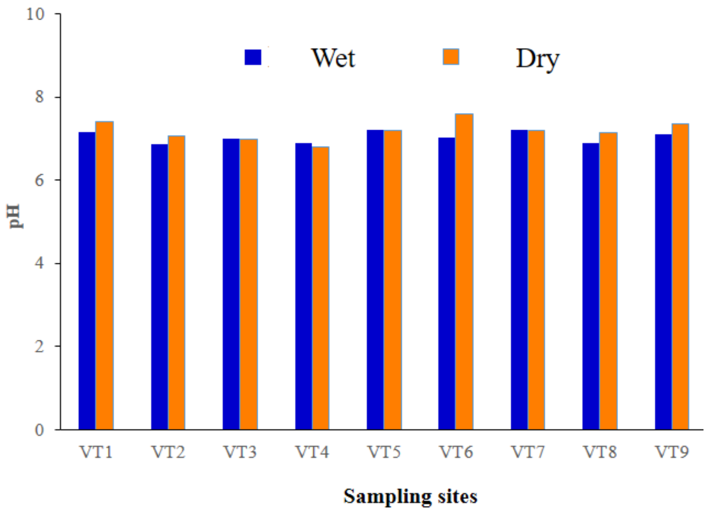

Figure 1. Seasonal variation of pH in the water bodies

Figure 2 showed that dissolved oxygen (DO) concentrations fluctuated in the range of 5.11-6.41 mg/L. The average DO concentration in the rainy season and the dry season was 5.05 mg/L and 6.24 mg/L, respectively. The DO fluctuated at the monitoring locations in the rainy season from 4.04 to 5.82 mg/L and in the dry season from 5.6 to 7.01 mg/L. Both seasons had DO concentration within the allowable limit of column B1 (≥4 mg/L) QCVN 08-MT:2015/BTNMT. The VT2 point in the rainy season has a concentration close to the lower limit of the allowable limit of 4.035±0.88 mg/L. Figure 2 clearly shows the difference in DO concentration between the two seasons, the average in dry season was 1.19 mg/L higher than that in the rainy season. All monitoring locations had high DO concentrations tolerated the allowable limit for irrigation and similar purposes. From the results at all monitoring locations, DO in the dry season is higher than that in the rainy season, showing that there are impacts from other factors causing the difference. The presence of organic matters, TSS, water volume and flow rate of the water bodies greatly affect oxygen concentration in water. The inability of the algae to photosynthesize causes the generation of oxygen in the water to decrease, the accumulation of organic residues in the canal is very large, which reduces the area and volume of the canal, and this affects the flow of water and diffusion of oxygen from the air into the water at the canal [3-4]. 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 to maintain metabolism, growth and development [11]. According to the national technical regulation on surface water quality, the DO content is ≥6, ≥5, ≥4, ≥2 (mg/L) respectively for columns A1, A2, B1 and B2. DO in canals of Soc Trang province, DO is lower than in other studies, ranging from 1.7-6.17 mg/L [12]. The DO concentration in the Tien River in the period from 2011 to 2019 was lower than the allowable limit of column A1 according to QCVN 08-MT:2015/BTNMT [10]. In water bodies such as Tien and Hau rivers, DO should be 5 mg/L or higher to be suitable for aquatic life [3]. The higher DO concentration could indicate better self-purification capacity of the lake. In the cold place, dissolved oxygen in water body could reach high between 9.22 ± 2.6 and 11.0 ± 1.6 mg/L, however, self-cleaning capacity could be low in comparing to the present study due to low temperature [13].

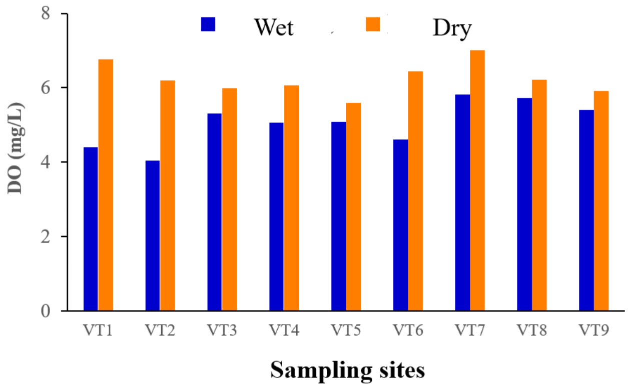

Figure 2. Seasonal variation of DO in the water bodies

The average total suspended solids (TSS) at the monitoring sites ranged from 15.5 to 46.75 mg/L **(**Figure 3). TSS values in the rainy season ranged from 18.5 to 59.25 mg/L and in the dry season from 12.5 to 59 mg/L (Figure 3). Occurrence of the locations exceeding the allowable threshold (50 mg/L) according to column B1 of QCVN 08-MT: 2015/BTNMT in the dry season was the position VT9 59 mg/L and in the rainy season was the position VT4 59.25mg/L, VT7 score 58.75 mg/L. According to QCVN 08-MT:2015/BTNMT, water quality with TSS within the limit of column A1 (20 mg/L) is good for domestic use, column A2 (30 mg/L) is of good quality. Water used for domestic water supply must have suitable treatment technology or use purposes such as grades B1 and B2 of 50 and 100 mg/L respectively for irrigation, irrigation or other uses with similar water quality requirements or only for navigation and other purposes with low quality water requirements. In main rivers and tributaries of the Hau river TSS ranged from 41.2±33.7 to 89.57±31.31 mg/L [6], in canals of An Giang province in the period 2009-2016, TSS ranged from 25.0 ± 11.5 mg/L to 93.7 ± 28.3 mg/L [14]. Total suspended solids in canals in Hau Giang province ranged from 32.8±6.4 to 101.8±40.9 mg/L (average 57±22.6 mg/L) [15]. In Dong Thap' water bodies, TSS also had a considerable seasonal variation, ranging from 21.71 ± 15.11 to 49.57 ± 33.58 mg/L, and the difference was statistically significant [7]. Former studies by Lien et al. [6] and Ut et al. [16] also showed that water quality is strongly influenced by time, in which the TSS is always higher than that of the rainy season due to the impact of rainwater runoff and erosion. TSS upstream tends to be higher than downstream because of the flow rate and the amount of sediment contained in the water column [15]. TSS increases the cost of water treatment, affecting aquatic life [3-4, 15].

Biochemical oxygen demand (BOD) is the amount of oxygen required to oxidize organic substances in water by aerobic microorganisms. This is an indicator used to determine the degree of contamination of water, the higher the BOD value, the higher the level of organic pollution. The BOD index depends on the temperature and time of stabilization.

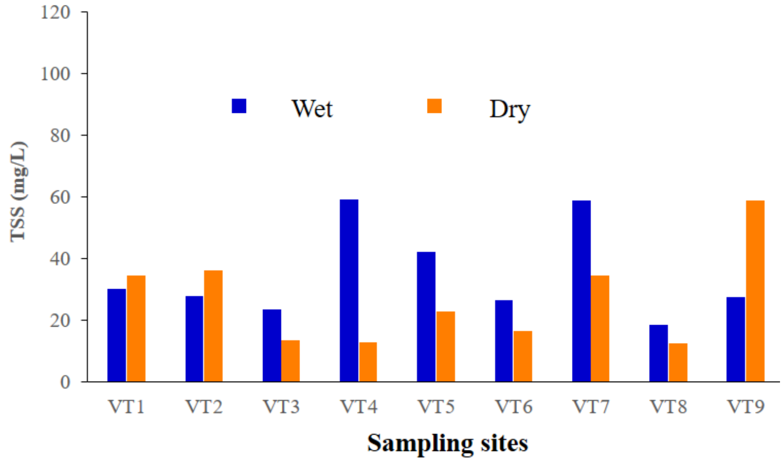

Figure 3. Seasonal variation of TSS in the water bodies

Biological oxygen demand is usually determined after a period of 5 days at 20°C, because after this time most of the organic matter is decomposed [5]. If more than 5 days, nitrification may affect the measurement of the BOD value of the sample. According to QCVN 08-MT:2015/BTNMT [10], water quality with BOD concentration within the limit of column A1 (4 mg/L) is good for domestic water supply and other purposes; limit column A2 (6 mg/L) of water quality used for domestic water supply must apply appropriate treatment technology or limit column B1 (15 mg/L) used for irrigation and irrigation purposes or other uses with similar water quality requirements or uses such as class B2 (25 mg/L) for navigation only and other purposes with low quality water requirements. In this study, BOD concentration in the rainy season fluctuated between 6.62 and 15.55 mg/L and in the dry season is 4.57 to 11.42 mg/L (Figure 4). Most of the locations are within the allowable QCVN 08-MT:2015/BTNMT column B1 (15 mg/L) [10], except the VT7 location in the rainy season with a BOD content of 15.55 mg/L. BOD in the surface water in Tien Giang province in 2019 ranged from 8.0 ± 2.7 to 8.9 ± 2.6 mg/L [7]. No significant changes were observed in all four observations of BOD. BOD content in Hau Giang canals reached an average value of 10.5±2.3 mg/L respectively, exceeding QCVN 08-MT:2015/BTNMT, column A [7]. BOD in canals in Soc Trang province is in the range of 2.2-22.4 mg/L [11]. River water with a BOD content exceeding QCVN 08-MT:2015/BTNMT poses many risks when used as feed water because carbon compounds can combine with chlorine during the disinfection phase to produce hazardous compounds and these compounds could result in health effects when exposed to the community through water use [17]. Like TSS, organic pollution due to high BOD content is a common problem of water bodies in the Mekong Delta. The origin of BOD can be due to waste from farming, livestock, landfill, domestic activities, and services that have discharged untreated waste into the surface water environment [4].

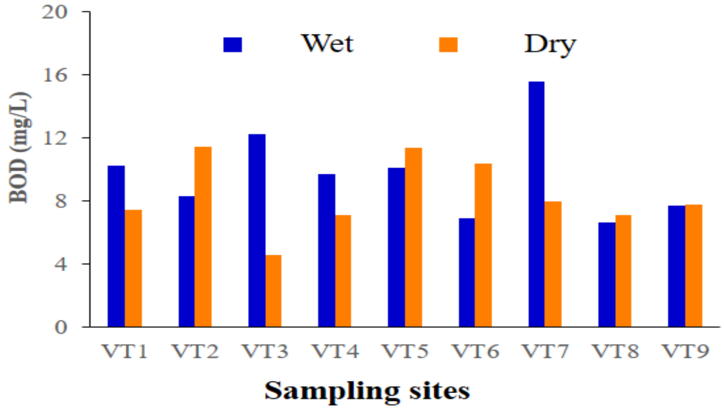

Figure 4. Seasonal variation of BOD in the water bodies

The amount of oxygen required to oxidize chemical compounds in water, both inorganic and organic, is called chemical oxygen demand (COD). Thus, COD is the amount of oxygen required to oxidize all chemical substances in water, while BOD is the amount of oxygen required to partially oxidize organic compounds easily decomposed by microorganisms. All oxygen used for the above reactions is obtained from dissolved oxygen in water (DO). Therefore, the high chemical and biological oxygen demand will reduce the DO concentration of the 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 [1-2]. According to QCVN 08-MT:2015/BTNMT [10], the COD value specified for columns A1, A2, B1, B2 is 10, 15, 30, 50 mg/L respectively, suitable for different surface water uses. In the current study, COD in the rainy season fluctuated between 10.35 and 26.02 mg/L and in the dry season about 8.72 to 18.39 mg/L (Figure 5). COD at the monitoring locations did not exceed the allowable limit for column B1 of QCVN 08-MT:2015/BTNMT. According to a study by [18], the average COD (11.55-17.82 mg/L) on some main rivers and canals in Can Tho city all exceeded QCVN 08-MT:2015/BTNMT column A1 (10 mg/L). COD in the surface water in Tien Giang province in 2019 ranged from 14.4 ± 4.8 to 17.3 ± 4.4 mg/L [7]. There were significant differences between seasons for COD. COD in Hau Giang canals reached an average value of 17.9±4.3 mg/L and exceeded QCVN 08-MT:2015/BTNMT, column A [15]. Former studies reported that COD in the river derived by several social-economic activities such as restaurants, intensive urban areas, and industrial settlements [13]. BOD and COD were used as indicators of organic waste concentration in water [19].

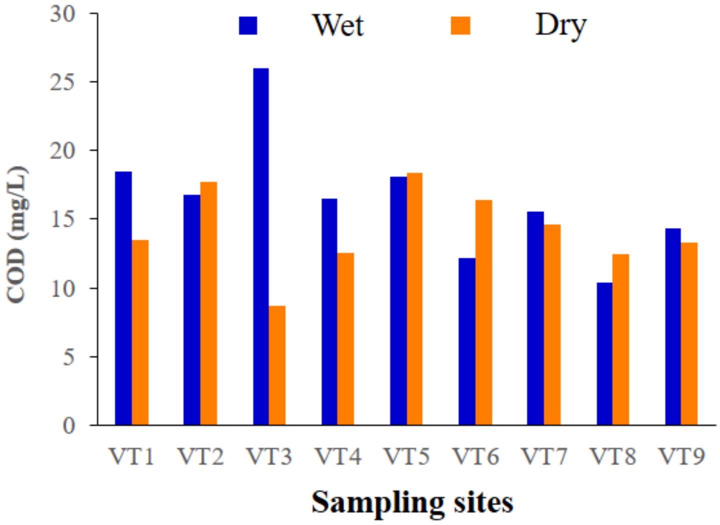

Figure 5. Seasonal variation of COD in the water bodies

The concentration of N-NO_3^- at the monitoring locations in the rainy season ranged from 0.1 to 0.5 mg/L and in the dry season was 0.02 to 0.18 mg/L (Figure 6). N-NO_3^- is a product of the nitrification process, nitrate is not toxic to shrimp and fish but can cause phytoplankton bloom, causing changes in water quality that are not beneficial to farmed shrimp and fish [11]. If the nitrogen in the water is mainly in the form of nitrate, there is enough dissolved oxygen in the water [3-4, 11]. However, nitrates are stable only under aerobic conditions, under anaerobic conditions they are quickly reduced to free nitrogen that separates from the water, eliminating the growth of algae and other aquatic plants. The high concentration of N-NO_3^- is a good nutrient environment for the growth of algae and algae, which affects the quality of drinking water and can be toxic to humans. The concentration of N-NO_3^- specified in QCVN 08-MT:2015/BTNMT column A1 (2 mg/L) [10] 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. Columns B1 and B2 are 10, 15 mg/L, respectively; for irrigation or other uses with similar water quality requirements or only for navigation and other purposes with low quality water requirements. Previous studies showed that N-NO_3^- concentrations in Hau river ranged from 0.002-0.395 mg/L [6], An Giang canals ranged from 0.31 ± 0.3 to 0.58 ± 0.64 mg/L [14], canals in Soc Trang province 0.05-0.14 mg/L [12]. N-NO_3^- concentration fluctuates and peaks in June, possibly due to the dry season month and also the time of fertilizing the fields [16]. N-NO_3^- concentration is greater than 0.7 mg/L and in the range 0.2-10 mg/L have eutrophication potential and are suitable for aquatic life [3, 11].

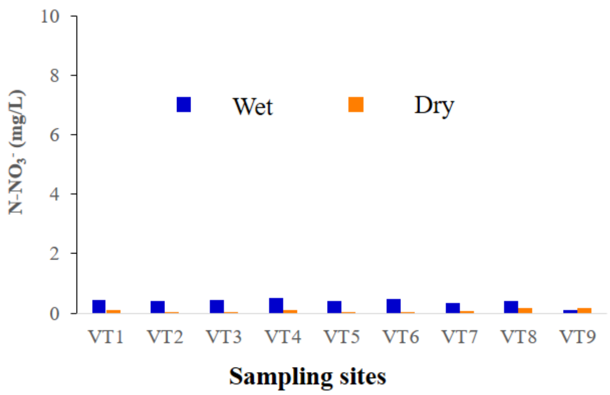

Figure 6. Seasonal variation of nitrate in the water bodies

Ammonium (N-NH_4^+) exists in water as an ion between N-NH_4^+ or dissolved N-NH_3. Depending on the pH of the water, there is always a balance between NH_4^+/NH_3 in the water. Ammonia is present in water as a product of the decomposition of organic substances (especially proteins), which is the ammonification of proteins in the nitrogen cycle in nature or water contaminated with domestic or industrial wastewater [11]. In domestic wastewater, up to 65% is N-NH_4^+ due to the process of urea decomposition in urine [17]. The value of N-NH_4^+ specified in QCVN 08-MT:2015/BTNMT in column A is 0.3 mg/l which is used for domestic supply water and 0.9 mg/L for column B which is used for for irrigation, irrigation and navigation purposes [10]. In this study, the concentration of N-NH_4^+ in the rainy season ranges from 0.07 to 0.15 mg/L and in the dry season from 0.02 to 0.17 mg/L (Figure 7). The concentration of N-NH_4^+ at all positions did not exceed the allowable threshold and was lower than the allowable limit (0.9 mg/L) column B1 of QCVN 08-MT:2015/BTNMT [10]. Previous research showed that the concentration of N-NH_4^+ in Xa No canal was only 0.07-0.81 mg/l [20]. Canals in Soc Trang province ammonia ranges from 0.35-4.14 mg/L [12]; canals in Ninh Kieu and Can Tho districts have high concentrations of N-NH_4^+ and allowable thresholds [15]. Ammonia nitrogen compounds in canals of Hau Giang province have an average concentration of 0.27±0.16 mg/L, respectively [12]. The concentration of N-NH_4^+ was found seasonally varied [22]. Low N-NH_4^+ concentration creates favourable conditions for aquatic organisms to grow well. The concentration of N-NH_4^+ in water should not exceed 5 mg/L, if it is greater than 5 mg/L, the water is in a very dirty condition [11]. Ammonium is not too toxic to the human body, but very toxic to aquatic life. High N-NH_4^+ has the potential to cause eutrophication of water resources and lead to undesirable environmental problems [3-4,11].

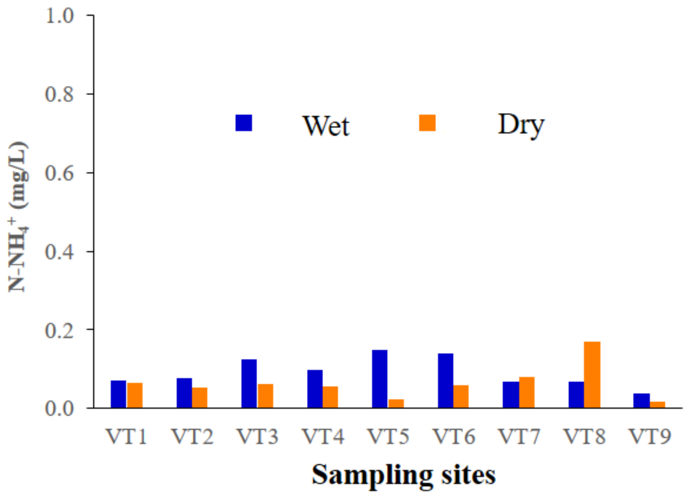

Figure 7. Seasonal variation of ammonium in the water bodies

Phosphate (P-PO_4^{3-}) is a product of the decomposition of organic matter. The sources of phosphate releases can be domestic wastewater, phosphate chemical fertilizer [2-4]. P-PO_4^{3-} is an important material for the growth of flora and fauna [11]. Normally, in natural surface water, P-PO_4^{3-} concentrations exist from 0.005 to 0.02 mg/L [22]. Although a necessary element, too much P-PO_4^{3-} would promote the growth of algae or large plants that clog the water body, a process called overnutrition or eutrophication [2-4, 11, 16,22]. Overgrowth of plants will cause problems that reduce dissolved oxygen, cause odors, and algae that produce toxins that are toxic to animals, aquatic animals or humans who use this water source [16,22]. In the current study, P-PO_4^{3-} in the rainy season ranges from 0.07 to 0.16 mg/L and in the dry season is 0.05 to 0.1 mg/L (Figure 8). The concentration of P-PO_4^{3-} in the rainy season was higher than that in the dry season, the variation in locations in the two seasons did not have a big difference. Dissolved phosphorus values in the infield canals and Hau river of An Giang province ranged from 0.02 to 0.47 mg/L [14], in the Hau river in the An Giang-Hau Giang section 0.04-0.11 mg/L [15], canals in Soc Trang province 0.05-0.9 mg/L [12]. In Tien Giang's water bodies, P-PO_4^{3-} concentration ranged from 0.1 ± 0.2 to 0.1 ± 0.1 mg L^{-1}, indicating the risk of causing eutrophication in the water bodies in the study area [7]. Although at the monitoring points, it does not exceed the allowable limit (0.3 mg/L) column B1 of QCVN 08-MT:2015/BTNMT [10], but according to [22] study, if P-PO_4^{3-} >0.1 mg/L, the possibility of eutrophication is very likely. This means that locations VT2, VT4, VT9 in the rainy season are likely to have eutrophication.

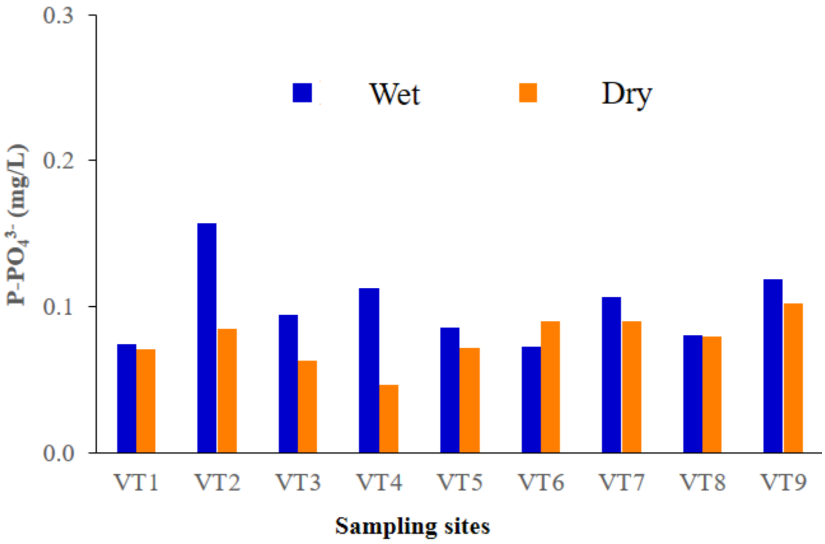

Figure 8. Seasonal variation of orthophosphate in the water bodies

Iron (Fe) concentrations at monitoring locations in the dry season were higher than that in the rainy season (Figure 9). The location with the highest Fe content in the dry season was three times higher than the location with the highest Fe concentration in the rainy season. All monitoring locations in the dry season had Fe concentration exceeding the allowable threshold (1.5 mg/L) except for the position VT9. For the study area in canals in Soc Trang province in the period 2012-2018 with traces of heavy metal pollution, Fe ranges from 0.3-3.75 mg/L [12]. Iron values in water bodies of Hau Giang province ranged from 0.3±0.1-2.3±1.9 mg/L (mean 1.2±0.6 mg/L) and exceeded QCVN 08-MT:2015/BTNMT, column A [10]. Causes of pollution Iron contamination in the aquatic environment is mainly due to natural conditions, domestic wastewater and industrial production. The presence of iron degrades water quality, incurs treatment costs and poses health risks to humans and the environment [15].

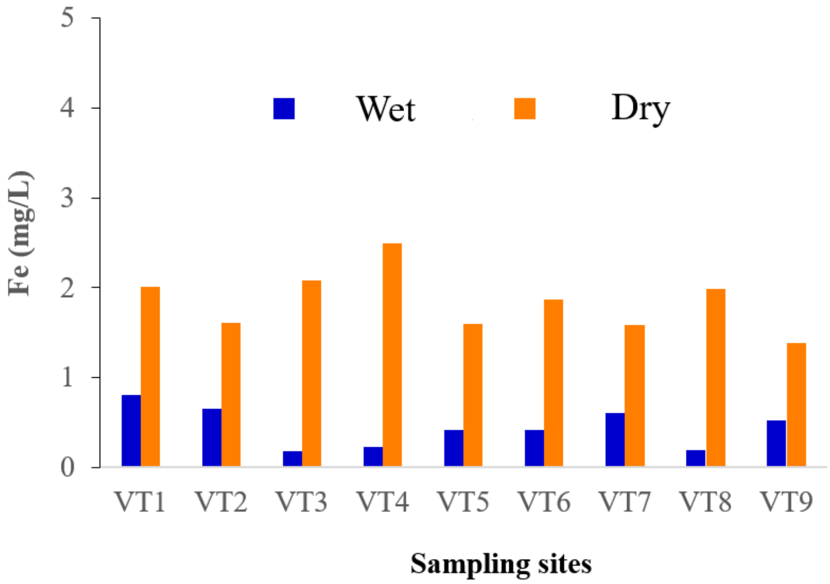

Figure 9. Seasonal variation of iron in the water bodies

Coliform is a group of microorganisms used to indicate the possibility of the presence of pathogenic microorganisms because they are the most important group of microorganisms (accounting for 80% of bacteria) and have all the criteria for the presence of pathogens [3]. According to QCVN 08-MT:2015/BTNMT [10], the regulation on Coliform content in surface water in column A1 is 2500 MPN/100mL which is good for domestic water supply and other purposes; column A2 is 5000 MPN/100mL of water quality used for domestic water supply purposes, suitable treatment technology must be applied; column B1 is 7500 MPN/100mL for irrigation, irrigation or other uses with similar water quality requirements and column B2 with 10000 MPN/100mL is for navigation and other purposes only with low quality water requirements. In the current study, the average value of Coliform in the rainy season is 2081.11 MPN/100mL and in the dry season is 1856.11 MPN/100mL (Figure 10). Coliforms at all monitoring locations did not exceed the allowable threshold according to column B1 (7500 MPN/100mL) QCVN 08-MT:2015/BTNMT. The Coliform density in Tien and Hau rivers over the years 2011-2019 tended to increase, with values from 2621±2379 to 11968±5615 MPN/100 mL [14]. In canals of Soc Trang province, Coliform exceeded from 1 to 36 times [11]. The population of Coliforms in the water bodies of Hau Giang province varied widely from 1156.3±500 to 15275±15244.8 MPN/100 mL, with the average value of 7478.9±5179.3 MPN/100 mL exceeding the allowable value in QCVN 08-MT:2015 /BTNMT, column A [14]. In the surface water bodies in Tien Giang province, the Coliform density in the observational periods tended to increase until the end of the year (November), ranging from 972.9 ± 718.3 to 2261.2 ± 1349.0 MPN/100mL [7]. The occurrence of Coliform in surface water is the main problem in Vietnamese

Mekong delta's water quality. The sources of Coliform contamination are from human and animal wastes, especially the fecal materials [2-4].

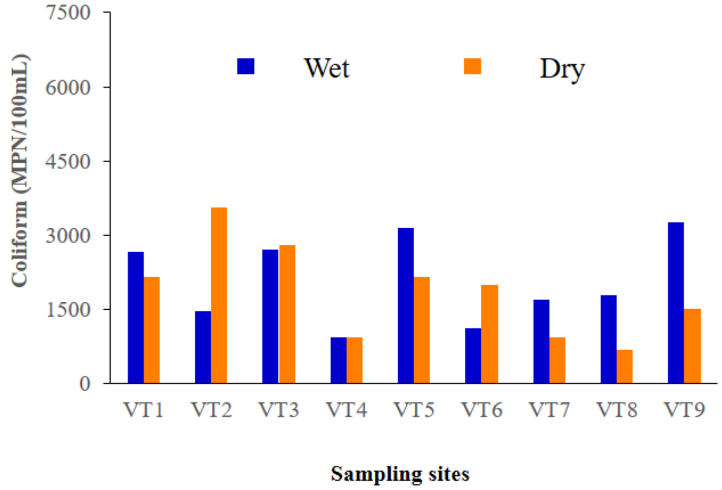

Figure 10. Seasonal variation of Coliform in the water bodies

The salinity recorded at the monitoring locations during the rainy and dry seasons is markedly different. The lowest recorded salinity in the dry season is 2‰ and the highest reaches 7.9‰ compared to the highest salinity in the rainy season of only 1.5‰ (Figure 11). In the dry season, the salinity is about 5 times higher than in the rainy season. Salinity changes show that salinity intrusion and salinity drought are happening more and more seriously in the inland area of Ben Tre province. In addition to the locations VT3 and VT9, the remaining locations in the dry season salinity are higher than 4‰. High salinity in the dry season is a serious problem and has a strong impact on surface water quality in the in-field irrigation system in Ben Tre. High salinity affects aquatic organisms, causing widespread death, affecting crops and causing heavy damage to agricultural activities as well as daily life activities [23].

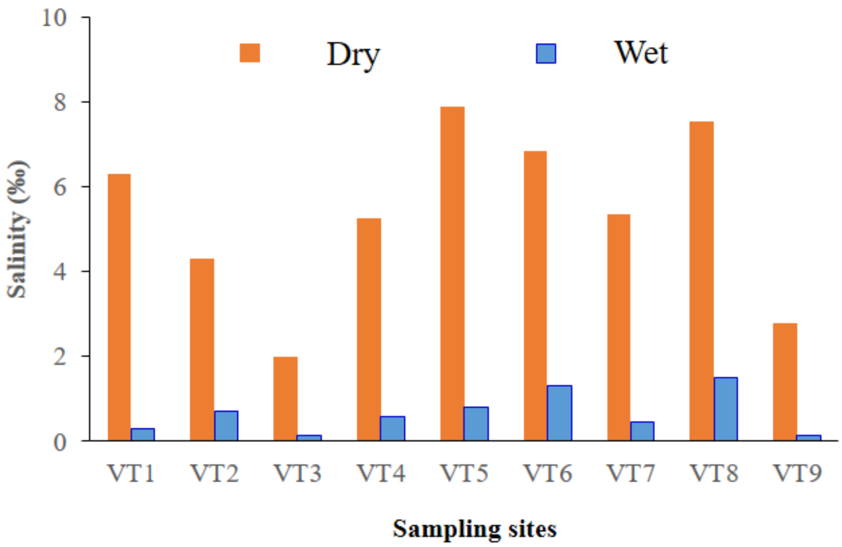

Figure 11. Seasonal variation of salinity in the water bodies

4. Conclusion

The study area appeared contaminated with analytical parameters TSS, BOD, Fe and high salinity. The concentration of TSS complicatedly changed at positions VT4, VT7 in the rainy season along with VT9 in the dry season, exceeding the allowable limit of column B1. Concentrations of organic matter COD and BOD in the study area were higher in the rainy season than in the dry season. Occurrence of organic pollution (BOD) at location VT7 in the rainy season. At the VT3 site, there is a high probability of organic contamination of both COD and BOD in the future. The value of P-PO_4^{3-} does not exceed the allowable threshold but some locations are likely to be eutrophicated. In the dry season, all monitoring locations have high Fe concentration, 8/9 points exceed the allowable threshold. Salinity in the study area recorded in the dry season was very high, reaching 7.9‰, in the rainy season, the salinity was ≤2‰. The remaining indicators showed no signs of pollution. Surface water quality according to research results in the rainy season is somewhat better than in the dry season. In the rainy season, water quality is suitable for irrigation and drainage purposes. In the dry season, water quality is more polluted so water uses for irrigation is limited.

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