

## Surface Water Quality Influenced by Tourism Activity in An Giang Province, Vietnam

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### Abstract

The study was conducted to assess the quality of surface water environment affected by tourism activities in An Giang province. Monitoring data was collected during the period from 2009 to 2018, at three tourist areas of Nui Sam (NT1), Lam Vien Nui Cam (NT2), Tra Su Melaleuca forest (NT3). Water parameters including temperature, pH, total suspended solids (TSS), nitrate ( $N-NO_3^-$ ), chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease and coliform were used to assess surface water quality in the study area. Surface water quality is assessed using the national technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT, column A1). The results showed that surface water quality at the sampling locations was polluted. The parameters of TSS, COD, BOD, oil and grease and Coliform exceeded the allowable limits of QCVN 08-MT: 2015/BTNMT, column A1. Water quality at the location of Tra Su Melaleuca forest was only used for navigation; the sites at Nui Sam and Lam Vien Nui Cam were in heavy pollution. The primary results showed that tourism activities had a significant impact on water quality. Sources of impact on water quality could be from transportation, domestic wastewater and solid waste.

## 1. Introduction

An Giang is a multi-ethnic and multi-religious province with 4 ethnic groups Kinh, Khmer, Cham and Chinese living together for a long time, creating rich and diverse national cultural values expressed through cultural festivals, ethnic culture, traditional craft villages, unique cultural and architectural works [1]. An Giang is a locality with many historical and cultural relics and scenic spots; has a famous mother-worshipping belief throughout the country, attracting millions of visitors every year to worship and offer thanksgiving; there is the majestic and mysterious. That Son area; including Oc Eo - Ba The culture; More specifically, An Giang is the hometown of the late President Ton Duc Thang with Uncle Ho's memorial site located on the green Ong Ho island in the middle of the Hau river [1, 2]. Telecommunication infrastructure has developed quite synchronously, service quality is getting better and better [1].

Traffic infrastructure is also invested in the direction of completing traffic routes to tourist areas and attractions. In the province, there are 14 tourist areas and attractions to welcome and serve guests,

of which 8 areas have been upgraded and supplemented with toilet equipment according to the criteria prescribed by the Ministry of Culture, Sports and Tourism. Two new construction sites for toilet systems (My Thoi park and My Khanh revolutionary relic site), the remaining 4 areas and points do not have standard toilets [1, 2]. In tourist areas and destinations for a long time, the situation of the toilet system is not suitable, the waste treatment system has not been completed [1-3]. Environmental monitoring in tourist areas is necessary to assess the impact of tourism development activities on the environment [1-3].

This study was conducted to assess the impact of tourism activities on water quality in some famous tourist areas of An Giang province. The results provide important information to review the current state of environmental management in tourist areas.

## 2. Materials and methods

The surface water quality was collected at three tourist areas of Nui Sam (NT1), Lam Vien Nui Cam (NT2), Tra Su Melaleuca forest (NT3) in March, June and September during 2009-2018. Water samples were collected according to the instructions of TCVN 5998:1995 (ISO 5667-9: 1992) and the preservation method was carried out according to the instructions of TCVN 5998:1995 and TCVN 6663-3:2016 (ISO 5667- 3:2012).

The water quality parameters including temperature, pH, total suspended solids (TSS), nitrate (N-NO<sub>3</sub><sup>-</sup>), orthophosphate (P-PO<sub>4</sub><sup>3-</sup>), chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease (O&G) and coliform were used to assess surface water quality in the study area. pH and temperature were measure at the field using hand-held meters while the remaining parameters were measured in the laboratory using the standard methods [4].

The analyzed water quality results were evaluated using the national technical regulation on surface water quality QCVN 08-MT: 2015/BTNMT, column A1 [5]. Details of water parameters, analytical methods and detection limits are presented in Table 1.

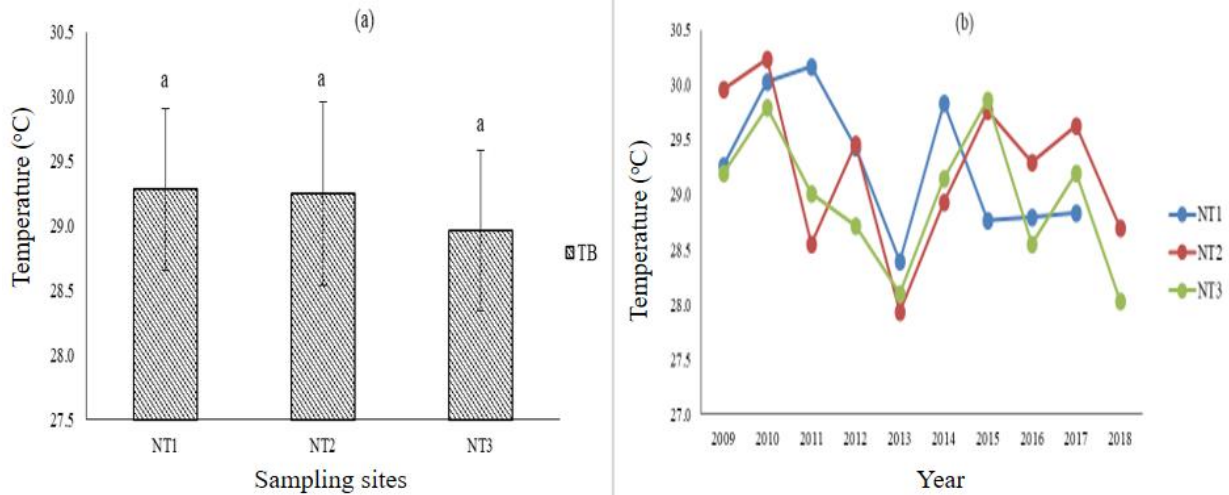
**Table 1. Analytical methods and threshold levels of water quality parameters**

Parameter	Description	Unit	Analytical methods	QCVN, A1
pH	pH	-	TCVN 6492:2011	6-8.5
Temp	Temperature	°C	SMEWW 2550B:2012	-
BOD	Biochemical oxygen demand	mg/l	TCVN 6001-1:2008	4
COD	Chemical oxygen demand	mg/l	TCVN 6491:1999	10
TSS	Total suspended solids	mg/l	TCVN 6625:2000	20
N-NO <sub>3</sub> <sup>-</sup>	Nitrate	mg/l	TCVN 6180:1996	2
O & G	Oil and Grease	mg/l	SMEWW 5520.B:2012	0.3
Coliform	Coliform	MPN/100ml	TCVN 6187-2:1996	2500

## 3. Results and discussion

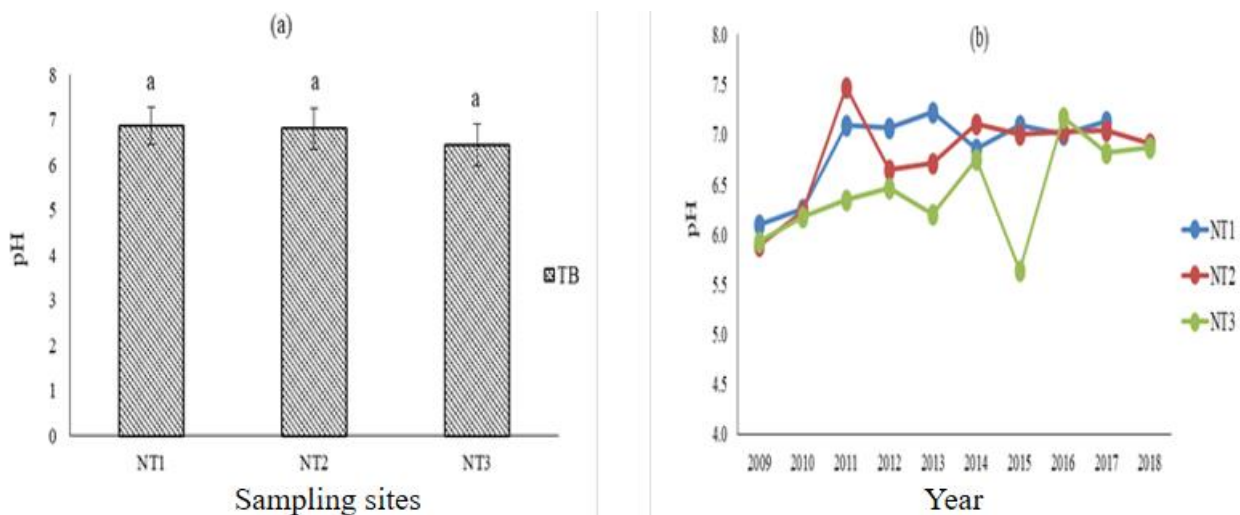
The average temperature collected at the three sampling sites over the 10 years from 2009 to 2018 is shown in Figure 1. Temperatures ranged from 29±1.5 °C to 29.3±1.2°C and did not differ significantly between locations (Figure 1a). The average temperature evolution of the three sampling sites was relatively stable, ranging from 28.6±2.8°C to 30.2±0.4°C (Figure 1b).

The temperature on the Tien River was in the range of 29.35 °C -30.2°C. Previous studies have also shown that there was little variation in water temperature. For example, the water temperature of Hau river ranges from 27.1 °C -32.0 °C [6-8]. Thus, the water temperature in the present study fluctuates within the general range of the area and is still suitable for aquatic development [5].



**Figure 1. The mean temperature in tourism affected water bodies**

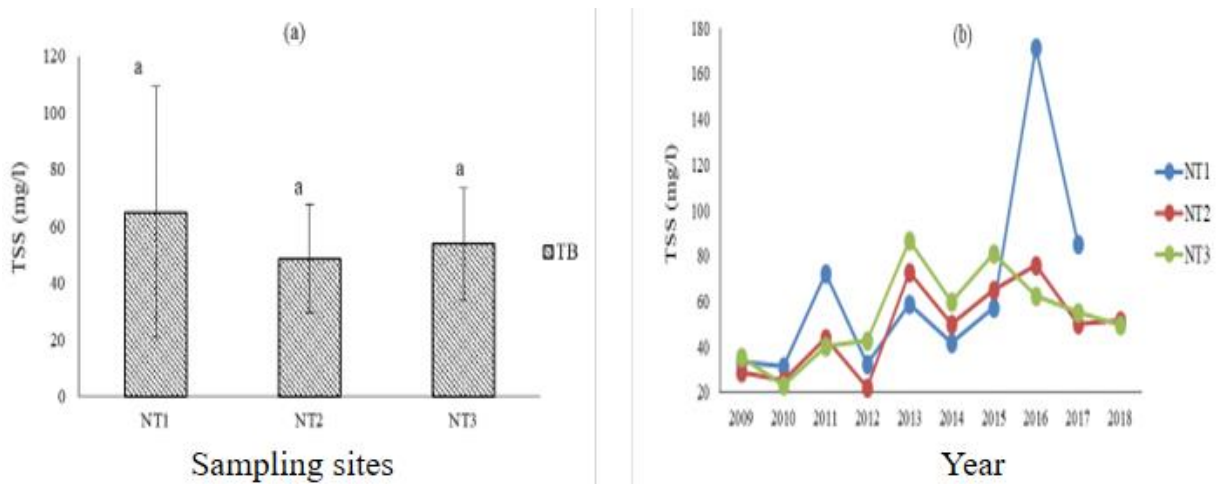
The average pH value at the sampling sites for 10 years from 2009 to 2018 is presented in Figure 2. The average pH value ranged from  $6.4 \pm 0.4$  to  $6.9 \pm 0.5$  (Figure 2a). The pH values between the years at the 3 sampling locations ranged from  $5.9 \pm 0.7$  to  $7.5 \pm 0.1$  (Figure 2b). Previous research showed that pH in canals in An Giang province 2006-2009 ranged from 6.9-7.1 [7], in main rivers and tributaries of Hau river in 2016 ranged from 6.3-8.0 [6] and Hau river section An Giang-Hau Giang ranges from 6.7-7.12 [8]. In general, the pH values in the studies are similar in that the pH has little variation in space and time and is within the allowable range of the National Technical Regulation on surface water quality QCVN 08-MT: 2015/BTNMT [5].



**Figure 2. The mean pH in tourism affected water bodies**

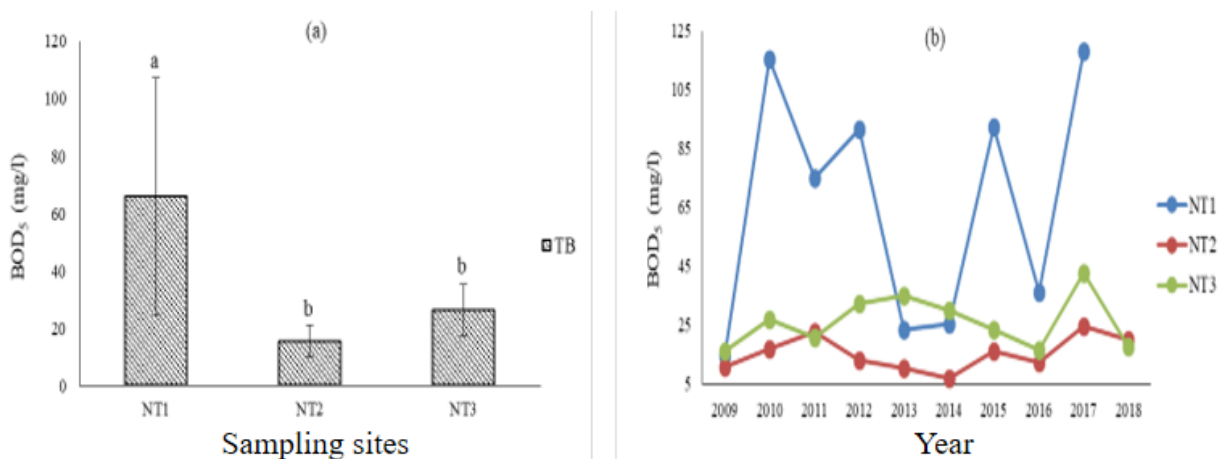
The mean TSS at the sampling sites over the 10 years from 2009 to 2018 ranged from  $48.5 \pm 19.5$  mg/L to  $64.9 \pm 37.4$  mg/l (Figure 3a). TSS variation at 3 sampling sites over 10 years ranged from  $23 \pm 4.6$  mg/L to  $171.7 \pm 114.3$  mg/l (Figure 3b). The mean TSS values were the highest at site NT1 (2016) ( $171.7 \pm 114.3$  mg/l) and the lowest at site NT2 (2011) ( $23 \pm 4.6$  mg/l) (Figure 3b). The results showed that activities from tourist areas had a great impact on TSS concentration. TSS was also recorded very high in the water bodies of the Mekong Delta. For example, TSS in main rivers and tributaries of Hau river ranged from  $41.2 \pm 33.7$  mg/L to  $89.57 \pm 31.31$  mg/L [6], in canals of An Giang province during 2009-2016 period from  $25.0 \pm 11.5$  mg/L to  $93.7 \pm 28.3$  mg/L [7]; Hau River alone in the period 2009-2016 was 40.1-68.0 mg/L [7] and in 2018 it was  $41.16 \pm 35.81$ -  $48.67 \pm 9.07$  mg/L

[8]. TSS is always an environmental issue in the Mekong Delta that reduces the use value of surface water. TSS increases the cost of water treatment, affects aquatic life, transports pollutants [9].



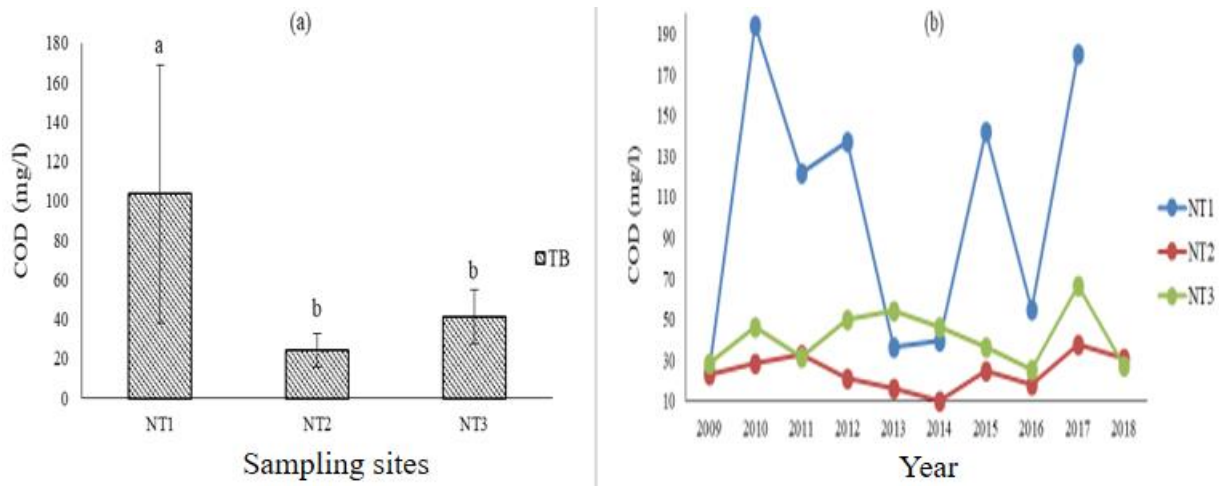
**Figure 3. The mean TSS in tourism affected water bodies**

The BOD concentration for 10 years from 2009 to 2018 at the sampling sites is shown in Figure 4. The average BOD value ranged from  $15.5 \pm 10.8$  mg/L to  $65.9 \pm 72.5$  mg/l. The 10-year mean BOD value by sampling site was highest at site NT1 ( $65.9 \pm 72.5$  mg/l) and lowest at site NT2 ( $15.5 \pm 10.8$  mg/l) (Figure 4a). BOD over 10 years ranged from  $7 \pm 1$  mg/l to  $118 \pm 129.3$  mg/l (Figure 4b). BOD at some time exceeded the allowable limit of QCVN 08- MT: 2015/BTNMT, column A1 6.4 times. Thus, the study shows that tourism activities increase the concentration of BOD in water. BOD is the amount of oxygen required to oxidize organic substances in water by aerobic microorganisms. BOD is used to assess the degree of organic pollution of water sources, the higher the BOD value, the higher the level of organic pollution. Previous studies also showed that BOD in the aquatic environment often exceeds the allowable limit of QCVN 08-MT: 2015/BTNMT, column A1. For example, BOD in rivers and canals including infield canals and Hau river in An Giang province was in the range of  $6.6 \pm 1.2$ -  $8.2 \pm 2.5$  mg/L [7], canals in Soc Trang province were in the range of 2.2-22.4 mg/L [10]. Like TSS, organic pollution due to high BOD was a common problem of water bodies in the Mekong Delta [6-10]. 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 [1-3,9].



**Figure 4. The mean BOD in tourism affected water bodies**

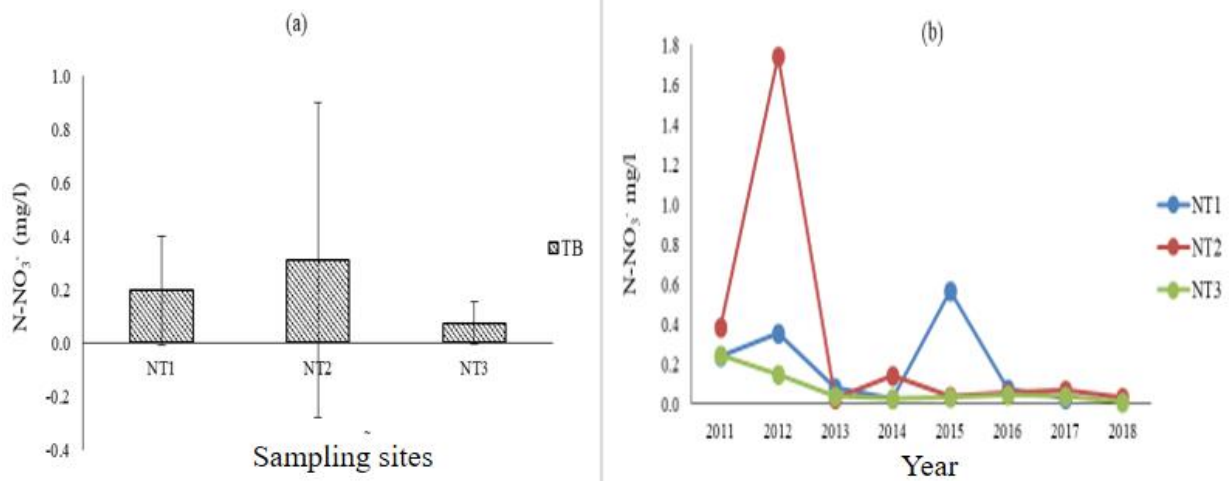
The mean COD values at the sampling sites over 10 years ranged from only  $24.3 \pm 16.7$  mg/L to  $103.5 \pm 113.2$  mg/l (Figure 5a). Variation of COD between years at sampling locations from  $10.3 \pm 1.5$  mg/L to  $194 \pm 266.2$  mg/l. The average COD value at 3 sampling sites by year was highest at site NT1 (2010) ( $194 \pm 266.2$  mg/l) and lowest at site NT2 (2014) ( $10.3 \pm 1.5$  mg/l) (Fig. 5b). The value of COD content at ecotourism sites in 10 years has exceeded the allowable limit according to surface water quality standards QCVN 08:2015/ BTNMT columns A1 and A2. The results showed that surface water quality is greatly affected by tourism activities. This result is consistent with the TSS and BOD measurements discussed in the previous section. BOD and COD values play an important role in the selection of wastewater treatment technology. In addition, BOD and COD were used as indicators of organic waste concentration in water [11].



**Figure 5. The mean COD in tourism affected water bodies**

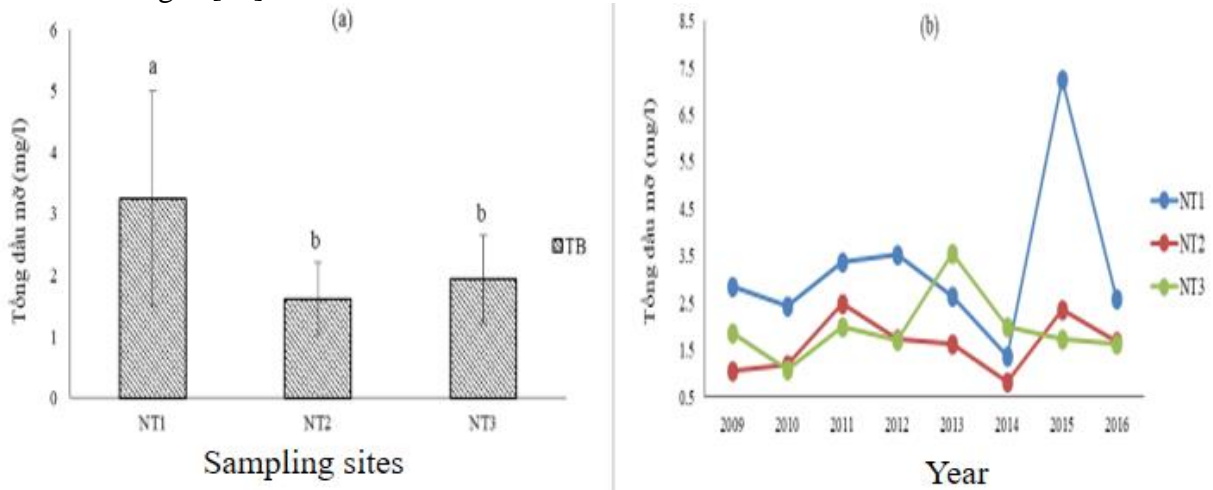
The average  $N-NO_3^-$  concentration at the tourist sites over the past 8 years is presented in Figure 6. The average  $N-NO_3^-$  value at the sampling sites ranges from  $0.1 \pm 0.1$  mg/L to  $0.3 \pm 0.4$  mg/l (Figure 6a). The concentration of  $N-NO_3^-$  fluctuated high but the trend gradually decreased from 2009 to 2018 ranging from  $0.1 \pm 0$  mg/L to  $1.7 \pm 1.6$  mg/l (Figure 6b). Thus, the concentrations of  $N-NO_3^-$  was less affected by tourism activities and was still within the allowable limit of QCVN 08-MT: 2015/BTNMT. Previous studies have also shown that nitrate levels in rivers and canals are often very low.  $N-NO_3^-$  concentration in Hau river ranged from 0.002 mg/L-0.395 mg/L [6], An Giang canals ranged from  $0.31 \pm 0.3$  mg/L to  $0.58 \pm 0.64$  mg/L [7], canals in Soc Trang province ranged from 0.05 mg/L to 0.14 mg/L [10]. Nitrate 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. If the nitrogen in the water is mainly in the form of nitrate, the oxidation is over. The concentration of  $N-NO_3^-$  specified in QCVN 08-MT:2015/BTNMT column A1 (2 mg/L) 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, irrigation or other uses with similar water quality requirements or only for navigation and other purposes with low quality water requirements [5].





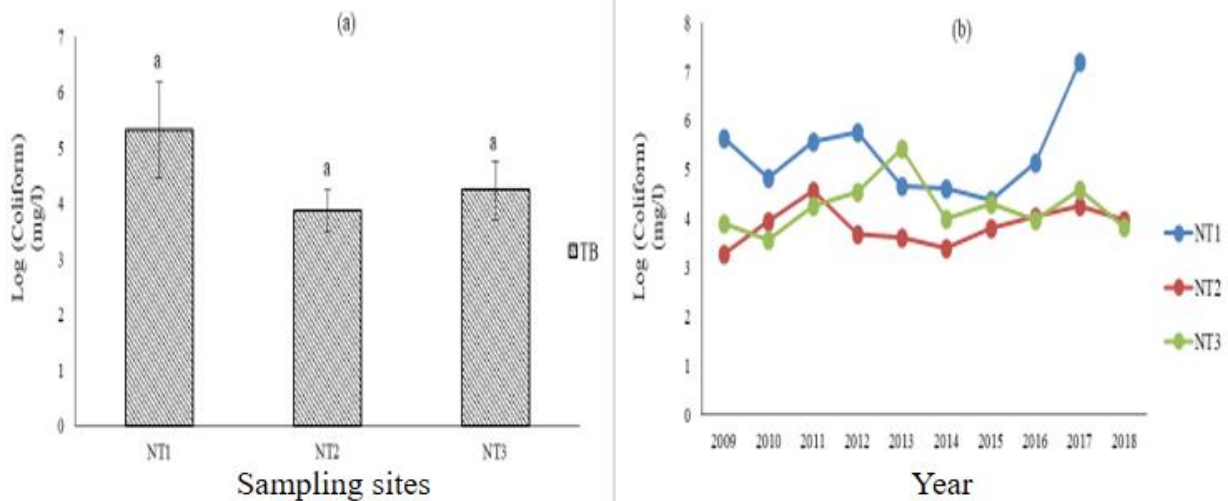
**Figure 6. The mean nitrate in tourism affected water bodies**

The mean total oil and grease at the sampling sites over the 8 years from 2009 to 2016 ranged from  $1.6 \pm 0.6$  mg/L to  $3.3 \pm 2.4$  mg/l on average (Figure 7a). Total oil and grease tended to increase over 8 years ranging from  $1.1 \pm 0.8$  to  $7.2 \pm 9.8$  mg/l (Figure 7b). The oil and grease at the sampling locations all exceeded the allowable limit of QCVN 08:2015/BTNMT. The results showed that tourism activities had an impact on the total amount of grease in the country. This is different from previous research showing that, in the water bodies in Tien Giang province, oil and grease concentration over the observed months were relatively low ranging from  $0.0024 \pm 0.00072$  -  $0.0027 \pm 0.00076$  mg/L [12] and within the allowable limit.



**Figure 7. The mean total oil and grease in tourism affected water bodies**

The average Log (Coliform) value affected by tourism activities over the 10 years from 2009 to 2018 is presented in Figure 8. The mean Log (Coliform) value ranged from  $3.9 \pm 3.8$  mg/L to  $5.3 \pm 5.4$  mg/L (Figure 8a). Coliform density in surface water at sampling sites during 10 years ranged from  $3.3 \pm 3.4$  mg/L to  $7.2 \pm 7.4$  mg/L (Figure 8b). Coliform density in water was very high, exceeding the allowable limit of QCVN 08:2015/BTNMT, column A1 from 1.2-3.0 times. The results showed that tourism activities had a great impact on the occurrence of pathogenic microorganisms in the aquatic environment. The results of this study are similar to previous studies, the surface water environment was contaminated with microorganisms. For example, the research by [7] showed that coliform in surface water of An Giang province in the period 2009-2016 exceeded the allowable limit 2.14-7.02 times.



**Figure 8. The mean coliform density in tourism affected water bodies**

#### 4. Conclusions

The results showed that tourism activities had an impact on surface water quality in the period 2009 to 2018. The TSS, BOD, COD and coliform parameters at the sampling locations over the years were all over the limits permitted by QCVN 08-MT:2015/BTNMT (column A1). TSS parameters exceeded 2.7-3.3 times, BOD exceeded 3.8-16.5 times, COD exceeded 2.4-5.2 times, coliform exceeded 1.2-3.0 times. Sources of impact on water quality can be recreational traffic, domestic wastewater and domestic waste. Management of surface water quality in the tourist areas should be enhanced.

#### Acknowledgements

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#### Nomenclature

Abbreviations	Full description
Temp	Temperature
pH	The potential of hydrogen
TSS	Total suspended solids
BOD	Biological oxygen demand
COD	Chemical oxygen demand
N-NO <sub>3</sub> <sup>-</sup>	Nitrate
Oil and grease	Total oil and grease
Coliform	Coliform density

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