



## EVALUATION OF THE SURFACE WATER QUALITY FOR AQUACULTURE IN KIEN GIANG PROVINCE

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### ABSTRACT

*Recently, the aquaculture sector of Kien Giang province has been facing many difficulties and challenges due to the changing water quality, causing serious degradation and pollution. Based on the results of the survey and measurement of surface water parameters in 2016 at Kien Giang province, the paper analyzes six water quality indicators in 10 locations of Kien Giang province. The results of analysis of indicators were compared with National Technical Regulation on Surface Water Quality (QCVN 08-MT: 2015/BTNMT) to evaluate surface water quality of this area. The paper also provides an assessment of the suitability of water quality status for aquaculture in the region.*

**Keywords:** aquaculture, Kien Giang province, surface water quality.

### TÓM TẮT

#### ***Đánh giá chất lượng môi trường nước mặt phục vụ nuôi trồng thủy sản ở tỉnh Kiên Giang***

*Gần đây, ngành nuôi trồng thủy sản của tỉnh Kiên Giang đang phải đối mặt với nhiều khó khăn, thách thức do sự thay đổi chất lượng môi trường nước, gây suy thoái và ô nhiễm nghiêm trọng. Dựa trên kết quả quan trắc các chỉ tiêu môi trường nước mặt năm 2016 ở các khu vực thuộc tỉnh Kiên Giang, bài báo tiến hành phân tích 6 chỉ tiêu chất lượng nước ở 10 địa điểm của tỉnh. Kết quả phân tích các chỉ tiêu được so sánh với Quy chuẩn kỹ thuật Quốc gia về chất lượng nước mặt của Bộ Tài nguyên và Môi trường (QCVN 08-MT: 2015/BTNMT) để đánh giá mức độ ô nhiễm của khu vực này. Từ đó, bài báo cũng đưa ra những đánh giá về mức độ phù hợp của hiện trạng chất lượng nước đối với hoạt động nuôi trồng thủy sản trong vùng.*

**Từ khóa:** nuôi trồng thủy sản, tỉnh Kiên Giang, chất lượng nước mặt.

### 1. Introduction

Based on favorable natural conditions, Kien Giang province has determined that aquaculture is one of the strengths of the province, contributing positively to the development of the agricultural economy in particular and the economy of the province in general. According to statistics from Ministry of Natural Resources and Environment, “in

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recent years, the area of aquaculture in Kien Giang has continuously increased, from 159,175 hectares in 2014 to 221,580 hectares in 2016, with the average growth rate in the period 2014-2016 is 18.3% per year. Total aquaculture production in the province increased from 136,626 tons in 2014 to 196,049 tons in 2016 and reached an average annual growth rate of 20.5% [1]". However, besides the achievements, the aquaculture sector of the province, especially the shrimp farming sector is facing many difficulties due to the water environment and ecosystems in the development of aquaculture is changing, causing degradation and environmental pollution.

The sources of discharges into rivers and canals have affected the surface water environment. Surface water quality in aquaculture ponds, including freshwater fish, coastal shrimp farming, especially in industrial aquaculture models, has shown signs of organic contamination (BOD, COD, nitrogen, phosphorus were higher than standard be allowed). The presence of toxic components such as  $H_2S$ ,  $NH_3^+$ , and Coliforms has shown that water is severely polluted [2].

Therefore, the protection of the surface water environment is a very important issue for developing sustainable aquaculture in Kien Giang province. To carry out this task, it is necessary to have a survey and evaluation of the surface water pollution in the area in order to propose measures that can both develop aquaculture and protect the water environment. The aim of this study is to analysis of water quality indicators and assesses that water quality is appropriate or inappropriate for the development of aquaculture in Kien Giang province.

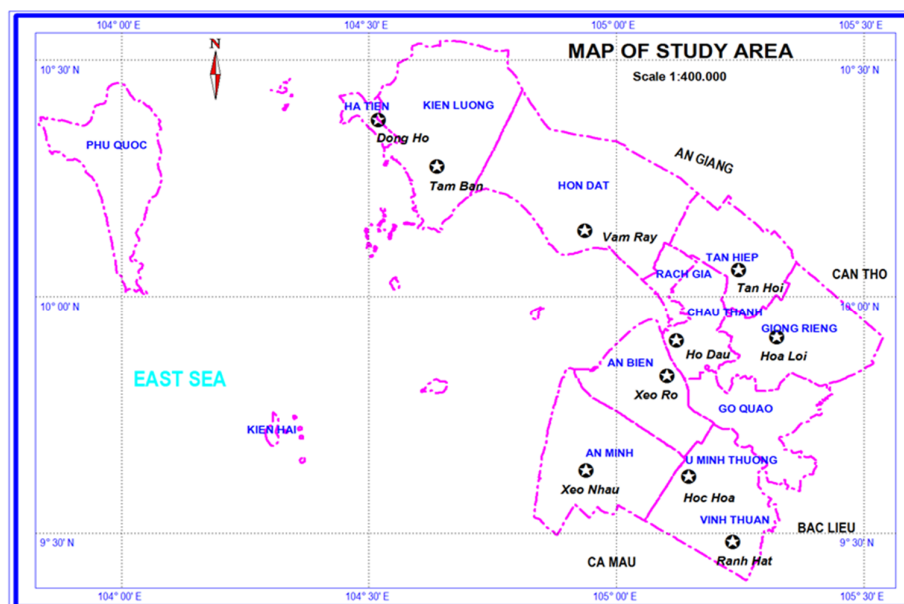


Figure 1. Map of study area

## 2. Scope and Methods

### 2.1. Scope of study

**Study area:** Kien Giang province is divided into three ecological zones: U Minh Thuong, Western Hau River and Long Xuyen Quadrangle [2]. This paper focuses on the quality of surface water environment in 10 locations in Kien Giang province, including Xeo Ro (An Bien District), Xeo Nheu (An Minh District), Hoc Hoa (U Minh Thuong District), Ranh Hat (Vinh Thuan District), Ho Dau (Chau Thanh District), Hoa Loi (Giong Rieng District), Tan Hoi (Tan Hiep District), Dong Ho (Ha Tien Town), Tam Ban (Kien Luong District), Vam Ray (Hon Dat District).

**Time of study:** Based on the results of the survey of surface water quality in 2016 by the Sub-Department of Aquaculture, Department of Agriculture and Rural Development of Kien Giang [2] and the results of field measurements, the paper analyzes the results of the six surveys over the course of 2016: 1st survey (February 2016), 2nd survey (April 2016), 3rd survey (June 2016), 4th survey (August 2016), 5th survey (October 2016), 6th survey (December 2016).

**Limitations of the study:** To assess surface water quality, the water quality indicators were utilized. Based on the ecological limits of the organism and National Technical Regulation on Surface Water Quality (QCVN 08-MT: 2015/BTNMT) for ensuring the survival and growth of organisms, 6 indicators of water environment for analysis include pH, DO, BOD,  $\text{NH}_4^+$ , coliforms, and salinity were selected.

### 2.2. Research Methods

The collecting, analyzing information and data from documents related to surface water environment in Kien Giang province were done. In addition, the article inherits some data from the previous survey, which was done by the Sub-Department of Aquaculture, Department of Agriculture and Rural Development of Kien Giang province.

To collect reliable sources of information, the field surveys was done. The survey focused on measuring, observing the water environment indicators to compare and verify with the research results.

Six water quality indicators at 10 locations of the study area were selected for the survey. The results were compared with National Technical Regulation on Surface Water Quality (column A1 - standards used for domestic water supply purposes, conservation of aquatic plants and for other purposes) for evaluation the surface water quality.

**Table 1.** Limiting value of surface water quality parameters

No.	Parameter	Units	Limiting value			
			A		B	
			A <sub>1</sub>	A <sub>2</sub>	B <sub>1</sub>	B <sub>2</sub>
1	pH		6-8.5	6-8.5	5.5-9	5.5-9
2	BOD (20 <sup>0</sup> C)	mg/l	4	6	15	25
3	Dissolved Oxygen DO	mg/l	≥ 6	≥ 5	≥ 4	≥ 2
4	Amoni (NH <sub>4</sub> <sup>+</sup> tính theo N)	mg/l	0,3	0,3	0,9	0,9
5	Coliforms	MPN/100ml	2,500	5,000	7,500	10,000
6	Salinity	‰	---	---	---	---

Source: National Technical Regulation on Surface Water Quality (Ministry of Natural Resources and Environment [3])

The classification of A<sub>1</sub>, A<sub>2</sub>, B<sub>1</sub>, B<sub>2</sub> for surface water sources to assess and control water quality the various purposes of water use, sorted by descending quality .

A<sub>1</sub> – Use for domestic water supply purposes (after applying conventional treatment), conservation of aquatic plants and for other purposes such as type A<sub>2</sub>, B<sub>1</sub> and B<sub>2</sub>.

A<sub>2</sub> – For the purpose of domestic water supply, but must apply appropriate processing technology or the purpose of use as type B<sub>1</sub> and B<sub>2</sub>.

B<sub>1</sub> – For irrigated agriculture, irrigation purposes or other purposes which require the same water quality or purposes as type B<sub>2</sub>.

B<sub>2</sub> – Waterway transport and other purposes with low quality water requirements.

In addition, the collected and surveyed data were analyzed by Microsoft Excel software. Indicators are analyzed by mean of parameter ( $\bar{x}$ ) and standard deviation ( $\sigma$ ) [4].

### 3. Research results

#### 3.1. Analysis of surface water quality parameters of survey sites in Kien Giang province

Based on the report on water environment survey of Kien Giang province [2] and the results of this research, it is possible to give some comments on the criteria of surface water quality as follows:

##### 3.1.1. pH values

pH is a measure of the hydrogen ion (H<sup>+</sup>) concentration of a solution, which is one of the most important and most frequently used parameters for assessing the level of water pollution, wastewater quality, and water hardness. Therefore, it is important to determine the pH level to complete the water quality in accordance with aquaculture technical requirements. In aquaculture, the pH of the water changes to affect the physical, chemical, biological and environmental health of the organism. The pH of the ponds is pH 7.2 - 8.8, preferably in the range of 7.8 - 8.5, the pH of the pond should not fluctuate more than 0.5.

If the pH fluctuates in wide range, the shrimp, fish may be shocked, weak and not eat. If the pH is high or low for a long time, it make the shrimp becomes slow to grow and susceptible to infection.

According to the results of the survey, the pH in most of the surveyed sites was moderate and within acceptable limitation of National technical regulation on surface water quality; the average pH at the sample sites ranged from 6.2 to 7.6; standard deviation ( $\pm 0.2 - \pm 1.3$ ). This indicates that the pH has a large variation over time and has a difference between places. In all locations, the highest pH in the first survey (February) or the second survey (April). For example, Xeo Ro (2nd - 7.5), Xeo Nheu (2nd - 8.0), Hoc Hoa (1st - 7,6), Tam Ban (2nd - 8.5), and so on. The reason of the highest pH at this time because this is the dry season in Kien Giang, the water is much evaporated, the rainfall is low, the water in the canal is less and alum.

However, the average pH value in some places is quite low, the lowest value were measured at Vam Ray which the average pH was only 6.2; the highest pH was 7.6 in the second survey (April 2016). The 3rd, 4th and 5th measurements were low in pH, the lowest value was measured in June; the pH was only 4.6 which was lower than that of QCVN 08-MT: 2015/BTNMT, standard deviation is greatest compared to the rest ( $\pm 1,3$ ). The reason for the low pH is due to the large rainfall lasting from May to October, the effect of washing alum from the field, making the water on the canal is strongly acid.

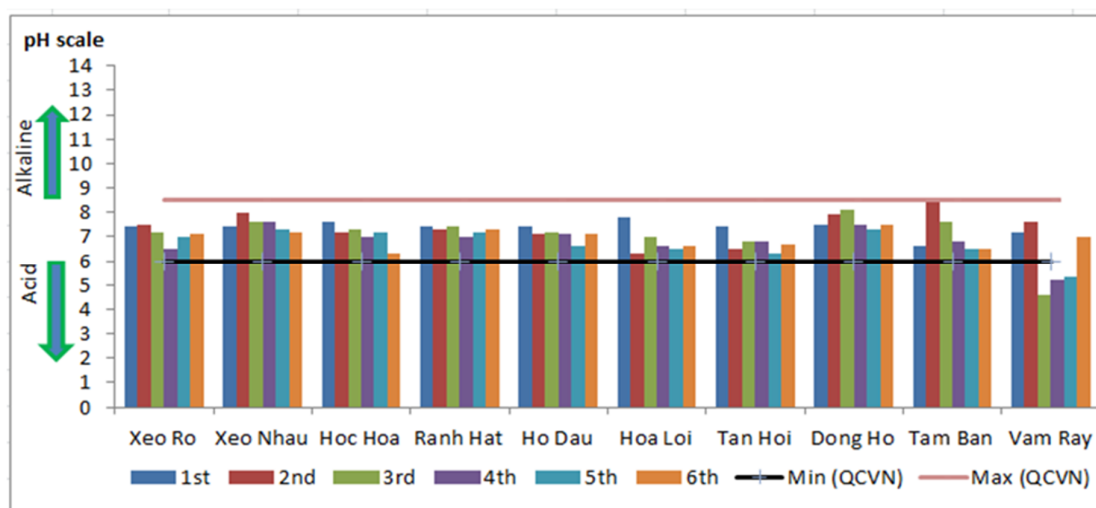


Figure 2. pH values at study area compared to QCVN 08-MT: 2015/BTNMT

### 3.1.2. Dissolved Oxygen (DO – mg/l)

The amount of dissolved oxygen in water is essential for the respiration of organisms, which play an important role in metabolism, maintaining energy for the development and reproduction of aquatic organisms. The oxygen in water is derived from the air and from the photosynthetic reactions of algae and aquatic plants. Rivers and lakes with high DO content are considered to be healthy and have many species living there. If the dissolved oxygen in the water is low or drops dramatically, it will reduce the growth of aquatic animals, even disappear or possibly kill some species. Thus, DO is used as a parameter to assess the level of organic pollution of water sources.

The results of survey showed that the average dissolved oxygen content in most samples was low (3.1-5.5 mg/l), the standard deviation was ( $\pm 0.1 - \pm 0.6$ ). The samples with high DO content are: Dong Ho ranges from 4.8 to 5.6 mg/l (mean 5.5 mg/l, standard deviation  $\pm 0.7$ ); Tam Ban ranges from 4.4 to 5.6 mg/l (mean 5.1 mg/l, standard deviation  $\pm 0.6$ ); Xeo Nhai ranges from to 5.6 mg/l (mean 4.9 mg/l, standard deviation  $\pm 0.5$ ). The samples with low DO content were Tan Hoi ranges from 2.1 to 4.3 mg/l (mean 3.1 mg/l, standard deviation  $\pm 0.8$ ), Hoa Loi ranges from 2.1 to 3.4 mg/l (mean 2.8 mg/l, standard deviation  $\pm 0.5$ ), and Ho Dau ranges from 3.1 to 4.2 mg/l (mean 3.9 mg/l, standard deviation  $\pm 0.4$ ).

The results of survey also showed that the average DO of all study sites in the study area was lower than that of QCVN 08 MT: 2015/BTNMT (except Dong Ho in the August with DO higher than that of QCVN 08-MT: 2015/BTNMT) (Figure 3). The survey sites in Kien Giang have a lower DO level than the standard allowed, which is not favorable for the growth and development of aquatic life, causing difficulties for the development of aquaculture in the area.

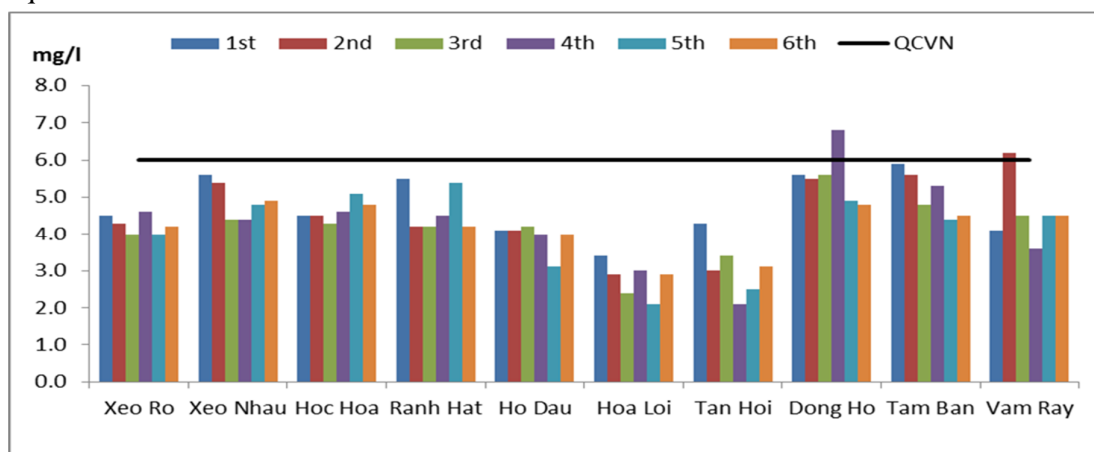


Figure 3. DO content at study area compared to QCVN 08-MT: 2015/BTNMT

### 3.1.3. Biochemical oxygen demand (BOD – mg/l)

Biochemical oxygen demand is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water [5]. BOD is the basic criterion for assessing the level of pollution of water resources, the greater the BOD value, the higher the level of organic pollution.

The results of survey showed that the average BOD at the sampling sites was significantly different (from 2.3 to 5.6 mg/l). The standard deviation was also significantly different between the survey sites ( $\pm 0, 4$  to  $\pm 1.5$ ). There are 5 sampling sites where the BOD content exceeds QCVN 08-MT: 2015/BTNMT: Tan Hoi ranges from 5.4 to 6.4mg/l (mean 5.6mg/l, standard deviation  $\pm 0.4$ ), Hoa Loi ranges from 4.6 to 5.4 mg/l (mean 5.3 mg/l, standard deviation  $\pm 0.7$ ), Xeo Nheu ranges from 3.9 to 5.8 mg/l (mean 4.9 mg/l, Xeo Ro ranges from 4.1 to 5.4mg/l (mean 4.3mg/l, standard deviation  $\pm 0.9$ ), and Ho Dau ranges from 3.6 to 4, 9 mg/l (mean 4.3 mg/l, standard deviation  $\pm 0.5$ ).

There were 5 sampling sites where BOD content was within the appropriate range ( $<4\text{mg/l}$ ): Tam Ban ranges from 0.6 to 6.1mg/l (mean 2.3 mg/l, standard deviation  $\pm 1.5$ , but the survey in June, BOD has a high value, reached 6.1mg/l, exceeded QCVN 08-MT: 2015/BTNMT); Dong Ho ranges from 0.9 to 6.1 mg/l (mean 3.4 mg/l, standard deviation  $\pm 1.3$ , but the survey in June, BOD was 6.1mg/l); Vam Ray fluctuates from 0.7 to 3.8 mg/l (mean 2.8 mg/l, standard deviation  $\pm 1.1$ ), Ranh Hat can range from 2.9 to 4.6 mg/l (average of 3.5 mg/l, standard deviation  $\pm 1.0$ ); and Hoc Hoa fluctuates from 2.0 to 5.4 mg/l (mean 3.8 mg/l, standard deviation  $\pm 1.1$ )

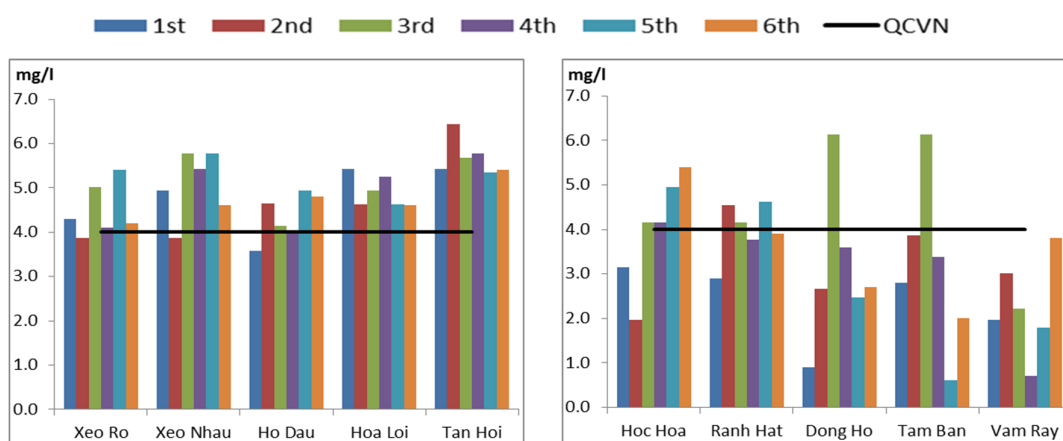


Figure 4. BOD at study area compared to QCVN 08-MT: 2015/BTNMT

### 3.1.4. Coliforms (MPN/100L)

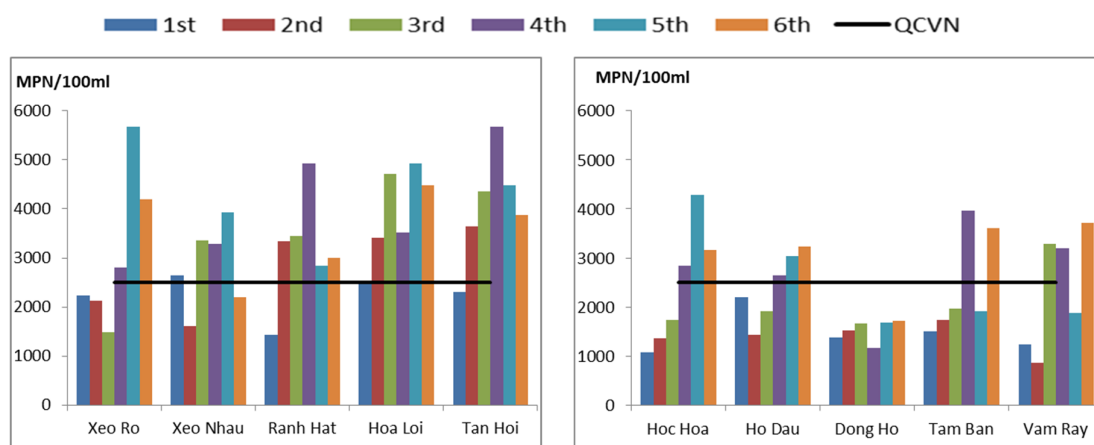
Coliforms are a broad class of bacteria found in water environment. The presence of coliform bacteria in water may indicate a possible presence of harmful, disease-causing organisms. Coliforms are a common indicator used to assess the level of hygiene in water. The higher the coliforms in water, the higher the water pollution.

The results showed that the average bacterial density was significantly different between sampling sites (1520 MPN/100L to 4057 MPN/100L). The standard deviation was also significantly different between the survey sites ( $\pm 688$  to  $\pm 1567$ ). There are five sampling sites having high bacterial densities exceeded QCVN: Xeo Ro ranges from 1480 to 4200 MPN/100L (mean 3087 MPN/100L, standard deviation  $\pm 1567$ ); Xeo Nhau fluctuates from 1620 to 3920 MPN/100L (mean 2837 MPH /100L, standard deviation  $\pm 845$ ); Ranh Hat fluctuates from 1440 to 4920 MPN/100L (mean 3163 MPN/100L, standard deviation  $\pm 1122$ ); Hoa Loi fluctuates from 2480 to 4920 MPN/100L (mean 3923 MPN/100L, standard deviation  $\pm 942$ ) and Tan Hoi fluctuates from 2300 to 4480 MPN/100L (mean 4057MPN/100L, standard deviation  $\pm 1113$ )

There were 5 sampling sites where BOD content was within the appropriate range (<2500 MPN/100l) by QCVN: Hoc Hoa fluctuates from 1080 to 4280 MPN/100L (mean 2410, standard deviation  $\pm 1230$ , but the survey in August, October and December, the bacterial density exceeded QCVN allowed); Ho Dau fluctuates from 1440 to 3240 MPN/100L (mean 2413 MPN/100L, standard deviation  $\pm 688$ , but the survey in August, October and December, the bacterial density exceeded QCVN allowed), Dong Ho fluctuates from 1380 to 1720 MPN/100L (average 1520, standard deviation  $\pm 217$ ); Tam Ban fluctuates from 1500 to 3600 MPN/100L (mean 2447 MPN/100L, standard deviation  $\pm 1052$ ) and Vam Ray fluctuates from 860 to 3720 MPN/100L (mean 2363 mg/l, standard deviation  $\pm 1195$ )

Figure 5 showed that all survey sites had Coliforms index in excess of the limit set in QCVN 08-MT: 2015/BTNMT (2500MPN/100L) mainly concentrated in the period from August to December, especially in August and October, the reason is that the rainy and flood months are the conditions for bacterial growth.





**Figure 5.** Coliforms at study area compared to QCVN 08 MT: 2015/BTNMT

### 3.1.5. Ammonium ion parameter ( $\text{NH}_4^+$ - N mg/l)

One of the known forms of N in water is ammonium ( $\text{NH}_4^+$ ). The high content of nitrogen in the water plus the phosphorus content can cause excess nutrients in the water, especially the amount of dissolved oxygen in the water greatly reduced asphyxiation of fish and organisms in the lake. Therefore, if the water contains more organic nitrogen then it is considered as contaminated and dangerous water.

The results showed that the N content in  $\text{NH}_4^+$  at most sampling sites was higher than that of QCVN 08-MT: 2015/BTNMT (0.3 mg/l). For example, two sampling sites of Hoa Loi and Tan Hoi  $\text{NH}_4^+$  is 0.8, 2.7 times higher than QCVN, the other sampling sites are 1.7 to 2.3 times higher than the permitted level. Fluctuations of  $\text{NH}_4^+$  through the survey were also high ( $\pm 0.2 - \pm 0.3$ ); Xeo Ro, Xeo Voi, Ho Dau, Vam Ray is  $\pm 0.2$ ; Loi, Tan Hoi, Tam Ban are  $\pm 0.3$ ; other sampling sites such as Hoc Hoa, Ranh Hat, Dong Ho do not have fluctuations  $\text{NH}_4^+$ .

**Table 3.**  $\text{NH}_4^+$  parameter at study area compared to QCVN 08 MT: 2015/BTNMT

Unit: mg/l										
No.	Key study	1st	2nd	3rd	4th	5th	6th	Mean	Standard deviation	QCVN 08 MT:2015/BTNMT
1	Xeo Ro	0.5	0.5	1.0	0.5	0.5	0.5	0.6	0.2	0.3
2	Xeo Nhai	0.5	0.5	0.5	0.5	0.5	1.0	0.6	0.2	0.3
3	Hoc Hoa	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.3
4	Ranh Hat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.3
5	Ho Dau	0.5	0.5	0.5	0.5	0.5	1.0	0.6	0.2	0.3
6	Hoa Loi	1.0	1.0	0.5	0.5	0.5	1.0	0.8	0.3	0.3
7	Tan Hoi	1.0	1.0	0.5	0.5	0.5	1.0	0.8	0.3	0.3
8	Dong Ho	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.3
9	Tam Ban	1.0	0.5	0.5	1.0	0.5	0.5	0.7	0.3	0.3
10	Vam Ray	0.5	0.5	1.0	0.5	0.5	0.5	0.6	0.2	0.3

$\text{NH}_4^+$  content in most sampling sites in Kien Giang province is always higher than the permitted limit of QCVN 08-MT: 2015/BTNMT, which reflects the high level of pollution of water sources, endangering aquatic organisms.

### 3.1.6. Salinity (‰):

Salinity is the amount of salts that are soluble in water, which is an important ecological factor that affects many types of aquatic organisms. Depending on the different organisms, they have ecological characteristics suitable for different salinity. However, a sudden change in salinity can harm aquatic organisms.

The results show that average salinity at all sites is suitable for the development of brackish water and saltwater species; The magnitude of salinity fluctuations between months in the sample sites was relatively high. Two sites, Ho Dau and Hoa Loi, have a salinity of 0‰ at all times, because these two sites are far from sea so they do not affect the salinity intrusion from the sea

From January to April, salinity is high because it is a dry season and saline intrusion into the interior. Average salinity in Dong Ho (Ha Tien) and Tam Ban (Kien Luong) is quite high (> 25‰) from January to June, which can cause difficulties for the survival and development of aquatic organisms. Salinity at the survey sites decreased from July, the lowest from September to October and lasted until early December; At this time the water environment is no longer suitable for the development of shrimp and crabs. In 2016, salinity intrusion hit a record in the Mekong Delta, but Kien Giang has a system of sewers, salt prevention dykes, so salt water intruded into the field less than other regions.

**Table 4.** Salinity parameter at study area compared to QCVN 08-MT: 2015/BTNMT

Unit: ‰									
No.	Key study	1st	2nd	3rd	4th	5th	6th	Mean	Standard deviation
1	Xeo Ro	7	11	8	4	0	12	7.0	4.5
2	Xeo Nhau	32	30	18	14	3	23	20.0	10.8
3	Hoc Hoa	6	8	4	3	0	2	3.8	2.9
4	Ranh Hat	17	20	15	11	2	6	11.8	6.9
5	Ho Dau	6	9	4	3	0	1	3.8	3.3
6	Hoa Loi	0	0	0	0	0	0	0.0	0.0
7	Tan Hoi	0	0	0	0	0	0	0.0	0.0
8	Dong Ho	32	30	27	25	8	24	24.3	8.5
9	Tam Ban	17	17	23	14	2	10	13.8	7.2
10	Vam Ray	20	19	5	2	2	12	10.0	8.2

### 3.2. Evaluation of surface water quality for aquaculture

Based on the results of analysis of surface water quality parameters (pH, DO, BOD, NH<sub>4</sub><sup>+</sup>, Coliforms and salinity) in 10 sample sites at Kien Giang province in 2016, surface water quality is reflected as follows:

**Table 5.** The average value of surface water quality at the study area in 2016

No.	Key study	Parameters											
		pH		DO (mg/l)		BOD (mg/l)		NH <sub>4</sub> <sup>+</sup> (mg/l)		Coliforms (MPN/100l)		Độ mặn (‰)	
		$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$
1	Xeo Ro	7.1	0.4	4.3	0.3	4.3	0.9	0.6	0.2	3087	1567	7.0	4.5
2	Xeo Nhau	7.5	0.3	4.9	0.5	4.9	1.0	0.6	0.2	2837	845	20.0	10.8
3	Hoc Hoa	7.1	0.4	4.6	0.3	3.8	1.1	0.5	0.0	2410	1230	3.8	2.9
4	Ranh Hat	7.3	0.2	4.7	0.6	3.5	1.0	0.5	0.0	3163	1122	11.8	6.9
5	Ho Dau	7.1	0.3	3.9	0.4	4.3	0.5	0.6	0.2	2413	688	3.8	3.3
6	Hoa Loi	6.8	0.5	2.8	0.5	5.3	0.7	0.8	0.3	3923	942	0.0	0.0
7	Tan Hoi	6.8	0.4	3.1	0.8	5.6	0.4	0.8	0.3	4057	1113	0.0	0.0
8	Dong Ho	7.6	0.3	5.5	0.7	3.4	1.3	0.5	0.0	1520	217	24.3	8.5
9	Tam Ban	7.1	0.8	5.1	0.6	2.3	1.5	0.7	0.3	2447	1052	13.8	7.2
10	Vam Ray	6.2	1.3	4.6	0.9	2.8	1.1	0.6	0.2	2363	1195	10.0	8.2
	QCVN 08												
	MT:2015/ BTNMT	6- 8.5		≥ 6		4		0.3		2500			

Based on the average value of surface water quality in the study area in 2016 compared to QCVN 08-MT: 2015 and ecological characteristics of aquatic organisms, the article gives some comments on water quality in study areas for aquaculture are as follows:

- *Xeo Ro (An Bien)*: Compared to QCVN 08-MT:2015/BTNMT, the pH is within the allowable limit, aquatic organisms can grow and develop. However, the remaining criteria are out of the limit, specifically: DO is 0.8 times lower, NH<sub>4</sub><sup>+</sup> is twice as high, BOD is 1.1 times higher than standard. This proves that the quality of surface water in Xeo Ro area is heavily polluted. The average salinity is 7‰, so it is only suitable for brackish aquatic organisms. However, it is important to pay attention to sudden changes in salinity which may be harmful to the organism.

- *Xeo Nhau (An Minh)*: The pH is within the allowable limit compared to QCVN 08-MT: 2015/BTNMT. From July to November, heavy rainfall along with the flood discharge from upstream makes the quality of water in some areas worse, most important indicators such as DO, BOD, NH<sub>4</sub><sup>+</sup> Coliforms... are out of the allowable limit; the average salinity is

20‰. Therefore, aquaculturists should pay attention to the treatment of water before supplying water to the farm.

- *Hoc Hoa (U Minh Thuong)*: Compared to QCVN 08-MT:2015/BTNMT, the pH and biochemical oxygen demand are within the allowable limit, aquatic organisms can grow and develop well. However, the others indicators are out of the limit, specifically: DO is 0.8 times lower,  $\text{NH}_4^+$  is 1.7 times higher than standard. This proves that the quality of surface water in Xeo Ro area is heavily polluted. The average salinity is 3.8‰, so it is only suitable for brackish aquatic organisms. However, it is important to pay attention to sudden changes in salinity which may be harmful to the organism.

- *Ranh Hat (Vinh Thuan)*: The pH and biochemical oxygen demand are within the allowable limit, aquatic organisms can grow and develop well. However, most important indicators such as DO, BOD,  $\text{NH}_4^+$  Coliforms... are out of the allowable limit of QCVN 08-MT: 2015/BTNMT. The average salinity is 11.8‰, so it is only suitable for saltwater and brackish aquatic organisms.

- *Ho Dau*: The average salinity is 3.8‰, so it is only suitable for brackish aquatic organisms, but it is important to pay attention to sudden changes in salinity which may be harmful to the organism. Most important indicators such as DO, BOD,  $\text{NH}_4^+$  Coliforms ... are out of the allowable limit of QCVN 08-MT: 2015/BTNMT. This proves that the quality of surface water in this area is heavily polluted, and it is necessary to renovate to suit aquatic organisms.

- *Hoa Loi*: As in some other sampling sites, except for the pH indicator and the BOD are within the allowable limit. Other indicators are out of the allowable limit, specifically DO is lower,  $\text{NH}_4^+$  is 1.7 higher and Coliform is 1.1 times higher than standard if its are compared with QCVN 08-MT:2015/BTNMT. This showed that the quality of surface water in this area is heavily polluted. Because these two sites are far from sea, the average salinity is 0‰ at all times, so it is only suitable for fresh water creatures.

- *Tan Hoi*: Compared to QCVN 08-MT:2015/BTNMT, the pH is within the allowable limit, aquatic organisms can grow and develop. However, the remaining criteria are out of the limit, specifically: DO is lower,  $\text{NH}_4^+$  is 1.3 times higher and BOD is 1.2 times higher than standard. Therefore, aquaculture needs measures to improve the above indicators.

- *Dong Ho (Ha Tien)*: Compared with QCVN 08-MT: 2015, the pH and biochemical oxygen demand are within the allowable limit. Aquatic organisms can grow and develop well. However, the remaining indicators are out of the limit, specifically: DO is lower,  $\text{NH}_4^+$  is 1.7 times higher and coliforms is 3.9 times higher than the allowed standard. This proves that the quality of surface water in Dong Ho lake is heavily polluted. The average salinity is high (24.3‰), so it is only suitable for saltwater aquifers, however, it should be noted that sudden salinity changes can be harmful to the organism.

- *Tam Ban (Kien Luong)*: Like in Dong Ho, except for the pH indicator and BOD biochemical oxygen demand, the majority of water quality indicators are outside the permitted limits in accordance with QCVN 08-MT:2015/BTNMT. DO is lower,  $\text{NH}_4^+$  is 2 times higher and coliforms is 4.5 times higher than the allowed standard. The average salinity is 13.8‰, so it is only suitable for brackish water organisms, however, it should be noted that sudden changes in salinity can be harmful to the organism.

- *Vam Ray (Hon Dat)*: The pH is within the allowable limit compared to QCVN 08-MT: 2015/BTNMT. From July to November, heavy rainfall along with the flood discharge from upstream makes the quality of water in some areas worse, most important indicators such as DO, BOD,  $\text{NH}_4^+$ , Coliforms,... are out of the allowable limit. Therefore, aquaculturists should pay attention to the treatment of water before supplying water to the farm.

#### 4. Conclusion

Surface water quality in aquaculture is one of the most important factors for aquatic organisms, because aquatic organisms will grow slowly or die if water quality is polluted. The physical properties, chemical composition of water - habitat of aquatic life - have a great influence on the physiological and pathological changes of the aquatic organism.

Nowdays, aquaculture in Kien Giang province is developing strongly, bringing many socio-economic benefits to people. In 2017, Kien Giang province produces 224,725 tonnes of seafood, an area of 232,150 hectares and strive to make the fisheries a key economic sector [6]. However, the development of aquaculture has a strong impact on the environment at large scale and diversity. The results of analysis six water quality indicators in 10 locations of Kien Giang province show that only the pH is within the allowable limit, other indicators are out of the allowable limit in accordance with QCVN 08-MT:2015/BTNMT. In some parts of the province, cultured aquatic species are infected and die in bulk. Therefore, environmental protection in aquaculture in Kien Giang is becoming a major issue that needs to be addressed to ensure sustainable development.

In order to solve this situation, Kien Giang needs to invest accordingly, especially investment in water supply and drainage. Local authorities should plan irrigation associated with aquaculture planning to ensure harmonization of ecological criteria, meet the needs of aquaculture, and suitable for agricultural production, especially not affect the living environment for local residents. In addition, the provincial government needs to plan water surface for aquaculture in a reasonable way, avoid pollution of surface water environment. At the same time, regular measurement and evaluation of surface water quality, observation of irregularities of water environment, warning of the risk of environmental pollution and possible risks.

❖ **Conflict of Interest:** Author have no conflict of interest to declare.

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#### CÁC SỐ TẠP CHÍ KHOA HỌC SẮP TỚI:

- Tập 15, Số 10 (2018): *Khoa học giáo dục*
- Tập 15, Số 11 (2018): *Khoa học xã hội và nhân văn*
- Tập 15, Số 12 (2018): *Khoa học tự nhiên và công nghệ*.

*Ban biên tập Tạp chí Khoa học rất mong nhận được sự trao đổi thông tin của các đơn vị bạn và được bạn đọc thường xuyên cộng tác bài vở, góp ý xây dựng.*