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Assessment of Surface Water Quality in the Water Bodies in Aquaculture Area in Kien Giang Province, Vietnam

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Abstract

The study was conducted to assess the quality of surface water in the aquaculture area of Kien Giang province in the period of 2019-2020. Water samples were collected twice per year (in March and September) at seven locations designated AQ1 to AQ7. The parameters of temperature (T), pH, salinity (S), total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), ammonium (N-NH_4^+), orthophosphate (P-PO_4^{3-}), Coliform, iron (Fe), and silicon dioxide (SiO_2) were used to assess water quality. The study used national regulation on marine water quality (QCVN 10-MT:2015/BTNMT) and multivariate statistical methods including cluster analysis (CA) and principal component analysis (PCA) to assess water quality. The results showed that the temperature and pH are within the allowable limits. Salinity, COD, and SiO_2 are in the ranges of 7.7-22.2‰, 18.3-22.8 mg/L, and 8-16.3 mg/L, respectively. These criteria are not specified in QCVN 10-MT:2015/BTNMT. TSS at positions AQ5-QW7 exceeded the allowable limit. DO at all positions in May 2019 and all sampling periods of 2020 were below the allowable limit. N-NH_4^+ appeared at all sampling locations in March 2019 while N-NH_4^+ appeared at only a few locations in September 2019 and also in 2020. In the locations where N-NH_4^+ was found, N-NH_4^+ were all over the allowable limit. P-PO_4^{3-} was found only at AQ1 (2019) and AQ4-AQ6 (2020) positions. Coliform at AQ3, AQ6, AQ7 exceeded the allowable limit of QCVN 10-MT:2015/BTNMT. Fe at all positions has exceeded the allowable limit. The large fluctuations in time and space of surface water quality was mainly due to COD, TSS, salinity, N-NH_4^+, coliform, Fe, SiO_2. The results of PCA analysis showed that the parameters of pH, salinity, TSS, COD, N-NH_4^+, P-PO_4^{3-}, Fe, SiO_2, coliform need to be continued to be monitored because they have the main impact on surface water quality. Further studies need to investigate specific sources of pollution in order to have appropriate treatment solutions.

1. Introduction

Kien Giang is located at the southwest end of Vietnam, with a total area of 6,346.27 km^2, of which the mainland has geographical coordinates from 104°40' to 105°32'4" East longitude and 9°23'50" to 10°32'30" North latitude. The East and Southeast borders the provinces: An Giang, Hau Giang; the South borders Bac Lieu and Ca Mau provinces; the West borders the Gulf of Thailand with a 200 km long coastline; the North borders Cambodia. With a land border of 56.8 km long, Kien

Giang has 105 different large and small islands, the largest is Phu Quoc island with an area of 589.23 km^2 and a population of 88,220 people, with great potential for development into a general marine economic zone with a very important role and position in the region. Kien Giang belongs to the Mekong Delta region, has hills, flooded forests, primeval forests on the mainland and islands, with a rich system of rivers and canals, especially the river road which has a length of 1,678 km [1].

The process of socio-economic development often leads to water environment problems [2-4]. The number of social economic activities in coastal areas increase the amount of waste discharged into the environment and into the sea through a system of rivers and canals. This amount of waste increases most strongly in coastal urban areas, where socio-economic development activities are concentrated and laborers from other provinces are concentrated. Wastewaters are generated from ships and marine vehicles, shipbuilding and ship repair factories, seaports, yards and warehouses. In addition, the collisions of ships at sea cause spills of chemicals, oil, toxic substances, etc. At the same time, the construction at the harbor would probably change the nature of the flow, increasing the risk of coastal erosion. Waste arising from fishing activities and daily life of crew members, if not treated and discharged directly into the sea, will cause organic pollution and grease, seriously affecting the living environment of aquatic species [1]. In addition, overexploitation and under-exploitation in coastal areas lead to depletion of aquatic resources and a decline in biodiversity. Besides fishing, aquaculture activities are putting a lot of pressure on coastal areas. Waste sludge, wastewater, chemicals used in the aquaculture process are discharged directly into the river and sea environment. In addition, coastal aquaculture will reduce the area of mangroves in the province, leading to saline intrusion deep into the field, seriously affecting freshwater quality in the area.

The strong development of industrial parks and industrial clusters along the coast is putting a lot of pressure on the marine environment. Waste from production and daily life activities, if not treated, will seriously affect the receiving environment [4]. In Kien Giang, surface water quality monitoring has been carried out for many years including aquaculture area [1]. However, the assessment is only based on Vietnamese standards [5]. This evaluation method has not extracted all the important information of the monitoring data. Currently, multivariate statistical methods are widely used in the assessment of water quality in ponds, lakes, rivers, and groundwater [6-10]. Important information such as criteria to be monitored, potential sources of pollution, selection of monitoring criteria can be extracted from the results of principal component analysis and cluster analysis [6-10].

This study uses multivariate statistics including cluster analysis (CA) and principal component analysis (PCA) to analyze water quality in aquaculture areas. The research results provide important information for the management of surface water quality in the study area.

2. Materials and methods

In this study, water samples in the aquaculture area were collected twice a year (in March and September of 2019, 2020). The study collected water samples at seven locations designated from AQ1 to AQ7 (Table 1), of which 3 samples were collected in Kien Luong district (AQ1-AQ3), 1 water sample was collected in An Bien district (AQ1-AQ3). AQ4), 1 water sample was collected in An Minh district (AQ7) and two water samples were collected in Vinh Thuan district (AQ6-AQ7) to analyze the parameters of temperature (T), pH, salinity (S), total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), ammonium nitrogen ($N\text{-}NH_4^+$), phosphate ($P\text{-}PO_4^{3-}$), Coliform, iron (Fe), and silicon dioxide (SiO_2). T, pH, salinity, DO were measured in the field while COD, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, Coliform, Fe, SiO_2 parameters were measured in the laboratory by standard methods [11]. Methods of field measurements and laboratory analysis are presented in Table 2.

Table 1. Brief description of the sampling sites

Code	Description
AQ1	Tam Ban sluice - Rach Gia Kinh to Ha Tien, Hoa Dien commune, Kien Luong district
AQ2	Ta Sang Bridge, Duong Hoa Commune, Kien Luong district
AQ3	Tam Ban Bridge, Duong Hoa Commune, Kien Luong district
AQ4	Chong My canal – Thu Ba canal, Nam Yen commune, An Bien district
AQ5	Chong My canal - Xeo Nhau canal, Dong Thanh commune, An Minh district
AQ6	Dap Da Hamlet, Vinh Phong Commune, Vinh Thuan District.
AQ7	Shrimp farming area belongs to Hoa Thanh Hamlet, Vinh Binh Nam Commune, Vinh Thuan district.

Surface water quality in the aquaculture area was assessed using national technical regulation on marine water quality (QCVN 10-MT:2015/BTNMT) [5] since the study areas are high salinity. The limit values of surface water quality are presented in Table 2. In addition, principal component analysis (PCA) and CA were used to identify potential polluting sources and key variables affecting water quality and classify surface water quality in the study areas. PCA and CA were performed using Primer Software Version 5.2.

Table 2. Analytical methods and limits of surface water quality

Variable		Unit	Analytical methods	Limit
Temp.	Temperature	^oC	TCVN 4557:1988	30
pH	pH		TCVN 6492:2011	6-5-8.5
S	Salinity	‰	Salinometer	-
TSS	Total suspended solids	mg/L	SMEWW 2540B 2012	50
DO	Dissolved oxygen	mg/L	TCVN 7325:2004	≥ 5
COD	Chemical oxygen demand	mg/L	TCVN 6491:1999	-
$N\text{-}NH_4^+$	Ammonium	mg/L	SMEWW 4500 NH3 F 2012	0.1
$P\text{-}PO_4^{3-}$	Orthophosphate	mg/L	Hach DR 4000/5000 Method 8048	0.2
Coliform	Coliform	MPN/100 mL	TCVN 6197-2:1996	1000
Fe	Iron	mg/L	TCVN 6177:1996	0.5
SiO_2	Silicon dioxide	mg/L	Hach DR 4000/5000 Method 8195	-

3. Results and discussion

3.1. Evaluating surface water quality in the study area

The water temperature at the sites in the aquaculture area was in the range of 28.8-29.9^{o}C while the average temperature at the study sites for 2019-2020 was in the range of 29.0-29.9^{o}C (Figure 1). The temperature in the aquatic environment in the aquaculture area in March and September of 2019-2020 did not differ much and was within the allowable limits of (QCVN 10-MT:2015/BTNMT) (30^{o}C). The temperature in the study area is in the suitable range for aquatic organisms [5].

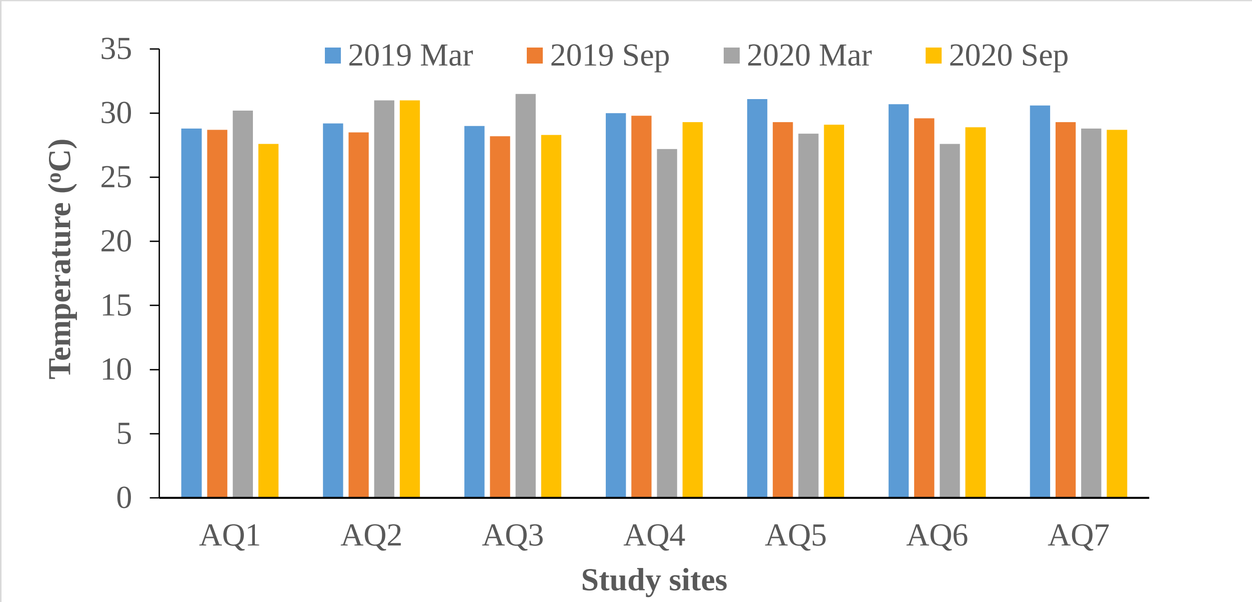

Figure 1. Temperature in surface water in aquaculture area

The pH value in the aquatic environment of the aquaculture area in 2019-2020 is presented in Figure 2. The average pH values at the locations in 2019 and 2020 were 6.8-7.3 and 6.9-7.5, respectively. Meanwhile, the average values of pH between March and September were 7.3-7.5 and 6.7-7.2, respectively. The pH value in the rainy season tends to be higher than that in the dry season. The cause may be due to the rain water diluted causing the pH to decrease. However, the average value of pH in the study area is still within the allowable limit of QCVN 10-MT:2015/BTNMT (6.5-8.5) [5]. This pH value is within the tolerance limit of aquatic organisms [5].

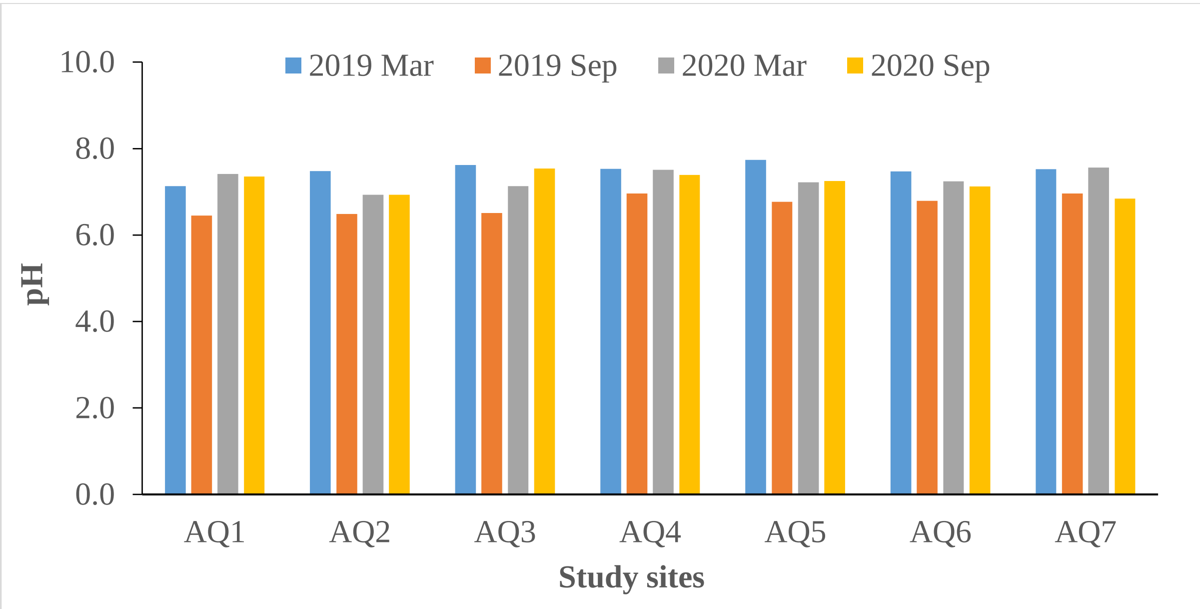

Figure 2. pH in surface water in aquaculture area

The average salinity in the study area ranged from 7.7-22.2‰. The concentrations of salinity in the study area in 2019 and 2020 were in the range of 5.5-21.0‰ and 10.0-25.2‰, respectively (Figure 3). The salinity in March was in the range of 20.2-26.0‰ while the salinity in September was in the range of 8.1-15.0‰. The results showed that the salinity in the rainy season was significantly lower than the salinity in the dry season. Salinity at AQ1-AQ4 sites was high and relatively stable while salinity at AQ4-AQ7 sites fluctuated greatly over time. Salinity was highest at AQ5 and lowest at AQ7.

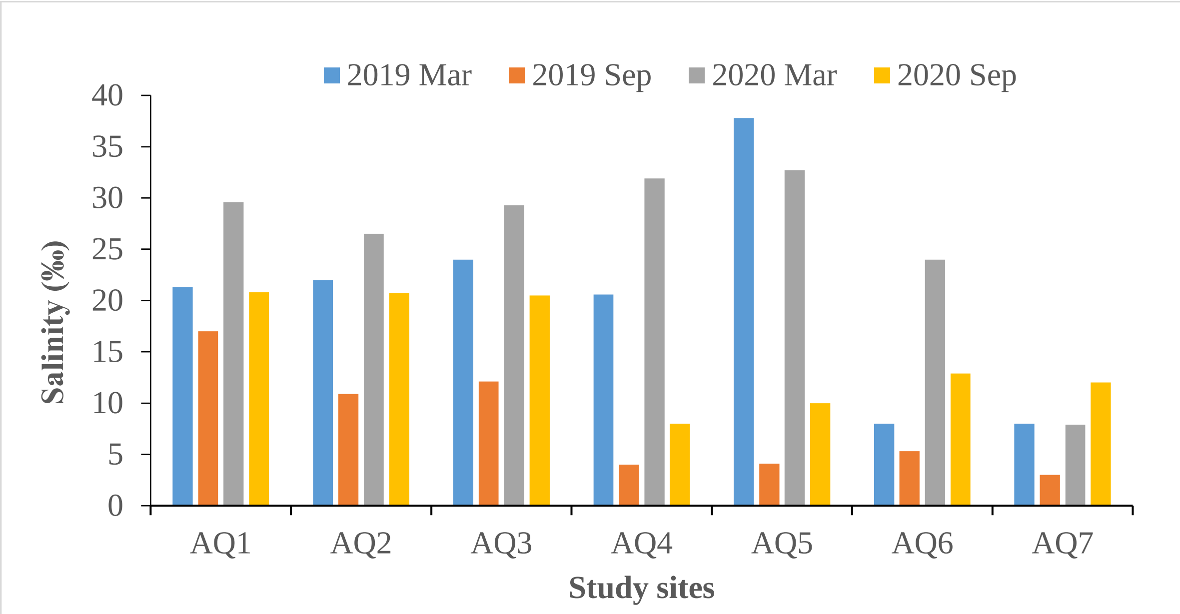

Figure 3. Salinity in surface water in aquaculture area

The concentration of total suspended solids in the study area is shown in Figure 4. TSS in the water body in 2019 ranged from 22.5 to 56.0 mg/L. TSS in rainy season (48 mg/L) was higher than TSS in dry season (32.7 mg/L) of 2019. TSS in 2020 was in the range of 21.0-169.5 mg/L (average 47.2 mg/L). In 2020, TSS at locations with high fluctuations and TSS in dry season tended to be higher than TSS of rainy season. The overall mean value of TSS for the period 2019-2020 was in the range of 26.8-112.5 mg/L. TSS at positions AQ5-QW7 exceeded the allowable limit of QCVN 10-MT:2015/BTNMT (50 mg/L) while TSS in the remaining positions were within the limit. TSS at position AQ5 in the dry season of 2020 was particularly high (307 mg/L) exceeding the allowable limit 6 times. Similar to the previous study, TSS in coastal waters can be up to 380 mg/L [12]. TSS is a major environmental problem of the Mekong Delta waters [13-16].

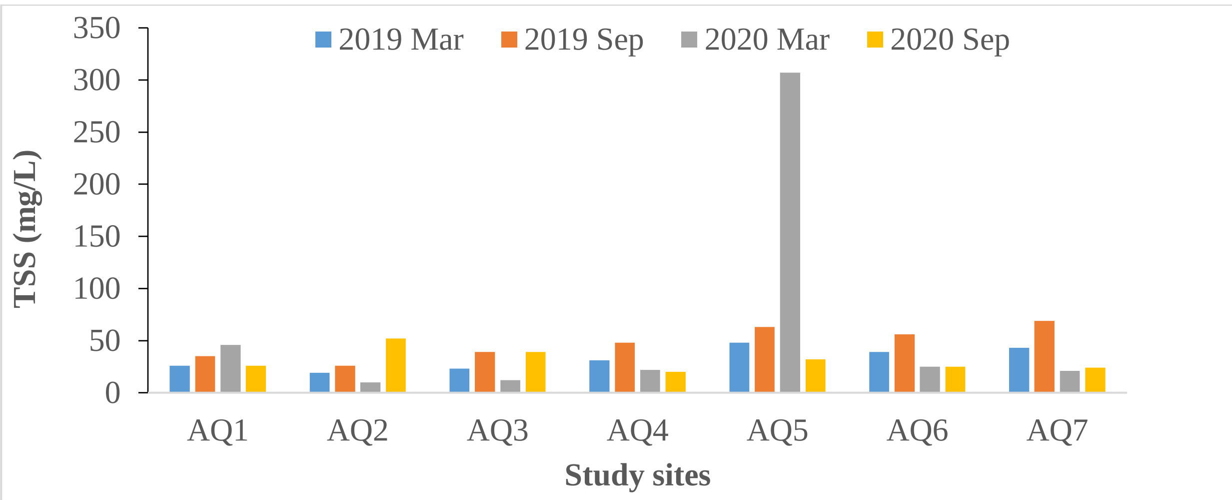

Figure 4. TSS in surface water in aquaculture area

Dissolved oxygen (DO) concentration in water bodies affected by aquaculture in the period 2019-2020 was in the range of 4.4-4.7 mg/L (Figure 5). The average values of DO at locations in 2019 and 2020 were in the range of 4.7-5.2 mg/L and 3.7-4.5 mg/L, respectively. The results showed that DO in 2020 tended to be lower than DO in 2019. DO in March and September were in the range of 4.3-4.9 mg/L and 4.3-4.6 mg/L, respectively. This result showed that DO had little seasonal variation. DO at all positions in May 2019 and 2020 were lower than the allowable limit of QCVN 10-MT:2015/BTNMT (≥5 mg/L). Previous studies showed that DO in coastal waters ranged from 4.0-6.8 mg/L [12]. In freshwater bodies of the Mekong Delta, DO is often lower than the allowable limit [12-16]. The low DO in the study area may be due to the presence of organic matters [13-14].

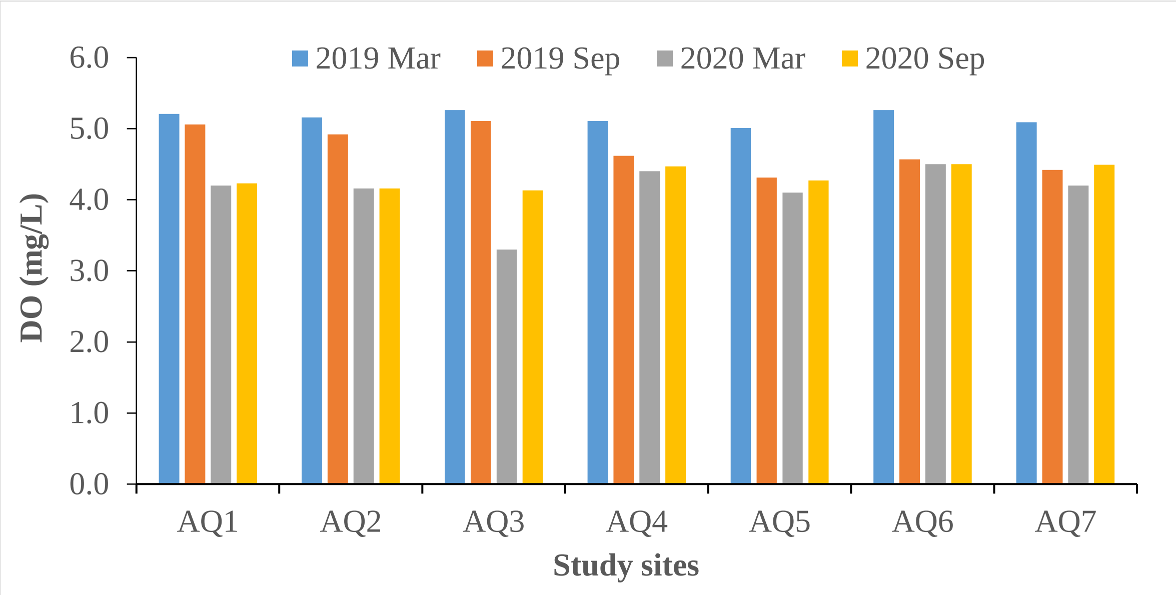

Figure 5. DO in surface water in aquaculture area

Chemical oxygen demand (COD) at all sites in the study area for the period 2019-2020 was in the range of 18.3-22.8 mg/L (Figure 6). The COD in the water bodies at the 2019 and 2020 sampling periods was 18.4-23.4 mg/L and 13.1-24.0 mg/L, respectively. COD in March and September was 20.3-26.1 mg/L and 14.6-19.4 mg/L, respectively. The findings showed that the COD in March 2019 was higher than that in the remaining months in the period 2019-2020. However, the overall mean value of COD showed that COD tended to decrease from 21.5 mg/L to 18.5 mg/L. This showed that the organic pollution in the study area has improved. COD is not specified in QCVN 10-MT:2015/BTNMT. In coastal surface water of Bac Lieu, COD concentration ranged from 20-282.6 mg/l [12]. According to QCVN 08-MT:2015/BTNMT, the COD values specified for columns A1, A2, B1, B2 are 10, 15, 30, 50 mg/L, respectively, suitable for different surface water uses [17]. COD in water bodies of the Mekong Delta is often higher than the allowable limit [13-16]. COD is used as indicator of organic waste concentration in water [13-14].

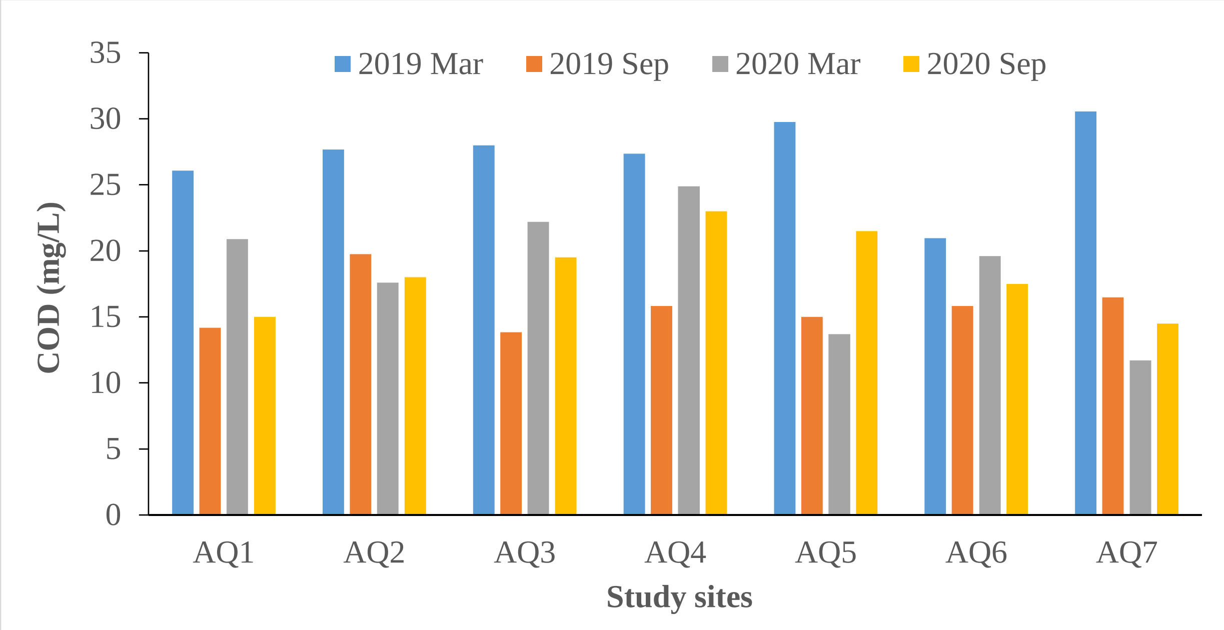

Figure 6. COD in surface water in aquaculture area

The ammonium concentration (N-NH_4^+) in the aquatic environment at the study area is shown in Figure 7. The N-NH_4^+ concentration in March and September for the period 2019-2020 ranged from 0.09-0.27 mg/L and 0.00-0.45 mg/L, respectively. The average value of N-NH_4^+ at sites during the period 2019-2020 was 0.13-0.28 mg/L. N-NH_4^+ in water bodies in 2019 and 2020 were 0.06-0.22 mg/L and 0.08-0.45 mg/L, respectively. N-NH_4^+ appeared at all sampling locations in March (ranging from 0.11-0.20 mg/L) of 2019 while N-NH_4^+ appeared at only a few locations in September 2019 and the whole of 2020. In the places where N-NH_4^+ was found, the N-NH_4^+ exceeded the allowable limit of QCVN 10-MT:2015/BTNMT (0.1 mg/L). N-NH_4^+ in the coastal area of Bac Lieu province was in the range of 0.099-1.79 mg/l [12] which was higher than N-NH_4^+ found in this study. In fresh water bodies, pollution caused by N-NH_4^+ is also very common, mainly due to waste from agricultural production, wastewater from domestic and industrial activities and unsanitary landfills [1-4].

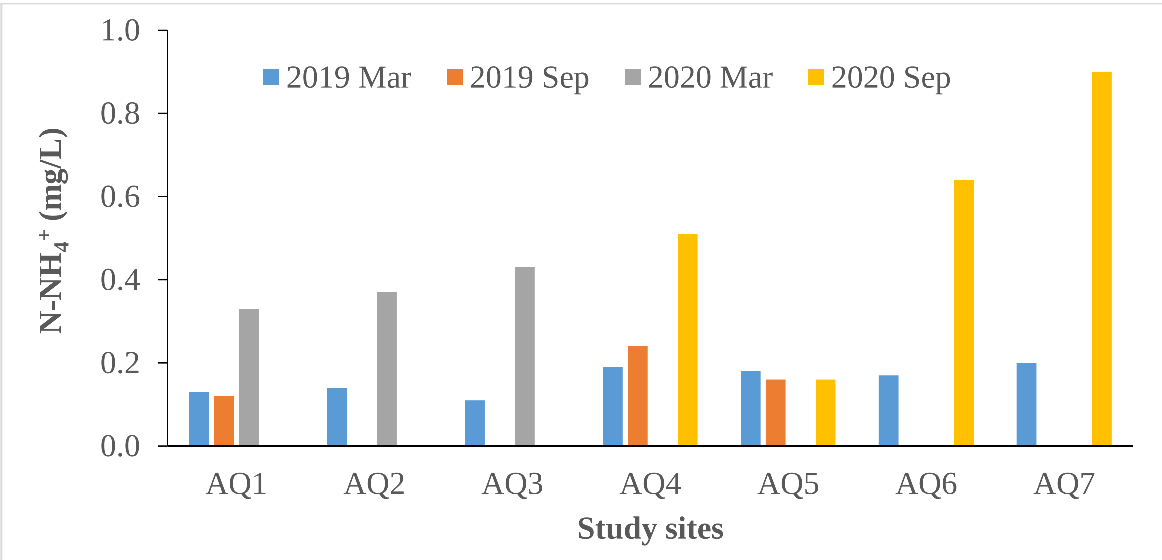

Figure 7. N-NH_4^+ in surface water in aquaculture area

The orthophosphate concentration (P-PO_4^{3-}) at the study site is shown in Figure 8. In March 2019, P-PO_4^{3-} was found only at the AQ1 site (0.77 mg/L). At this AQ1 position, P-PO_4^{3-} exceeded the allowable limit of QCVN 10-MT:2015/BTNMT (0.2 mg/L). In 2020, P-PO_4^{3-} was found at AQ6 in March and AQ4, AQ5 in September. The concentration of P-PO_4^{3-} in the coastal area of Bac Lieu province was 0.11 to 0.718 mg/l [12]. The concentration of P-PO_4^{3-} is often below the allowable limit in freshwater bodies, but there is also a potential risk due to eutrophication [4].

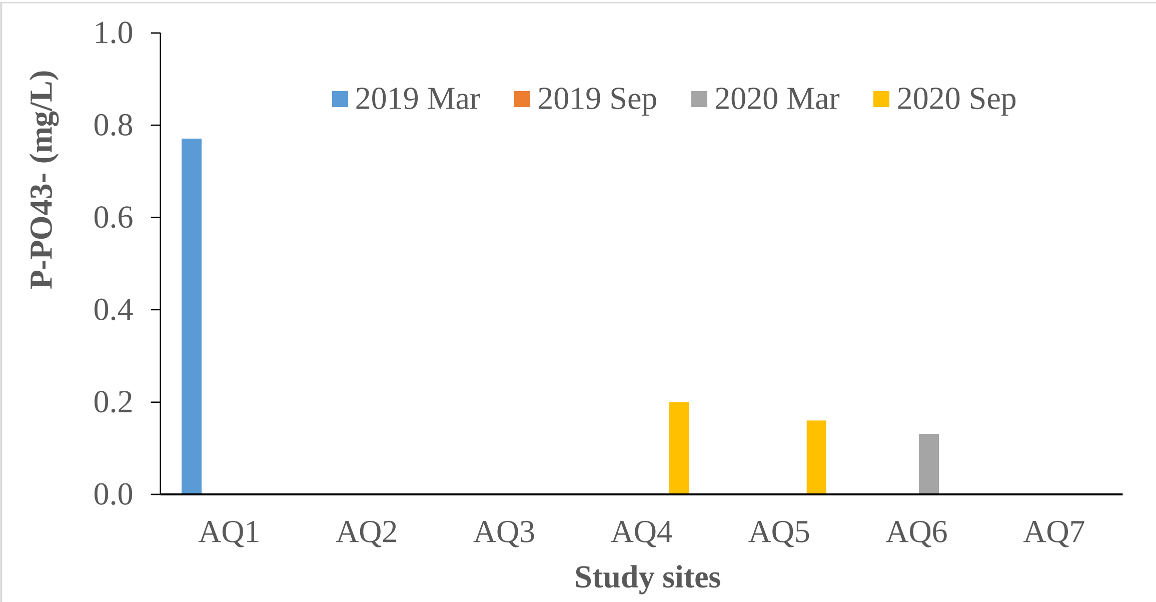

Figure 8. P-PO43- in surface water in aquaculture area

The coliform density in the study area during the period 2019-2020 ranged from 363-3650 MPN/100 mL (Figure 9). The coliform populations in 2019 and 2020 were in the range of 95-2850 MPN/100 mL and 215-4450 MPN/100 mL, respectively. The average value of coliform showed that the coliform density in 2020 was higher than that in 2019. The average coliform density in the rainy season (September, 1958 MPN/100 mL) was higher than the coliform density in the dry season (March, 830 MPN/ 100 mL). The number of coliforms at positions AQ3, AQ6, and AQ7 was significantly higher than that of the rest. The results showed that AQ3, AQ6, AQ7 sites in the study area were contaminated with microorganisms because the average value of coliform at these locations exceeded the allowable limit of QCVN 10-MT:2015. /BTNMT (1000 MPN/100 mL). Coliform in the coastal area of Bac Lieu in the range of 1,100-9,500 MPN/100ml [12]. In general, coliform is a water problem in the Mekong Delta waters [2,13-16]. Coliform is the indicator for environmental contamination of warm-blooded animal feces [2].

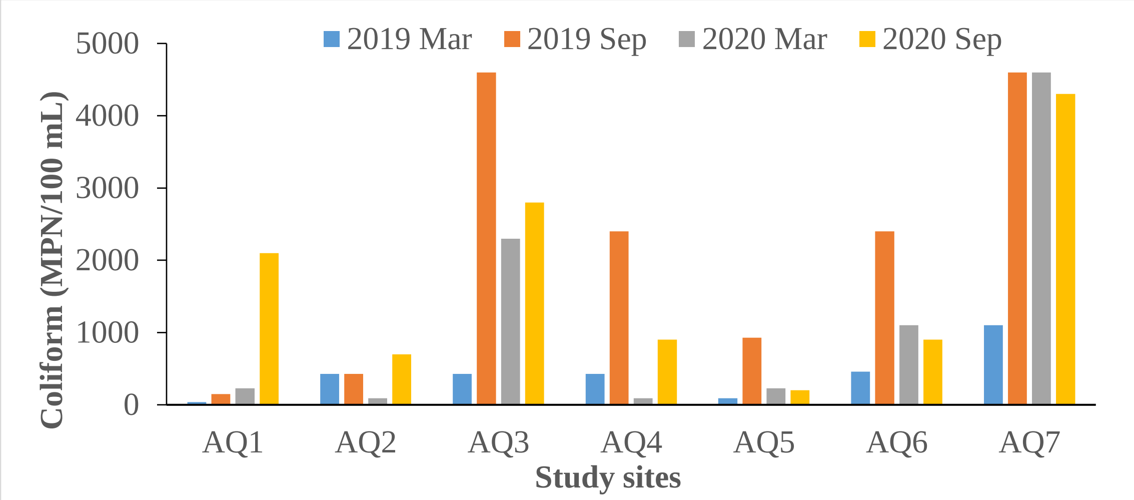

Figure 9. Coliform in surface water in aquaculture area

/The average iron (Fe) concentration at the study sites in the aquaculture area ranged from 0.44 to 0.87 mg/L, with an average of 0.67 mg/L (Figure 10). The average value of Fe in water bodies in 2019 and 2020 is 0.53 and 0.80 mg/L, respectively. Fe concentration tended to increase over time. Fe concentration also has seasonal fluctuations in which the Fe concentration in dry season and rainy season is 0.55 mg/L and 0.78 mg/L, respectively. The results showed that the average Fe concentration at all locations exceeded the allowable limit of QCVN 10-MT:2015/BTNMT (0.5 mg/L). Fe is the main environmental problem of surface water in the Mekong Delta region due to the impact of natural factors (acid sulfate soil) [2] and wastewater from socio-economic development processes [6].

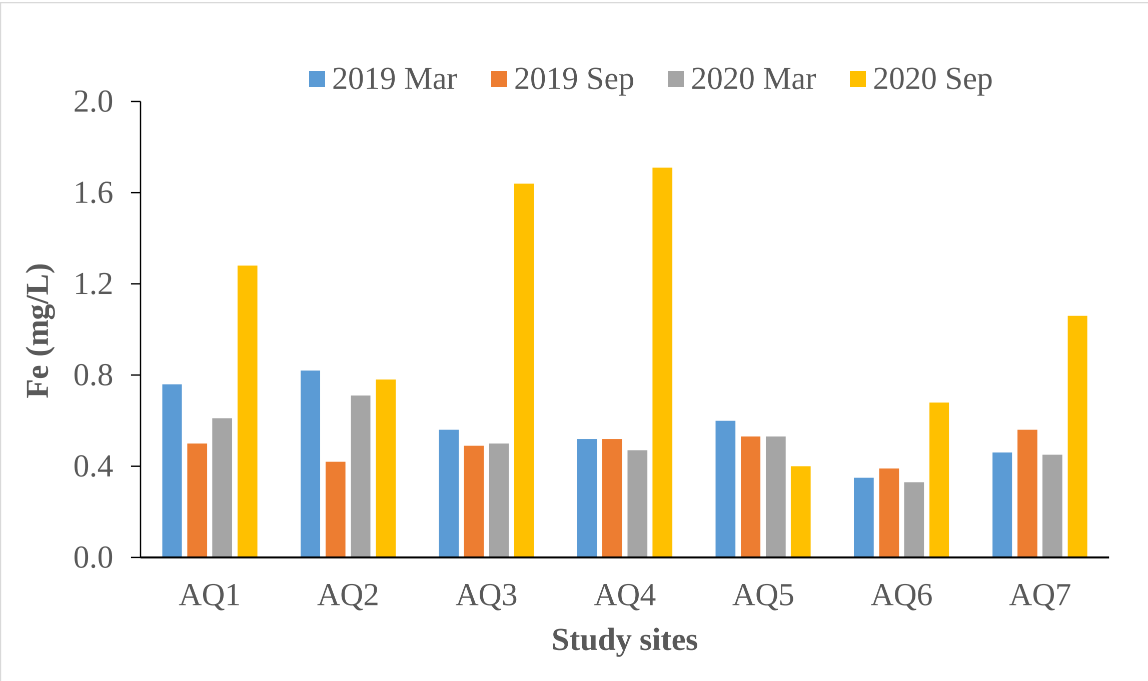

Figure 10. Fe in surface water in aquaculture area

The concentration of SiO_2 in the water bodies of the aquaculture area was in the range of 8-16.3 mg/L, averaging at 10.6 mg/L (Figure 11). The average concentration of SiO_2 in 2019 and 2020 was in the range of 8-18.5 mg/L and 6.5-15.0 mg/L, respectively. SiO_2 in March and September were

4.5-11.5 mg/L and 7-21.0 mg/L, respectively. The average concentration of SiO_2 in 2019 was higher than that of SiO_2 in 2020, and SiO_2 in the rainy season is higher than that in the dry season. SiO_2 is not regulated in QCVN 10-MT:2015/BTNMT.

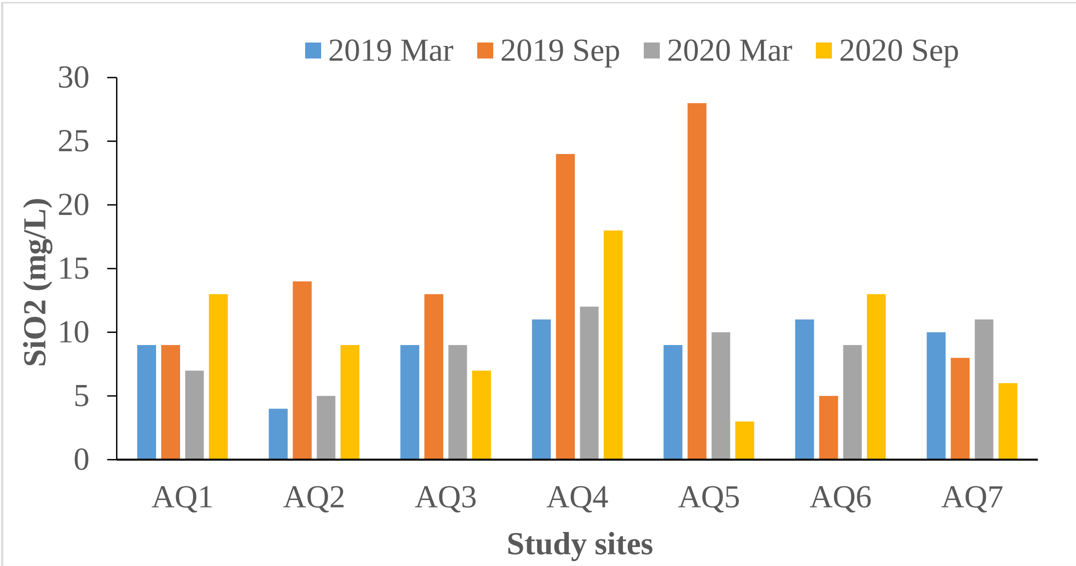

Figure 11. SiO2 in surface water in aquaculture area

3.2 Spatial variation of surface water quality in the study area

The spatial variation of water quality in 2019 and 2020 is presented in Figure 12 and Figure 12. In 2019, surface water quality in the aquaculture area was classified into 3 clusters including cluster 1 (AQ1), cluster 2 (AQ3, AQ4, AQ6, AQ7) and cluster 3 (AQ2, AQ5). Cluster 1 is characterized by salinity, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, and Fe above the allowable limit. Cluster 2 is characterized by TSS and coliform while cluster 3 is characterized by higher COD and SiO_2 compared to other clusters (Table 3).

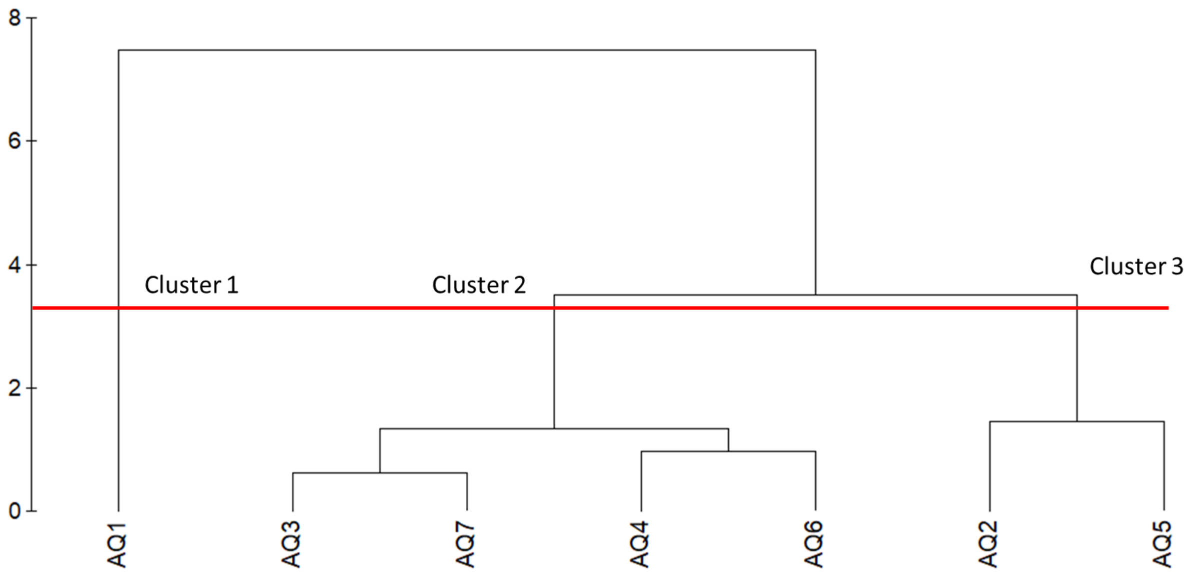

Figure 12. Spatial variation of surface water quality in 2019

Water quality in 2020 is also classified into 3 clusters (Figure 13). Cluster 1 includes 4 positions (AQ1, AQ3, AQ6, AQ7), cluster 2 includes only 1 position (AQ5) and cluster 3 includes two positions (AQ2, AQ4). Cluster 1 is characterized by $N\text{-}NH_4^+$, Coliform and Fe criteria. Cluster 2 is characterized by TSS parameters while cluster 3 is characterized by COD and SiO_2 (Table 3). The results showed that the indicators of COD, TSS, salinity, $N\text{-}NH_4^+$, coliform, Fe, SiO_2 cause spatial fluctuations of water quality in the study area in the period 2019-2020.

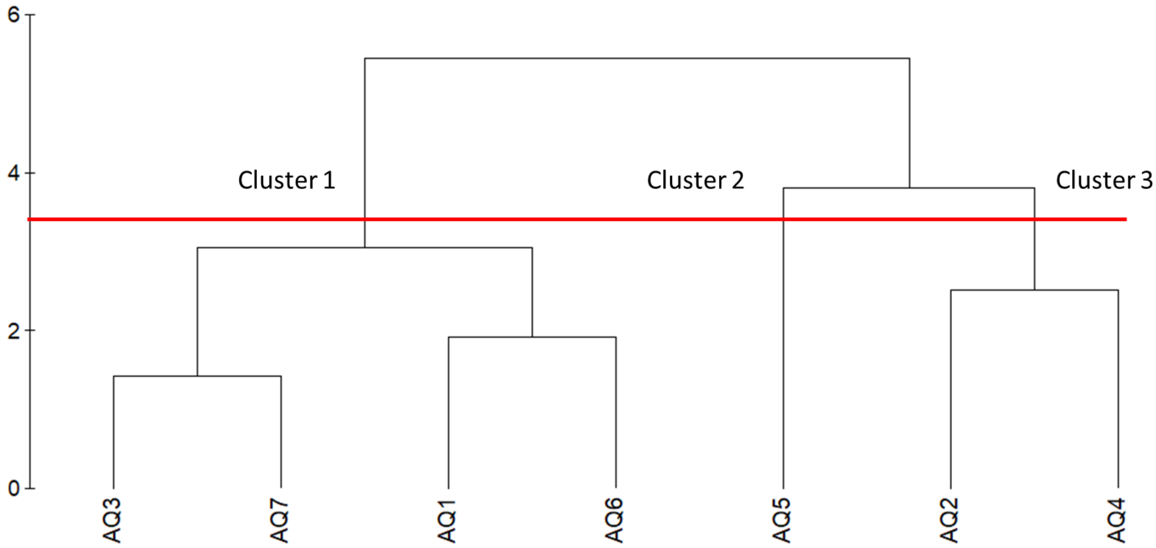

Figure 13. Spatial variation of surface water quality in 2020

Figure 14. Spatial variation of surface water quality in 2019-2020

Table 3. Values of water variables in the identified clusters

Variables	2019 Cluster 1	2019 Cluster 2	2019 Cluster 3	2020 Cluster 1	2020 Cluster 2	2020 Cluster 3	Limits
Temp.	28.8	29.7	29.5	29.0	28.8	29.6	-
pH	6.8	7.2	7.1	7.3	7.2	7.2	6.5-8.5
Sal.	19.2	10.6	18.7	19.6	21.4	21.8	-
TSS	30.5	43.5	39.0	27.3	169.5	26.0	50
DO	5.1	4.9	4.9	4.2	4.2	4.3	≥ 5
COD	20.1	21.1	23.0	17.6	17.6	20.9	-
$N\text{-}NH_4^+$	0.13	0.11	0.12	0.29	0.08	0.22	0.1
$P\text{-}PO_4^{3-}$	0.39	0.00	0.00	0.02	0.08	0.05	0.2
Coliform	95	2053	470	2291	215	445	1000
Fe	0.63	0.48	0.59	0.82	0.47	0.92	0.5
SiO_2	9.0	11.4	13.8	9.4	6.5	11.0	-

3.3 Identifying key variables influencing water quality in the study area

The results of the analysis of the main components affecting water quality in the aquaculture area are presented in Tables 4 and 5. In 2019, water quality was affected by 3 main components (explaining 84.6% variation) and three sub-components (which explain 15.4% of the variation). Meanwhile in 2020, water quality was affected by 4 main components (explaining 95.3% of the variation) and two minor components (explaining 4.7% of the variation). Thus, the source affecting water quality has changed from 2019 to 2020. The main indicators affecting surface water quality in 2019 include salinity, TSS, COD, and coliform (Table 4). Meanwhile, water quality in the aquaculture area in 2020 was mainly affected by the parameters of pH, salinity, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, Fe and SiO_2 (Table 5). From the analysis results, it is shown that the indicators of pH, salinity, TSS, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, Fe, SiO_2, coliform have the main influence on water quality in the period 2019-2020, so it should be considered. continue monitoring.

Table 4. Key variables influencing surface water quality in 2019

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Temp.	-0.413	0.052	0.237	-0.169	-0.210	0.061
pH	-0.426	0.043	-0.176	0.194	0.032	-0.001
Sal.	0.244	0.411	-0.052	0.330	-0.152	**-0.587**
TSS	-0.387	0.007	0.152	-0.296	0.117	**-0.574**
DO	0.391	-0.202	-0.003	0.339	0.190	0.122
COD	-0.055	0.232	**-0.681**	-0.382	0.006	0.144
$N\text{-}NH_4^+$	-0.191	0.444	0.266	0.068	0.402	0.468
$P\text{-}PO_4^{3-}$	0.301	0.117	0.414	-0.407	0.454	-0.146
Coliform	-0.197	-0.375	-0.316	0.165	**0.684**	-0.208
Fe	0.272	0.395	-0.286	-0.278	0.154	-0.038
SiO_2	-0.205	0.473	0.001	0.450	0.152	-0.043
E.val.	5.04	2.72	1.54	0.81	0.49	0.39
%Var.	45.9	24.8	14.0	7.4	4.4	3.6
C.%Var.	45.9	70.6	84.6	92.0	96.4	100.0

Table 5. Key variables influencing surface water quality in 2020

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Temp.	0.424	-0.169	0.204	0.341	0.272	0.348
pH	-0.382	-0.074	0.212	**-0.554**	-0.241	-0.005
Sal.	0.071	**-0.501**	0.162	0.081	-0.374	-0.372
TSS	0.086	-0.230	-0.460	-0.451	0.143	0.356
DO	-0.305	0.241	-0.317	0.373	-0.385	0.340
COD	-0.329	-0.350	0.210	0.147	0.447	-0.225
$N\text{-}NH_4^+$	-0.082	**0.517**	0.129	0.119	0.240	-0.236
$P\text{-}PO_4^{3-}$	-0.405	-0.133	-0.329	0.008	**0.513**	0.010
Coliform	0.131	0.433	0.242	-0.373	0.171	-0.083
Fe	-0.144	-0.083	**0.570**	-0.072	0.029	**0.615**
SiO_2	**-0.502**	0.046	0.154	0.218	-0.093	0.080
E.val.	3.47	3.33	2.57	1.11	0.35	0.17
%Var.	31.5	30.2	23.4	10.1	3.2	1.5
C.%Var.	31.5	61.8	85.2	95.3	98.5	100.0

4. Conclusions

The study found that temperature and pH values in the aquaculture area were within the allowable ranges, pH in the rainy season tended to be lower than that in the dry season. The average salinity in the study area ranged from 7.7 to 22.2‰. Salinity in the rainy season was significantly lower than in the dry season. TSS at positions AQ5-QW7 exceeded the allowable limit of QCVN 10-

MT:2015/BTNMT. DO at all positions in May 2019 and all 2020 were below the allowable limit. DO has little seasonal variation. COD was in the range of 18.3-22.8 mg/L, of which COD in March 2019 is higher than the rest of the months. $N\text{-}NH_4^+$ appeared at all sampling locations in March 2019 while $N\text{-}NH_4^+$ appeared at only a few locations in September 2019 and also in 2020. $N\text{-}NH_4^+$ was over the allowable limit at the sites it was found. $P\text{-}PO_4^{3-}$ was found only at AQ1 (2019) and AQ4-AQ6 (2020) positions. The concentration of coliform in the study area during the period 2019-2020 ranged from 363-3650 MPN/100 mL. Coliform at AQ3, AQ6, AQ7 exceeded the allowable limit of QCVN 10-MT:2015/BTNMT. Fe at all locations has exceeded the allowable limit, there was little seasonal fluctuation. The concentration of SiO_2 in water bodies in the aquaculture area is in the range of 8-16.3 mg/L. The average concentration of SiO_2 in 2019 was higher than SiO_2 in 2020, and SiO_2 in the rainy season was higher than that in the dry season. CA results showed that surface water quality 2019-2020 had large fluctuations over time and space mainly due to COD, TSS, salinity, $N\text{-}NH_4^+$, coliform, Fe, SiO_2. The results of PCA analysis showed that the parameters of pH, salinity, TSS, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$, Fe, SiO_2, coliform had the main influence on water quality in the period 2019-2020, so it should be monitoring.

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