



## RESEARCH AND ASSESSMENT OF SURFACE WATER QUALITY IN XUAN THUY RAMSAR SITE

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### ABSTRACT

Xuan Thuy Ramsar site is recognized the first Ramsar site in Vietnam and South East Asia in 1989. This is an internationally important wetland area for migratory water birds and shorebirds, regularly supporting several globally threatened species. It comprises of three islands and mudflats, the most important habitat being the intertidal mudflats and natural mangroves. The mangrove forest is one of considerable importance in maintaining the fishery, as a source of timber, and in protecting coastal settlements from the full impact of typhoons. Water quality is main component that plays important role with the development of mangrove ecosystem and aquatic species. Today, there are a lot of activities as fishing and aquaculture, which carries out in the Ramsar site and they can cause influence in water quality and ecological character of Ramsar site. This research focus on survey, collection of surface water samples and analysis these samples, and assessment of water quality via some of parameter as pH, BOD, COD, T-N, T-P, T-coliform and metals. Result research showed that all of parameters are in allowable limit of Vietnam Standards on surface water and coastal water quality, except for BOD and COD in some positions of Ramsar site are higher than that in Vietnam Standards. So that, Xuan Thuy Ramsar site should implement on wise use of wetland in order to manage and control the surface water quality for sustainable development of Ramsar site.

**Keywords:** Xuan Thuy Ramsar site, surface water quality, heavy metal, BOD, COD, T-N, T-P, T-coliform.

### 1. INTRODUCTION

Xuan Thuy Ramsar site is the internationally important wetland area where located at the south of the Red River, belongs to Giao Thuy district, Nam Dinh province. Its geographic coordinates range from 20°11' to 20°16' N and from 106°29' to 106°37' E. It has the total area of 7100 ha (including Lu, Ngan and Xanh Islands) and a wide buffer zone of 8000 ha in which 3000 ha is the mangrove community with many high value aquatic species makes the region rich, especially many species of migratory birds and endangered species in the Red Book of Vietnam and the Red List of IUCN.

The good quality of environment is convenient condition for development of mangrove ecosystem that is one of habitats for many aquatic species and migratory birds in this area. However, Xuan Thuy Ramsar site is facing with many problems on management and conservation of biodiversity and environment, it will cause biodiversity loss and degradation of environmental quality.

Thus, research on water quality in the Xuan Thuy Ramsar site is helpful for managers to identify, control and ensure the good water quality in order to protect, maintain and develop sustainability of biodiversity in there.

### 2. METHODS

**Expert method:** Expert method is used via collect data on primary and secondary documents, processing and evaluation information, inheritance of the results of the environmental studies related to Xuan Thuy Ramsar site.

**Survey methods:** Conducting survey and collecting water samples according to the environmental monitoring analysis (EMA) methods and preserving the environmental samples according the regulations of the Department of

Environmental Protection (2002) and the Vietnam Standards and the reference "Standard Methods for the Examination of Water and Wastewater, 20<sup>th</sup> Edition, 1998."

**Laboratory analysis:** Analyzing the water samples which collected in survey methods according to the instructions in: Regulation on monitoring methods and environmental analysis of the Ministry of Natural Resources and Environment (2002); Vietnam Standards (TCVN); and Standard Methods for the Examination of Water and Wastewater.

### 3. RESULTS AND DISCUSSIONS

#### 3.1. Characteristic of the Xuan Thuy Ramsar site

**Natural conditions:** Xuan Thuy Ramsar site is located in the tropical monsoon climate region and the natural topography was formed by the sedimentation of alluvium in coastal estuaries (the Red River) with a tidal flat outside the coastal dike including islands, rivers and runnels.

+ **Ngan Island:** Due to dike formation, Ngan Island is divided into two parts: one outside of Ramsar site coastal dike and another lying between coastal dike and Tra Creek. Most of the north area of Ngan Island was divided into squares used for fisheries. The remaining area at the north of Tra Creek estuary is slough and cultivated soil. From the slough to the end of Ngan Island is a mangrove community.

+ **Lu Island:** It lies between Tra Creek and tidal runnel separating from Xanh Island, parallel with Ngan Island. The east and southeast of Lu Island have a non- flooded high sand dune of which a part is covered by casuarina trees, the remaining area by mangrove community.



+ **Xanh Island:** It is located adjacent to Lu Island, is composed of sand. Xanh Island is being built up to expand and raise the ground area. Xanh Island is always flooded by high tide. At low tide, Xanh Island has two sand dunes, one is at the east and one is at southeast. These islands are being formed to expand.

+ **Tidal and river runnels:** Tidal and river runnels are regular flooded negative terrain. They are being accumulated by alluvial sediment (mud, clay and sand), raising the height and narrowing the water flow. Most of the tidal and river runnels have a thick and silky mud paste having a large area of about 4000 ha and having the potential to expand in the future.

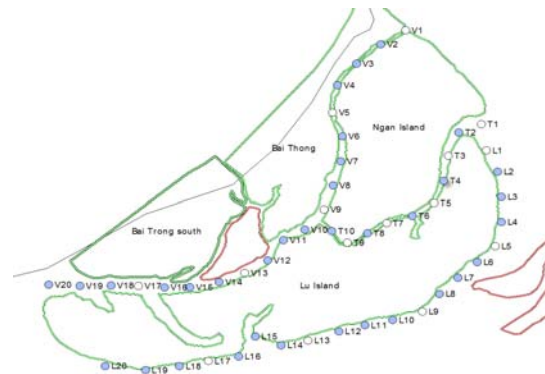
**Meteorological:** Temperature variation is quite large, about 6.8-40.1°C; the average temperature is 24°C. The average temperature during the dry season is below 18°C, in the rainy season is above 25°C. The maximum amount of radiation is quite large, from 95 to 105 Kcal/cm<sup>2</sup>/years. The humidity is high, ranging from 70 to 90%. From October to December, the humidity is often low (usually less than 75%). From February to April, the humidity is very high (80-90%) and is often accompanied by wet drizzle. The highest rainfall is 2754 mm, the lowest is 978 mm. Average evaporation is 86-126 mm/month and reaches the maximum in July. The annual average is 817.4 mm. Average wind speed is about 4-6 m/s. There are stormy days, the wind speeds can reach up to 40-50 m/s. Each year, there are about 3-5 storms, mainly in the months of June to September.

**Hydrological:** Xuan Thuy Ramsar site water is supplied mainly from the Red River to the sea and from the tide raising. There are two main rivers in this area, which are Vop Creek and Tra Creek. In addition, a number of natural drainage creeks also supply water to the region. Vop Creek flows from Ba Lat estuary to Giao Hai Sea approximately 12 km, being the boundary separating the Ngan Island and Bai Trong. In 1986, the Vop dam divided Vop Creek into Vop East and Vop West. Therefore, there is no water circulation for many years, Vop Creek runnel was filled up by the Red River alluvial. Tra Creek flows from Ba Lat estuary to the south, meets Vop Creek at Giao Hai Sea, about 12 km long and is the boundary separating the Ngan Island and Lu Island. Tra Creek was filled in the middle of (from Tan Island and Nut flat to the end of Ngan Island) because the ocean waves push the sand dunes crossing Ba Mo region (Lu Island) flowing through the flooded wetlands and fills up the Tra Creek section (the middle of Tra Creek was filled nearly 3 km). Thus, Tra Creek only flows when tide sweeps through the mangrove. This is a major limitation due to the hydrological conditions in the region, leaving a negative impact on the survival and inefficient development of many plant and animal species at the end of Ngan Island and Lu Island.

Natural conditions, meteorological and pedological of Xuan Thuy Ramsar site are suitable for development of various mangrove species and other aquatic species.

### 3.2. Analysis results and assessment on surface water quality in Suan Thuy Ramsar site

Surface water samples were monitored at 46 points including 10 points in Lu Island, 6 points in Ngan Island, 10 points in Tra Creek and 20 points in Vop Creek. The number of samples was taken for laboratory analysis for each area is 5. Located points are showed in the Figure-1 and Figure-2.



**Figure-1.** Conceptual location of sampling points for surficial waters survey in Vop Creek, Tra Creek, and Lu Island (excepting fragmented area of mangrove community in Ngan Island).



**Figure-2.** Conceptual location of sampling points for surficial water of streams in fragmented area of mangrove community of Ngan Island.

Base on the effect of physical, chemical and organism elements in surface water quality, some of parameters are selected in order to analyze water samples in Xuan Thuy Ramsar site:

**DO (Dissolved oxygen):** is an important parameter to evaluate the water quality and is a vital indicator for the life of aquatic species.

**BOD and COD:** are two important parameters to evaluate the level of organic pollution and also index to assess the development and survival of aquatic species.

**Total nitrogen and total phosphorus:** are not specified in Vietnam Standards on coastal water and surface water quality.



**The total coliform (T-Coliform):** is used to assess the pollution level caused by microbiological species toward the water quality.

**pH and metal:** if they exceed the allowed standards of surface water quality, they will directly impact on the

development of aquatic species and mangrove ecosystem in Xuan Thuy Ramsar site.

### 3.2.1. Analysis results of Vop creek water samples

**Table-1.** Analysis results of Vop creek surface water samples.

Parameters	Unit	Samples					Allowable limit
		V1	V5	V9	V13	V17	
		20°16'11.7"	20°15'05.6"	20°13'37.0"	20°12'52.8"	20°12'32.6"	
		106°33'30.6"	106°32'45.1"	106°32'31.2"	106°31'29.5"	106°30'08.3"	
<b>pH</b>	-	8.08	7.99	7.95	8.05	8.08	6-8.5 (1); 6.5-8.5 (2)
<b>DO</b>	mg/L	5.80	5.60	4.23	5.10	5.30	≥ 5 (1); ≥ 5 (2)
<b>BOD</b>	mg/L	5.3	6.0	7.0	6.8	6.8	6 (1)
<b>COD</b>	mg/L	7.8	8.2	9.5	9.7	8.2	15 (1); 3 (2)
<b>Total N</b>	mg/L	0.022	0.028	0.034	0.032	0.024	
<b>Total P</b>	mg/L	0.063	0.056	0.065	0.034	0.040	
<b>Coliform</b>	MPN/100mL	611	248	225	232	42	5000 (1) 1000 (2)

Note: (1): QCVN 08:2008/BTNMT (surface water) and (2): QCVN 10:2008/BTNMT (coastal water)

**Table-2.** Metal concentration in Vop creek surface water samples (mg/L).

Metals	Samples					Allowable limit
	V1	V5	V9	V13	V17	
	20°16'11.7"	20°15'05.6"	20°13'37.0"	20°12'52.8"	20°12'32.6"	
	106°33'30.6"	106°32'45.1"	106°32'31.2"	106°31'29.5"	106°30'08.3"	
<b>Aluminum</b>	0.007	0.009	0.009	0.008	0.01	-
<b>Antimony</b>	0.002	0.002	0.002	0.001	0.001	-
<b>Arsenic</b>	0.0017	0.0013	0.0015	0.0021	0.0014	0.02
<b>Barium</b>	0.091	0.063	0.084	0.058	0.077	-
<b>Beryllium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Bismuth</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Cadmium</b>	0.00018	0.00017	0.00029	0.00014	0.00021	0.005
<b>Calcium</b>	216.0	176.0	200.0	264.0	284.0	-
<b>Chromium</b>	0.0082	0.0089	0.0091	0.0037	0.0058	0.01
<b>Cobalt</b>	0.0021	0.0019	0.0024	0.0021	0.0018	-
<b>Copper</b>	0.0034	0.0039	0.0027	0.0031	0.0028	0.2
<b>Lanthanum</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Lead</b>	0.0023	0.0025	0.0019	0.0027	0.0034	0.02
<b>Magnesium</b>	672.0	535.2	648.0	873.6	864.0	-
<b>Manganese</b>	0.015	0.023	0.021	0.015	0.017	-
<b>Mercury</b>	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
<b>Nickel</b>	0.003	0.0029	0.0018	0.0027	0.0015	0.1
<b>Potassium</b>	219.847	192.366	251.582	281.645	278.481	-
<b>Sodium</b>	4,773.663	4,120.649	4,979.424	6,116.992	6,317.549	-
<b>Strontium</b>	4.235	3.210	4.572	5.040	5.369	-
<b>Tellurium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Thallium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Tin</b>	0.0021	0.0037	0.0025	0.0029	0.0031	-
<b>Uranium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Vanadium</b>	0.077	0.098	0.081	0.098	0.069	-
<b>Zinc</b>	0.0512	0.0485	0.0371	0.0781	0.0214	1.0



According to the analysis results in Tables 1 and 2:

- The greatest DO is at V1 position (originated from Ba Lat) and decreases to position V9, after meeting Tra Creek the DO value increases. The increase or decrease of the DO may be due to increasing of water flow after crossing with Tra Creek or the present of polluted agents from aquaculture activities. There is only at V9, the DO is lower than that in Vietnam Standard on the quality of surface and coastal water ( $DO > 5 \text{ mg/l}$ ).
- BOD increases from V1 position to V9 position, and then decreases from V9 position to V17 position. The greatest BOD is at V9 position (7.0 mg/l). The average value of the BOD in Vop Creek is 6.38 mg/l. Compared to surface water standards (BOD > 6 mg/l), at 3 out of 5 sampling points in Vop Creek the BOD exceed the allowable limit.
- COD tends to increase from Ba Lat to downstream. The highest COD at V9 position and V13 position equal 9.5 mg/l and 9.7 mg/l, respectively. According to Vietnam Standard (QCVN 10:2008) on coastal water quality (COD < 3 mg/l), all Vop Creek samples exceed the allowable limit. When compared to Vietnam Standard (QCVN 08:2008) on surface water quality (COD < 15 mg/l) the recorded values are within the allowable limit.
- The total nitrogen is within the range of 0.022 and 0.034 mg/l; the mean value is 0.028 mg/l. The total Phosphorus ranges from 0.034 to 0.065 mg/l; the mean value is 0.052 mg/l. The total nitrogen tends to slightly increase from V1 to V9 position. In contrast, the total phosphorus at both V13 and V17 positions are lower than that at V1 position. In general, the total nitrogen and the total phosphorus in Vop Creek are rather low and there is no sign of pollution caused by nitrogen and phosphorus.
- The T-Coliform is the maximum at V1 position and gradually decreases to V17 position. Compared to Vietnam Standard on surface water quality (5000 MPN/100 ml) and coastal water quality (1000 MPN/100 ml), there is no sign of microbiological pollution in Vop Creek.
- pH of all samples collected in Vop Creek are with the allowable limit according Vietnam Standard on surface water and coastal water quality.
- Metal concentrations of all Vop Creek surface water samples are within the allowable limits according to Vietnam Standard on surface water and coastal water quality.

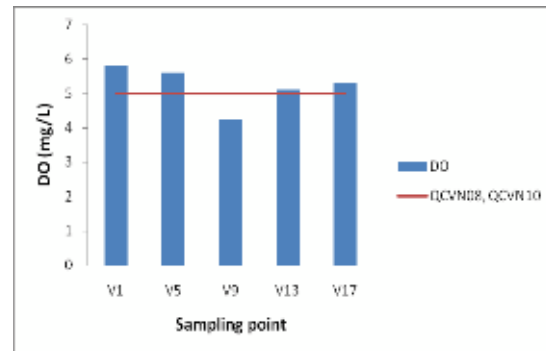


Figure-3. DO variation in Vop Creek surface water sample.

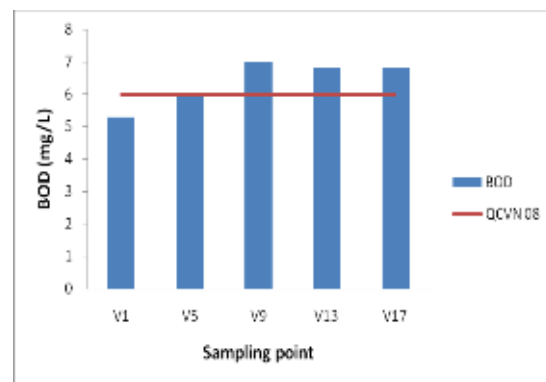


Figure-4. DO variation in Vop Creek surface water sample.

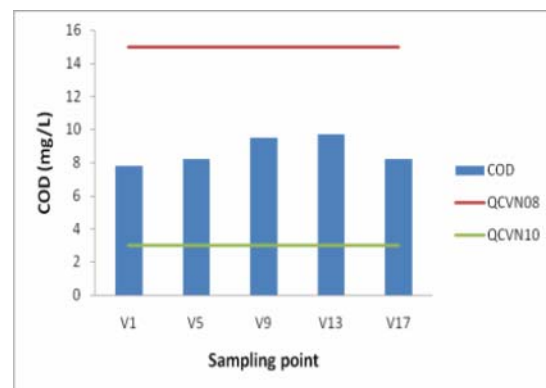


Figure-5. COD variation in Vop Creek surface water samples.

### 3.2.2. Analysis results of Tra Creek water samples

**Table-3.** Analysis results of Tra Creek surface water samples.

Parameters	Unit	Samples					Allowable limit
		T1	T3	T5	T7	T9	
		20 <sup>0</sup> 14'57.8"	20 <sup>0</sup> 14'27.2"	20 <sup>0</sup> 13'57.5"	20 <sup>0</sup> 13'38.1"	20 <sup>0</sup> 13'12.7"	
		106 <sup>0</sup> 34'43.5"	106 <sup>0</sup> 34'24.4"	106 <sup>0</sup> 34'16.6"	106 <sup>0</sup> 33'41.4"	106 <sup>0</sup> 33'01.9"	
<b>pH</b>		7.91	7.80	7.64	7.75	7.67	6-8.5 (1); 6.5-8.5 (2)
<b>DO</b>	mg/L	5.40	5.59	1.65	1.96	2.47	≥ 5 (1); ≥ 5 (2)
<b>BOD</b>	mg/L	6.7	6.1	17.5	17.4	16.5	6 (1)
<b>COD</b>	mg/L	8.4	8.3	26.4	27.7	25.4	15 (1); 3 (2)
<b>Total N</b>	mg/L	0.022	0.027	0.032	0.029	0.031	
<b>Total P</b>	mg/L	0.047	0.052	0.055	0.069	0.045	
<b>Coliform</b>	MPN/ 100mL	327	295	1266	644	63	5000 (1) 1000 (2)

Note: (1): QCVN 08:2008/BTNMT (surface water) and (2): QCVN 10:2008/BTNMT (coastal water)

**Table-4.** Metal concentration in Tra Creek surface water samples (mg/l).

Metals	Samples					Allowable limit
	T1	T3	T5	T7	T9	
	20 <sup>0</sup> 14'57.8"	20 <sup>0</sup> 14'27.2"	20 <sup>0</sup> 13'57.5"	20 <sup>0</sup> 13'38.1"	20 <sup>0</sup> 13'12.7"	
	106 <sup>0</sup> 34'43.5"	106 <sup>0</sup> 34'24.4"	106 <sup>0</sup> 34'16.6"	106 <sup>0</sup> 33'41.4"	106 <sup>0</sup> 33'01.9"	
<b>Aluminum</b>	0.009	0.009	0.011	0.01	0.012	-
<b>Antimony</b>	0.001	0.002	0.002	0.001	0.002	-
<b>Arsenic</b>	0.0013	0.0024	0.0028	0.0028	0.0019	0.02
<b>Barium</b>	0.051	0.065	0.081	0.077	0.066	-
<b>Beryllium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Bismuth</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Cadmium</b>	0.00018	0.00016	0.00014	0.00017	0.00019	0.005
<b>Calcium</b>	168.0	172.0	176.0	184.0	180.0	-
<b>Chromium</b>	0.0063	0.0072	0.0059	0.0061	0.0077	0.01
<b>Cobalt</b>	0.0017	0.0031	0.0024	0.0026	0.0025	-
<b>Copper</b>	0.0033	0.0039	0.0028	0.0037	0.0025	0.2
<b>Lanthanum</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Lead</b>	0.0018	0.0022	0.0019	0.0031	0.0027	0.02
<b>Magnesium</b>	499.2	511.2	525.6	535.2	501.6	-
<b>Manganese</b>	0.012	0.018	0.02	0.018	0.017	-
<b>Mercury</b>	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
<b>Nickel</b>	0.0014	0.0024	0.0019	0.0021	0.0024	0.1
<b>Potassium</b>	206.107	207.633	212.213	200.001	127.118	-
<b>Sodium</b>	3,907.193	3,916.473	3,944.316	3,962.877	3,990.719	-
<b>Strontium</b>	2.990	2.837	3.014	3.122	3.021	-
<b>Tellurium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Thallium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Tin</b>	0.0028	0.0033	0.0029	0.0021	0.0019	-
<b>Uranium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Vanadium</b>	0.091	0.082	0.085	0.079	0.066	-
<b>Zinc</b>	0.032	0.0285	0.0297	0.0288	0.0312	1.0



The analysis results of Tra Creek water samples in Table-3 and Table-4 showed that:

- DO in Tra Creek is the largest variation. DO at T1 and T3 positions are 5.4 and 5.95 mg/l, respectively. The lowest DO (1.65 mg/l) is recorded at T5 position. DO at T7 and T9 are 1.96 and 2.47 mg/l, respectively. The low DO in Tra Creek shows that Tra Creek water is seriously polluted. Compared to Vietnam Standard on surface water and coastal water quality (DO > 5 mg/l), the DO exceed the allowable limit at most of Tra Creek downstream positions, thereby causing serious influence on the life of aquatic species in the basin.
- Similar to DO, BOD and COD in Tra Creek have shown a sign of serious pollution. COD at all positions are higher than 8 mg/l and BOD are higher than 5 mg/l. Especially, at T5, T7, T9 positions, COD ranges from 25.4 to 27.7 mg/l and BOD ranges from 16.5 to 17.5 mg/l. Compared to QCVN 10:2008 (COD < 3 mg/l) and QCVN 08:2008 (COD < 15 mg/l), all the recorded values exceed the allowable limits a multiple times. It's proves that the water at Tra Creek downstream is polluted by organic substances.
- Total nitrogen in Tra Creek ranges from 0.022 to 0.032 mg/l. The mean T-N is 0.028 mg/l. Total phosphorus ranges from 0.045 to 0.069 mg/l. The mean T-P is 0.054 mg/l. The total nitrogen and total phosphorus tends to slightly increase from upstream to downstream. Compared with Vop Creek, the total phosphorus at Tra Creek is higher; however, the total nitrogen and the total phosphorus in Tra Creek are quite low and there is no sign of pollution by nitrogen and phosphorus.
- T-Coliform in Tra Creek is higher than that in Vop Creek. The mean value of Coliform is 519 MPN/100 ml and the Coliform at T5 is 1266 MPN/100 ml higher than that in Vietnam Standard on coastal water quality (1000 MPN/100 ml). To compare to Vietnam Standard on surface water quality, Tra Creek shows no sign of pollution caused by microbiology.
- pH and metal concentrations of all samples recorded in Tra Creek surface water are within the allowable limit in Vietnam Standard on surface water and coastal water quality.

### 3.2.3. Analysis results of Ngan Island water samples

**Table-5.** Analysis results of Ngan Island surface water samples.

Parameters	Unit	Samples					Allowable limit
		F4	F7	F10	F16	F19	
		20 <sup>0</sup> 15'31.2"	20 <sup>0</sup> 15'13.4"	20 <sup>0</sup> 14'55.6"	20 <sup>0</sup> 14'39.3"	20 <sup>0</sup> 14'15.1"	
		106 <sup>0</sup> 34'33.1"	106 <sup>0</sup> 34'35.6"	106 <sup>0</sup> 34'16.7"	106 <sup>0</sup> 33'48.9"	106 <sup>0</sup> 34'09.3"	
<b>pH</b>		7.92	8.01	7.93	8.01	7.96	6-8.5 (1); 6.5-8.5 (2)
<b>DO</b>	mg/L	7.53	6.40	6.40	5.53	5.71	≥ 5 (1); ≥ 5 (2)
<b>BOD</b>	mg/L	4.2	4.4	5.1	5.2	4.8	6 (1)
<b>COD</b>	mg/L	5.8	5.7	7.8	7.9	6.5	15 (1); 3 (2)
<b>Total N</b>	mg/L	0.029	0.032	0.024	0.023	0.022	
<b>Total P</b>	mg/L	0.086	0.059	0.075	0.072	0.071	
<b>Coliform</b>	MPN/ 100mL	2176	173	743	978	1240	5000 (1) 1000 (2)

Note: (1): QCVN 08:2008/BTNMT (surface water) and (2): QCVN 10:2008/BTNMT (coastal water)

**Table-6.** Metal concentration in Ngan Island surface water samples (mg/l).

Metals	Samples					Allowable limit
	F4	F7	F10	F16	F19	
	20 <sup>o</sup> 15'31.2"	20 <sup>o</sup> 15'13.4"	20 <sup>o</sup> 14'55.6"	20 <sup>o</sup> 14'39.3"	20 <sup>o</sup> 14'15.1"	
	106 <sup>o</sup> 34'33.1"	106 <sup>o</sup> 34'35.6"	106 <sup>o</sup> 34'16.7"	106 <sup>o</sup> 33'48.9"	106 <sup>o</sup> 34'09.3"	
<b>Aluminum</b>	0.009	0.01	0.008	0.011	0.007	-
<b>Antimony</b>	0.002	0.003	0.002	0.002	0.001	-
<b>Arsenic</b>	0.0024	0.0021	0.0018	0.0027	0.0028	0.02
<b>Barium</b>	0.075	0.063	0.081	0.078	0.058	-
<b>Beryllium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Bismuth</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Cadmium</b>	0.00018	0.00013	0.00015	0.0002	0.00029	0.005
<b>Calcium</b>	160.0	160.0	192.0		204.0	-
<b>Chromium</b>	0.0079	0.0081	0.0074	0.0078	0.0085	0.01
<b>Cobalt</b>	0.0017	0.0019	0.0021	0.0015	0.0018	-
<b>Copper</b>	0.0029	0.0027	0.0021	0.0031	0.0029	0.2
<b>Lanthanum</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Lead</b>	0.0035	0.0028	0.0031	0.0025	0.0017	0.02
<b>Magnesium</b>	388.8	456.0	566.4		631.2	-
<b>Manganese</b>	0.023	0.014	0.011	0.018	0.021	-
<b>Mercury</b>	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
<b>Nickel</b>	0.002	0.0018	0.0017	0.002	0.0018	0.1
<b>Potassium</b>	118.220	127.118	198.473	210.687	134.745	-
<b>Sodium</b>	5,532.033	5,632.312	6,167.131	5,582.172	2,899.721	-
<b>Strontium</b>	4.877	4.910	4.567	4	2.810	-
<b>Tellurium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Thallium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Tin</b>	0.0027	0.0028	0.0028	0.0029	0.0022	-
<b>Uranium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	-
<b>Vanadium</b>	0.057	0.081	0.077	0.079	0.079	-
<b>Zinc</b>	0.0288	0.0355	0.04	0.037	0.0301	1.0

The analysis result of Ngan Island in Tables 5 and 6 showed that:

- DO in Ngan Island mangrove area is quite high. Compared to Vietnam Standard on surface water and coastal water quality (DO > 5 mg/l), DO at most of Ngan Island positions are within the allowable limit.
- BOD and COD in Ngan Island mangrove area are lower than that in Vop Creek and Tra Creek. The mean values of BOD and COD in Ngan Island (5.2 mg/l and 7.90 mg/l) are lower than that in Tra Creek (12.84 mg/l, and 19.24 mg/l) and in Vop Creek (6.38 mg/l and 8.68 mg/l). At most of survey points in Ngan Island, BOD is lower than that in Vietnam Standard on surface water quality. COD in Ngan

Island are also lower than that in Vietnam Standard on surface water quality (15 mg/l) but higher than the allowable limit when compared to Vietnam Standard on coastal water quality.

- Total phosphorus in Ngan Island tends to be higher than that in Tra Creek, Vop Creek, and Lu Island. The mean T-P in Ngan Island is 0.086 mg/l while in Vop Creek is 0.052 mg/l, in Tra Creek is 0.054 mg/l and in Lu Island is 0.069 mg/l. The rising of T-P in Ngan Island needs further studies toward the P cycle in mangrove area.
- Similar to survey points in Vop Creek and Tra Creek, T-Coliform in Ngan Island are lower than that in Vietnam Standard on surface water quality. In



contrast, compared to Vietnam Standard on coastal water quality, F4 and F19 samples are higher than the allowable limit.

- pH and heavy metal concentrations of all samples in Ngan Island are within the allowable limits

according to Vietnam Standard on surface water and coastal water quality.

### 3.2.4. Analysis results of Lu Island water samples

**Table-7.** Analysis results of Lu Island surface water samples.

Parameters	Unit	Samples					Allowable limit
		L1	L5	L9	L13	L17	
		20 <sup>0</sup> 14'55.8"	20 <sup>0</sup> 13'41.5"	20 <sup>0</sup> 12'54.8"	20 <sup>0</sup> 11'57.6"	20 <sup>0</sup> 11'19.6"	
		106 <sup>0</sup> 35'11.3"	106 <sup>0</sup> 35'16.2"	106 <sup>0</sup> 35'02.2"	106 <sup>0</sup> 33'09.2"	106 <sup>0</sup> 31'06.5"	
pH	-	8.10	8.07	8.25	8.05	8.10	6-8.5 (1); 6.5-8.5 (2)
DO	mg/L	6.34	6.40	6.75	6.67	6.50	≥ 5 (1); ≥ 5 (2)
BOD	mg/L	4.2	4.1	3.1	3.0	3.1	6 (1)
COD	mg/L	6.1	6.0	4.5	4.5	4.6	15 (1); 3 (2)
Total N	mg/L	0.019	0.027	0.019	0.026	0.024	
Total P	mg/L	0.072	0.069	0.057	0.071	0.077	
Coliform	MPN/100mL	3065	1071	428	331	757	5000 (1) 1000 (2)

Note: (1): QCVN 08:2008/BTNMT (surface water) and (2): QCVN 10:2008/BTNMT (coastal water)

**Table-8.** Metal concentration in Lu Island surface water samples (mg/l).

Metal	Samples					Allowable limit
	L1	L5	L9	L13	L17	
	20 <sup>0</sup> 14'55.8"	20 <sup>0</sup> 13'41.5"	20 <sup>0</sup> 12'54.8"	20 <sup>0</sup> 11'57.6"	20 <sup>0</sup> 11'19.6"	
	106 <sup>0</sup> 35'11.3"	106 <sup>0</sup> 35'16.2"	106 <sup>0</sup> 35'02.2"	106 <sup>0</sup> 33'09.2"	106 <sup>0</sup> 31'06.5"	
Aluminum	0.009	0.012	0.016	0.008	0.011	-
Antimony	0.003	0.003	0.001	0.002	0.002	-
Arsenic	0.0031	0.0027	0.0024	0.0024	0.0029	0.02
Barium	0.062	0.079	0.045	0.061	0.054	-
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	-
Bismuth	<0.001	<0.001	<0.001	<0.001	<0.001	-
Cadmium	0.00014	0.00018	0.00019	0.00011	0.00017	0.005
Calcium	236.0	240.0	232.0	200.0	256.0	-
Chromium	0.0076	0.0081	0.008	0.0079	0.0082	0.01
Cobalt	0.0018	0.0018	0.0021	0.0018	0.0024	-
Copper	0.0017	0.0022	0.0027	0.0031	0.0025	0.2
Lanthanum	<0.001	<0.001	<0.001	<0.001	<0.001	-
Lead	0.0022	0.0021	0.0024	0.003	0.0031	0.02
Magnesium	724.8	744.0	768.0	628.8	835.2	-
Manganese	0.019	0.031	0.02	0.018	0.022	-
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Nickel	0.0019	0.002	0.0016	0.0019	0.0023	0.1
Potassium	237.341	251.582	245.253	153.813	240.506	-
Sodium	4157.773	6133.705	6050.139	6016.713	6100.279	-
Strontium	3.587	4.611	4.660	4.735	4.56	-
Tellurium	<0.001	<0.001	<0.001	<0.001	<0.001	-
Thallium	<0.001	<0.001	<0.001	<0.001	<0.001	-
Tin	0.0027	0.0019	0.0033	0.0027	0.0028	-
Uranium	<0.001	<0.001	<0.001	<0.001	<0.001	-
Vanadium	0.075	0.08	0.081	0.091	0.077	-
Zinc	0.0315	0.0322	0.0324	0.0298	0.0311	1.0





Compared to other survey points, the surface water quality in Lu Island has the lowest pollution level. All survey points have DO within the allowable limit specified in Vietnam Standard on coastal water and surface water quality. The mean of DO in Lu Island is 6.53 mg/l, which is quite higher than the allowable limit of 5.0 mg/l.

BOD and COD in Lu Island are the lowest compared to other survey points in Vop Creek, Tra Creek and Ngan Island. Most of survey points have BOD, which are lower than that in Vietnam Standard on surface water quality. The mean COD in Lu Island is 5.14 mg/l satisfying the Vietnam Standard on surface water quality. However, compared to the Vietnam Standard on the coastal water quality (COD <3 mg/l) all survey points COD exceed the allowable limit. Total nitrogen and total phosphorus in Lu Island are low. Hence, there is no sign of nitrogen and phosphorus pollution.

Similar to other survey points, T-Coliform in Lu Island are lower than that in Vietnam Standard on surface water; however when compared to Vietnam Standard on coastal water quality, L1 and L5 samples are higher than the allowable limit. The value of pH and heavy metal concentration of all samples recorded in Lu Island are within the Vietnam Standard on surface water and coastal water quality.

#### 4. CONCLUSIONS

The research results showed that BOD and COD in the surface water at Vop Creek, Tra Creek and Ngan Island in Xuan Thuy Ramsar site are higher than that in Vietnam Standards on surface water and coastal water quality. Some places are polluted by T-coliform due to aquaculture activities in the Ramsar site. All of other parameter, especially pH and heavy metals are in allowable limit of Vietnam Standards on surface water and coastal water quality. Hence, it is required to have management and monitoring activities in order to strictly control BOD and COD in the surface water quality in Xuan Thuy Ramsar site. This is important to ensure the maintaining of ecological characters of Ramsar site and the development of species in there.

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