

연구논문

## Evaluation of the Surface Water in Southwest Area of Vietnam

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### Abstract

This study surveys the surface water environment in Southwest sea areas of Vietnam in order to evaluate the current environment. It collects and analyzes experimental results of programs, scientific subjects, and international projects relevant to ecological areas and coastlines of Kien Giang province. The methods analyzed and discussed by specialists are evaluated according to pollution coefficients established by the World Health Organization (WHO), sampling methods, and case study analyses. Comparison between the scale of pollution levels and the surface water quality in experimental areas of Long Xuyen Quadrangle shows a light-moderate pollution level. In Ca Mau Peninsula, the surface water source is only slightly polluted. Sea areas and islands are also light-moderately polluted. Computing results from water quality indices (WQI) show the level of pollution in experimental sites. Activities such as constructing infrastructures for tourism, exploiting minerals, and increasing population accelerate environmental pollution by deteriorating inherently sensitive ecosystems like corals, sea grass, mangrove swamps, and Melaleuca forests. Surveying and evaluating the present situation of surface water are fundamental solutions for environmental protection in the Southwest sea areas of Vietnam.

**Keywords :** Surface water environment, Southwest sea areas of Vietnam

### I. Introduction

Biodiversity resource in Southwest sea areas of Vietnam is very diverse and abundant in natural ecosystems. This marine ecosystem is the most representing protection area because it includes

coral reefs and sea grass beds (Vo, 2005), Mullica forest U Minh Thuong, coastal mangroves, sea areas and Sea Islands, Natural Reserve Areas, and National Parks. In past years, the socio-economic development resulted in a declining trend of the environmental progress. Also, aquaculture

development considerably contaminated coastal sea water, increasing organic matters and submerged forest area damages were rather large. Shrimp breeding in mangrove areas severely influenced the management of sustainable planning and exploiting coastal resource sources. The soil environment was polluted due to the increased process of acidification at a large scale. In addition, rush development of dispersed and polluted processing areas and concentrated processing of aquaculture severely polluted the marine ecosystem because there was no sewage treatment system. Exploiting minerals was one of causes of reduced biodiversity resource in the province, especially in Nui Sot ecosystem of Hon Chong and developing tourism became also a critical factor of a gradual diminution of biodiversity (DARD and OBI, 2001).

The issues above greatly influenced the aquaculture resources and threatened natural resources around the coast of Southwest areas of Vietnam. Thus, surveying, studying, evaluating the current situation of ecological areas, and suggesting solutions are important managements of biodiversity resource. These will achieve the sustainable development of marine ecosystem in Southwest sea areas of Vietnam.

## II. Experimental Method

Research includes a variety of methods (DONRE, 2008).

### 1. Collection of related information

The results of research programs, scientific themes, and international projects related to ecological and coastal province of Kien Giang are based on monitoring data of surface water and

marine resources from an environment research center of Kien Giang. The data collection and processing procedures review and evaluate the water environment in coastal marine areas.

### 2. Analysis and consultation

This method is mainly based on the seminar held in Kien Giang. After we monitored, analyzed, synthesized, and drafted the reports, we opened the meeting for discussion. Then we applied the comments made by experts in order to implement more practical methods.

### 3. Rapid assessment methods

This method is based on the coefficient of pollution made by the WHO to estimate loads of pollutants from the socio-economic activities. It uses the tools of the monitoring resources and the environmental research center of Kien Giang province. The scene can be more quickly measured by instruments, recording the form outside the system than the targets. The results are then synthesized and revised.

### 4. Sampling and analyzing outside the field and laboratory

The layout method system points each typical for sampling region and four samples will be collected from each location. Samples taken and stored in the storage tanks are recorded with brief description and the day on sample taken, and will be preserved and analyzed in laboratory for a final integrated report.



Figure 1. View of Long Xuyen Quadrangle

### III. Experimental Results

#### 1. Surface water environment relevant to sea products

##### 1) Survey results from Long Xuyen Quadrangle

###### (1) Natural state of water

This is the area with acid sulfate soil; thus, surface water has pH values ranging from 3.46 to 7.78. Especially in the location of NM-11, pH value is 4.36. Surface water source influenced by brackish water from West Sea has high salinity values (see Fig. 2). EC and Cl<sup>-</sup> concentration are rather high in dry season and tend to be high around coastal areas (NM-09, NM-10, and NM-12). Suspended solids (SS) in the region are high, ranging from 25 to 260 mg/l. It exceeds TCVN (VN Standard) 5942-1995 (A) about 1.25 - 13 times (see Fig. 3). Although it is a large area of acid sulfate soils, an irrigation system develops its efficiency. The capability to drain out alum has been limited which is expressed via total Fe values. Mostly locations are in the permissible

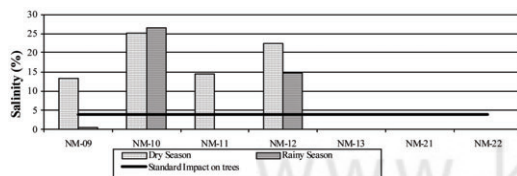


Figure 2. Percentage of Salinity in surface water

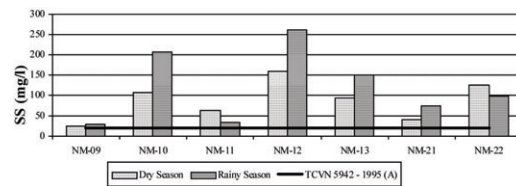


Figure 3. Concentration of SS in surface water

limits (0.03-1.61 mg/l). Only two locations (NM-09, NM-21) exceeded TCVN 5492-1995 (A) (Thai and Phung, 2009).

###### (2) Pollution with organic matter

The pollution of organic matter on surface water is evaluated by DO, BOD<sub>5</sub>, and COD. The DO concentration with 4.02-8.18 mg/l mostly does not reach the allowable standard and BOD<sub>5</sub> ranges from 3 to 6 mg/l reaching TCVN 5942-1995 (A). However, the concentration of COD in most of locations exceeds allowable standards, ranging from 4 to 38 mg/l (see Fig. 4). Only NM-11 and NM-13 are around TCVN 5942-1995 (A) (DONRE, 2008). Therefore, surface water in the region has an indication of being polluted by organic matter that is difficult to biologically

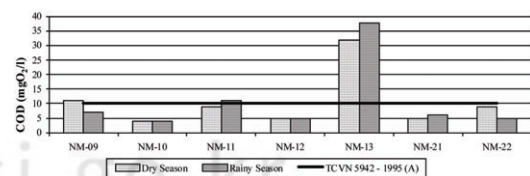


Figure 4. Concentration of COD in surface water

decompose.

### (3) Pollution with nutrients

The concentrations of nutrients in surface water of Long Xuyen Quadrangle are lower during rainy season than those of dry season because of self-purification of river and partly sediment. The concentration of ammonium ranges from 0.01 to 0.38 mg/l and most of it has higher value than TCVN 5942-1995 (A) (see Fig. 5). The concentration of nitrate ranges from 0.05 to 2.7 mg/l and the concentration of nitrite in water reflect the influence of sewage and production on surface water source in the region. Usually in river, it is difficult to detect the concentration of nitrite due to quick oxidation and aeration process (see Fig. 6). The presence of nitrite, which is an intermediate product of specification process, shows that surface water source in the region is lightly polluted. When comparing it with TCVN 5942-1995 (A), the concentration of nitrate reached the standard but the concentration of nitrite in most of sites exceeded the standard, especially during dry season (DONRE, 2008) (see Figure 3).

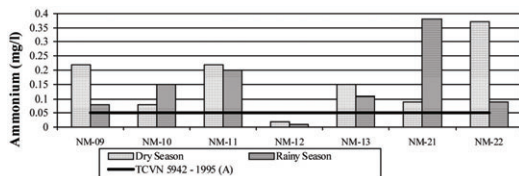


Figure 5. Concentration of Ammonium in surface water

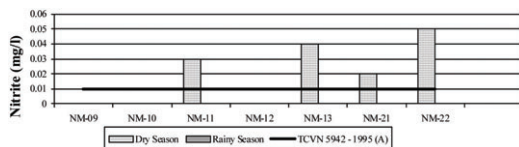


Figure 6. Concentration of Nitrite in surface water

### (4) Pollution of harmful chemicals

The concentration of lead (Pb) in water has

values from not detect (ND) to 0.02 mg/l and reaches TCVN 5942-1995 (A). Surface water of Long Xuyen Quadrangle has been polluted by oil with lubricants ranging from 0.01 to 0.2 mg/l; however, insecticides were not detected (DONRE, 2008). The only sites of not detecting the lubricants in surface water are two tourist locations, Mui Nai and Hon Phu Tu-Chua Hang (NM-10, NM-12) where there are no waterway activities.

### (5) Pollution of micro-organisms

The concentration of coliform ranges from 3 to 24,000 MPN/100ml and has a trend of getting higher values during rainy season (see Fig. 7). The concentration of total coliform in observing sites exceeds TCVN 5942-1995 except in NM-10 and NM-12 locations (DONRE, 2008). This shows that surface water in the region is influenced by sewage activity from populated areas.

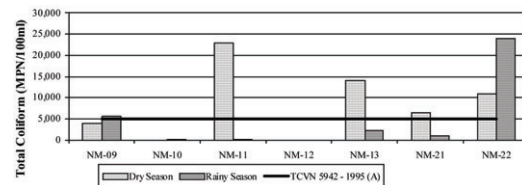


Figure 7. Concentration of Total Coliform in surface water

## 2) Surveying results from U Minh Thuong.

### (1) Natural properties of water

Surface water in this region has a light acidity with pH values of ranging from 6.43 to 6.83. The only two locations, NM-08 with acidity (pH 4.25) and NM-04 with alkalinity (pH 9.5), are exceptions. Due to the intrusion of tides, salinity, EC, and Cl<sup>-</sup> on surface water have higher values during dry season. Especially, the concentration of Cl<sup>-</sup> exhibits a clear difference between two seasons (see Fig. 8). The concentration of SS ranges from 5 to 62 mg/l. The concentration of total Fe in rainy season is higher than that in dry season

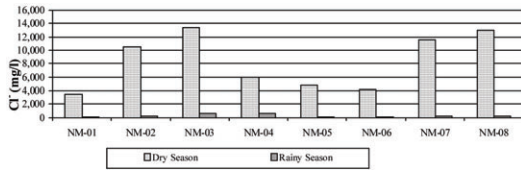


Figure 8. Concentration of Cl- in surface water

due to alum drainage; however in surface water of Ca Mau Peninsula, all reach allowable standards except NM-02 (see Fig 9). In location NM-02, its value of total Fe exceeds the standard, TCVN 5942-1995 with a value of 1.24 mg/l during rainy season. This shows that surface water is not polluted by alum (Thai and Phung, 2009).

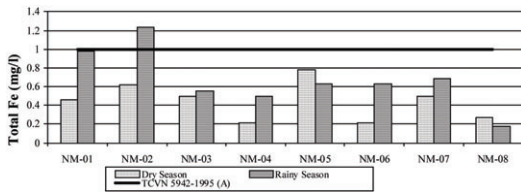


Figure 9. Concentration of Total Fe in surface water

(2) The Pollution of organic matter

The values of DO, BOD5 and COD are 2.59-9.62 mg/l, 3- 8 mg/l and 4- 23 mg/l, respectively, which mean they are only lightly polluted (DONRE, 2008) (see Fig. 10 and 11).

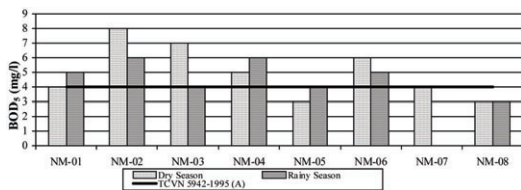


Figure 10. Concentration of BOD5 in surface water

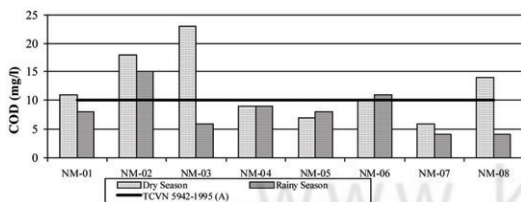


Figure 11. Concentration of COD in surface water

(3) The Pollution of nutrients

Surface water of Ca Mau Peninsula is polluted by nutrients with ammonium and nitrite and both exceed the standard with ammonium value = 0.06-2.4 mg/l and nitrite = 0-0.11 mg/l (see Fig. 12 and 13). The nitrate concentration in the region reached the standard TCVN 5942- 1995 (A) with value of 0.05-3.72 mg/l (DONRE, 2008).

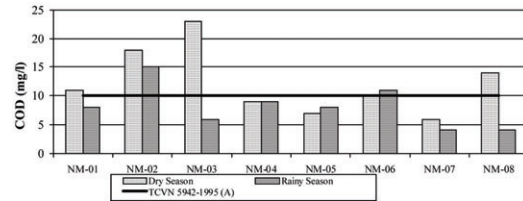


Figure 12. Concentration of Ammonium in surface water

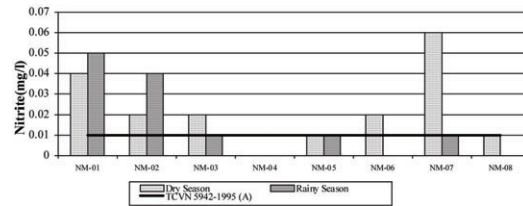


Figure 13. Concentration of Nitrite in surface water

(4) The Pollution of harmful chemicals

Most observed samples of surface water in the region do not detect the concentration of Pb; however, if Pb is detected, it should be a lower value than TCVN 5942-1995 (A) (DONRE, 2008). Although the regional surface water in U Minh Thuong was polluted by lubricants, the concentration of insecticides was not detected.

(5) The Pollution of micro-organisms

The values of total coliform range from 3 to 24,000,000 MPN/100ml (see Fig. 14). In dry season, the values of total coliform in most of observing locations exceed the allowable standard with water source which is used for running water. Only two locations, NM-01 and NM-02 reached the standard TCVN 5942- 1995 (A) (DONRE, 2008).

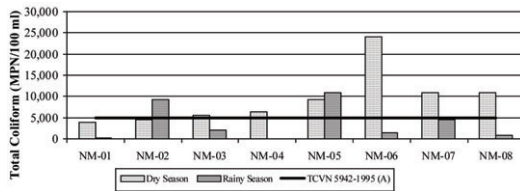


Figure 14. Concentration of Total Coliform in surface water

### 3) Territorial waters and Sea Islands

#### (1) Natural properties of water

Surface water in the region has neutral pH values ranging from 6.53 to 7.93. Due to the fact that this is coastal sea water, EC and Cl<sup>-</sup> concentration are rather high. The conductivity is  $32.1 \times 10^3$  -  $44.1 \times 10^3$   $\mu\text{s}/\text{cm}$  and salinity ranges from 19.8 to 28‰. The concentration of Cl<sup>-</sup> ranges from 11.280 to 16.410 mg/l. Most of the suspended solids (SS) reaches the standard TCVN 5943-1995 and ranges from 14 to 118 mg/l. The concentration of total Fe in the region ranges from 0.05 to 2.26 mg/l (see Fig. 15). Out of three observation locations, wharf of Hon Tre, only reaches the allowable standard; the two remaining locations exceed the standard TCVN 5943-1995 (Thai and Phung, 2009).

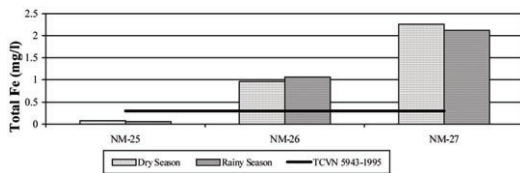
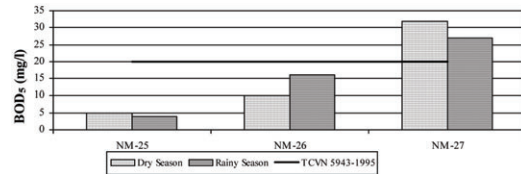


Figure 15. Concentration of Total Fe in surface water

#### (2) The pollution of organic matter

Surface water source in territorial waters and Sea Islands is not indicative of the organic pollution matter which is expressed in DO and BOD<sub>5</sub>, and reaches the standard TCVN 5943-1995 (see Fig. 16). In 3 observing sites, only the concentration of BOD<sub>5</sub> at NM-27 (the bridge in Nguyen Trung Truc district of the Phu Quoc Island)

Figure 16. Concentration of BOD<sub>5</sub> in surface water

exceeds the standard because the place receives sewage from fish sauce production units along with two river sides (DONRE, 2008). Duong Dong and mostly these production units have no sewage treatment system.

#### (3) The pollution of nutrients

Similar to the concentration of organic matter, surface water source in the region is polluted by nutrients at NM-27 with the ammonium value equal to 1.29 mg/l in rainy season and 1.42 mg/l in dry season (DONRE, 2008).

#### (4) The pollution of harmful chemicals

Surface water source in territorial waters and Sea Islands of Southwest areas of Vietnam has not been polluted by Pb and residual insecticides. However, lubricants particularly contaminate the Phu Quoc Island. Observational results of the concentration of lubricants from NM-26 and NM-27 exceed the standard TCVN 5943-1995 due to the fact that it is the sea wharf of An Thoi and the concentrated place of fishing ships (DONRE, 2008).

#### (5) The pollution of micro-organisms

In NM-26 and NM-27, the values of total coliform exceed the standard TCVN 5943-1995 (see Fig 17). It shows that surface water in these regions is polluted by micro-organisms. However, the value of coliform at NM-25 reaches the allowable standard (DONRE, 2008).

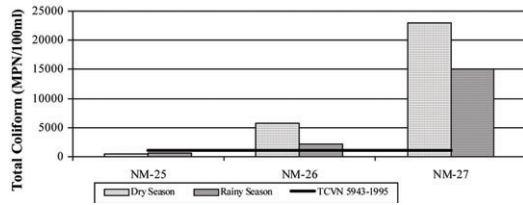


Figure 17. Concentration of Total Coliform in surface water

## 2. Observations of Surface Water Environment

The surface water quality Southwest areas of Vietnam is evaluated via water quality indices (WQI). Due to characteristics of surface water source in the provincial territories, selected parameters to evaluate the current situation of water environment are BOD<sub>5</sub>, COD, DO, Fe, SS, and total coliform (see Figure 7).

$$WQI = \frac{\frac{C_{BOD5}}{TCVN} + \frac{C_{COD}}{TCVN} + \frac{TCVN}{DO} + \frac{C_{Fe}}{TCVN} + \frac{C_{SS}}{TCVN} + \frac{C_{Coliform}}{TCVN}}{6}$$

Water quality indices calculated according to the formula be low (Thai and Phung, 2009).

Table 1. Pollution levels of surface water source Southwest areas of Vietnam

WQI indices	Pollution level
< 1.0	Not polluted
[1.0 - 2.5)	Lightly polluted
[2.5 - 5.0)	Moderately polluted
≥ 5.0	Heavily polluted



Comparing pollution scale with surface water environment of experimental sites shows that Long Xuyen Quadrangle and the territorial waters and sea-islands have a light-moderate polluted level, and Ca Mau Peninsula has a lightly polluted level.

From results of surface water indices, it indicates a light-moderate pollution level in Southwest areas of Vietnam. The natural properties of surface waters of Southwest areas of Vietnam are heavily acidified and salted. The surface water source is polluted mainly by organic matter, nutrients, and total coliform and is not polluted by harmful chemicals such as Pb, insecticides. Also due to strong development of waterway traffic and operations of fishing ships in the region, surface water source was severely polluted by lubricants.

## IV. Conclusion

The real situations of surface water in territorial waters and coastlines in Southwest of Kien Giang and Ca Mau province are evaluated. Long Xuyen Quadrangle is polluted at a light-moderate level. Surface water source in the region of Ca Mau Peninsula is only lightly polluted. Territorial waters and Sea Island are also light-



Figure 18. The current situation of surface water environment of Southwest areas of Vietnam

moderately polluted.

Activities such as exploitation, catching sea products not as regulated made the resources in territorial waters scarcer. Cultivation and processing sea products, which are not planned to protect and to treat the wastewater, would increase pollutants and change the living environment of fauna and flora.

Developing eco-tourism increases infrastructure construction to serve tourists; therefore, wastes should be collected and treated hygienically. Urban areas, populated areas, production and trading bases, processing sea products, exploiting minerals, tourism, and health establishments, all must have regulated environmental treatment system. We should plan restricted zones for mineral exploiting areas, and regulations for observing Law to protect the environment. Also, we need to protect territorial waters and marine protection areas in biosphere reserve areas and develop coral reefs and sea grass beds in direction of culturing artificial reefs and planting sea grass beds with leading priority.

\* This is the revision of the paper from Vietnamese and Korean Experiences in Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) which was published in the Vietnam-Korea Workshop on August 21, 2009.

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