

Surface Water Quality in Tien and Hau Rivers in an Giang Province For The Period Of 2009 – 2016

Nguyen Thanh Giao

Department of Environmental Management, College of Environment and Natural Resource,
Can Tho University, Vietnam

Abstract: *The study was conducted by collecting water quality data for the 8-year period from 2009 to 2016 from the Department of Natural Resources and Environment, An Giang province to evaluate the surface water quality in Tien and Hau rivers' segments belonging to An Giang province. The results showed that surface water of Tien and Hau Rivers were organically polluted and microbial contamination. The water quality parameters including biological oxygen demand (BOD), total suspended solids (TSS) and total coliforms were much higher than the National Technical Standards for Surface Water Quality (QCVN 08-MT:2015/BTNMT). The surface water pollution at evaluating sites has been existed for over eight years. The causes of water pollution could be from wastes generated during agricultural, industrial and service activities that have not been thoroughly treated. The results of surface water quality assessment on Tien and Hau Rivers suggested that the current management practices from the governments of upstream and downstream on water quality are not really effective. The appropriate measures are needed to manage surface water quality based on suitable local and international environmental management tools since these rivers are extremely important water sources for people who their lives heavily relying on water quality of the Mekong river.*

Keywords: *surface water quality, organic pollution, coliforms, Mekong river, An Giang province*

1. Introduction

The Mekong delta is the important areas for developing agricultural production, with agricultural outputs accounting for more than 50% of the whole country's production. According to the National Environment Report (2012), the Mekong Delta has 61 industrial zones in 13 provinces. Majority of the industrial zones and clusters of industrial activated are located along Tien and Hau rivers since these rivers support cheap and convenient transportation and supply free surface water sources. Due to naturally favorable conditions, the Mekong Delta has also strongly developed in aquaculture. Several studies have reported that aquacultural activities could release significant amounts of wastewater

containing nitrogen and phosphorus, suspended solids, microorganisms, and even antibiotics (Nga and Nghiep, 2009; Nguyen et al., 2014; Be et al., 2017) into the receiving waters. Disposal of untreated or improperly treated wastes is one of the causes of water pollution in waterways. An Giang province is one of the four key economic regions of the Mekong Delta, with a high economic growth rate of 5.29% in 2017. The development of An Giang province over the last years has been heavily relying on the agricultural, aquacultural, industrial, and tourism activities. Therefore, An Giang province has set up stations for monitoring of quality of water along Tien and Hau rivers to record variations of water quality along with socio-economic development to track, to respond and to prevent degradation of surface water quality which could affect human health as well as retard the development of the area. Five-year report of water quality in the province has been issued to the public, however, a report on assessment of the water quality in the Tien and Hau rivers for a longer period of time, for example from 2009 to 2016) has not been yet published. This study aimed at evaluating progress of surface water quality on Tien and Hau rivers over the period of eight years to provide more useful information on water quality management and protection and to suggest strategies for managing water environment in Delta rivers.

2. Research methodology

Water quality parameters and data analysis

The data on water quality parameters including temperature, pH, total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), ammonium nitrogen ($\text{NH}_4^+\text{-N}$), Nitrate ($\text{NO}_3^- \text{- N}$) and total coliforms were collected from the Department of Natural Resources and Environment of An Giang province for the period 2009-2016. The data were yearly collected in March, June and September. The processed data were presented in terms of mean \pm standard deviation. The statistically significant differences of the collected data between the sampling sites and between the rivers were determined using one-way Analysis of Variance (ANOVA) and the significant levels were determined using Duncan's test at $\alpha = 5\%$. The statistical analysis

was performed using IBM SPSS statistics for Windows, version 19.0 (IBM Corp., Armonk, NY, USA).



Figure 1. Location of data collection for water quality assessment on Tien and Hau rivers. Data collection included 5 points on Tien river (MT2 to MT6) and 5 points on Hau river (MH2 to MH6).

3. Results and discussion

3.1 Progress of surface water quality in Tien and Hau Rivers in 2009-2016

Temperature, pH, and total suspended solids

The average temperature in the Tien and Hau rivers was not significantly different. Temperature ranged from 29.7 ± 1.1 °C to 30.9 ± 0.4 °C in Tien River and 28.7 ± 0.7 °C to 31.0 ± 0.4 °C in Hau River. The mean temperatures in the Tien and Hau rivers in

2009, 2010 and 2015 were significantly different ($p < 0.05$) (Figure 2). In the period 2009 - 2016, seasonal variation of temperature in the rivers was significantly different.

However, temperature is generally suitable with the technical national regulation on surface water quality QCVN 08-MT: 2015/BTNMT.

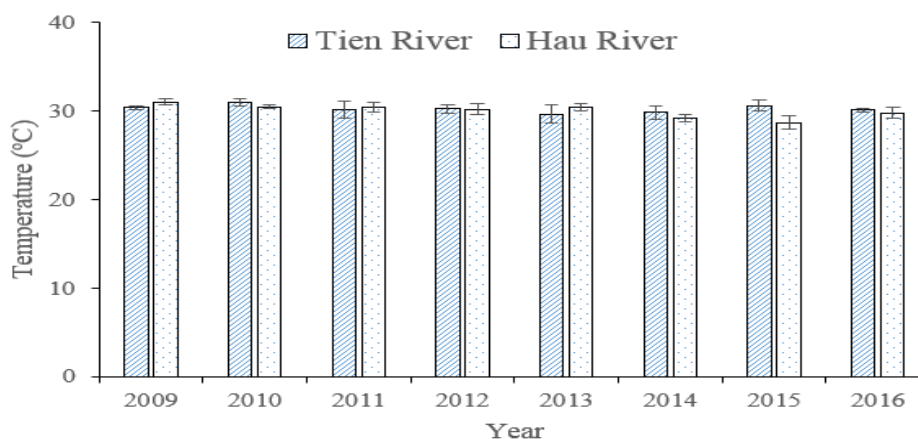


Figure 2. Temperature in Tien and Hau rivers from 2009-2016

pH in Tien and Hau rivers was in the neutral range. pH in the years of 2011, 2013 and 2014 were significantly different ($p < 0.05$) compared to the other years (Figure 3), pH at all

observed sites remained within the permissible level ($pH = 6 - 8.5$) regulated in QCVN 08-MT: 2015/BTNMT which is suitable for human use and living of aquatic lives.

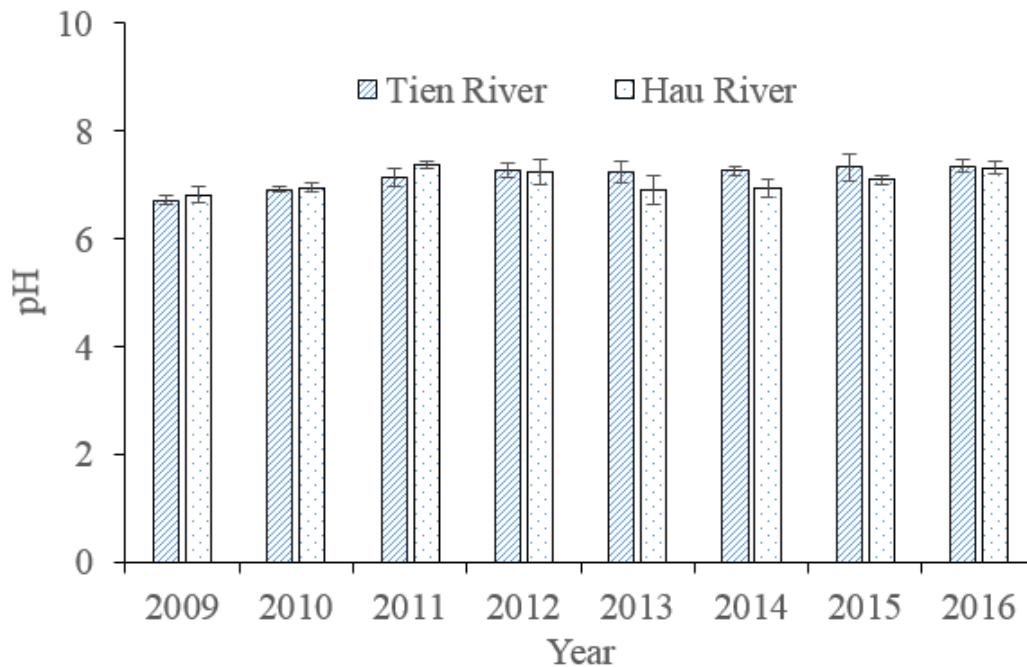


Figure 3. pH in Tien and Hau rivers from 2009-2016

The total suspended solids (TSS) on the two rivers exceeded the permitted level of 20 mg/L (Figure 4). In 2009, 2010, 2011 and 2013, concentrations of TSS in Tien and Hau were significantly different ($p < 0.05$) compared to the other years and the concentrations of TSS in Tien river were higher than those in Hau river. The results also showed that TSS

in Tien and Hau rivers in rainy season (80.2 ± 8.8 mg/l - 199.6 ± 39.9 mg/l and 60.8 ± 29.5 mg/l - 148.4 ± 26.7 mg/l, respectively) were significant higher than those in dry season (16.8 ± 6.4 - 67 ± 50.1 mg/l, 7.6 ± 2.7 mg/l - 53.4 ± 9.7 mg/l, respectively).

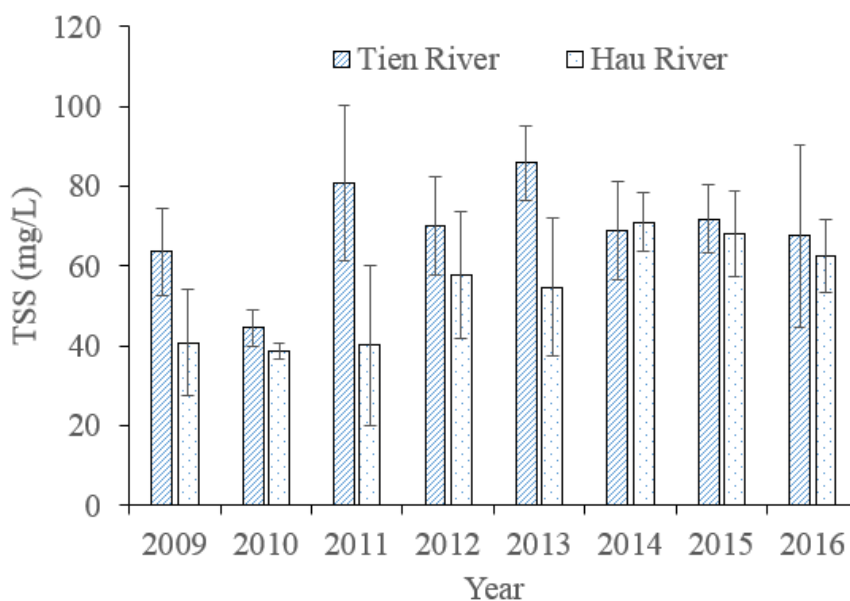


Figure 4. Total suspended solids in Tien and Hau rivers from 2009-2016

Dissolved oxygen and biological oxygen demand

Concentrations of dissolved oxygen (DO) in Tien and Hau rivers in 2009, 2012, 2013 and 2016 were significant differences ($p < 0.05$) and DO in Tien river tended to be higher than those in Hau river.

On these rivers, the areas of the surfaces are wide so the turbulence is good due to influence of wind and transportation means leading to good diffusion of oxygen into the rivers. Thus, low DO concentrations in these rivers may be because of presence of organic matters from human and other activities.

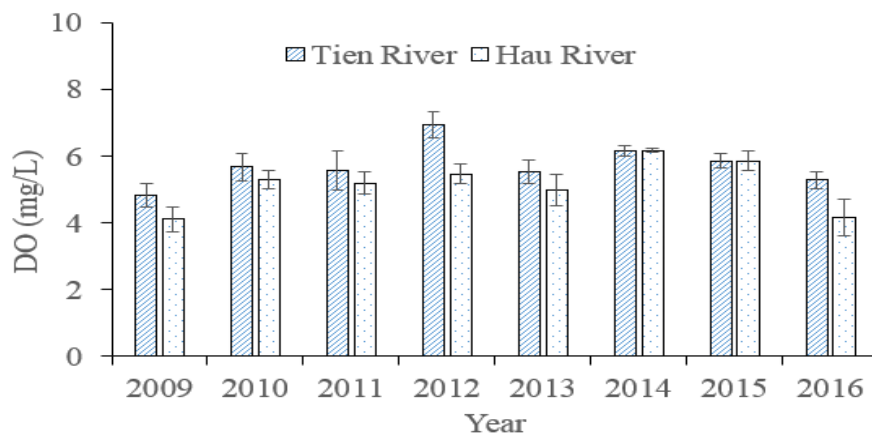


Figure 5. DO in Tien and Hau rivers from 2009-2016

As shown in Figure 5, some of the DO values were within the acceptable ranges (5-6 mg/L) as regulated by Vietnamese standards for surface water quality. Seasonal variations of DO were found in Tien and Hau rivers during the period of 2009-2016.

The concentrations of BOD in Tien and Hau rivers during the wet season (9.0 ± 0.6 mg/l, 9.3 ± 1.1 mg/l, respectively) was higher than that in the dry season (5.9 ± 0.5 mg/l, 8.1 ± 0.5 mg/L, respectively). BOD in Tien and Hau rivers exceeded the permitted level of 4 mg/l. This result was consistent with DO values that BOD concentrations are inversely proportional to the concentrations of DO. It was clearly showed

that Tien and Hau rivers has been contaminated with organic matters. It was observed that organic pollution on the two rivers tended to increase from 2009 to 2016 (Figure 6) indicating increase of pollution loads. The concentrations of BOD in Tien and Hau rivers were significantly different ($p < 0.05$) in 2009, 2011 and 2014. The concentration of BOD in Hau river tended to be higher than that in Tien river. This result reinforced the correctness of the DO data in Hau river which were generally lower than those in Tien river. In other words, Hau river was more organically polluted than Tien river.

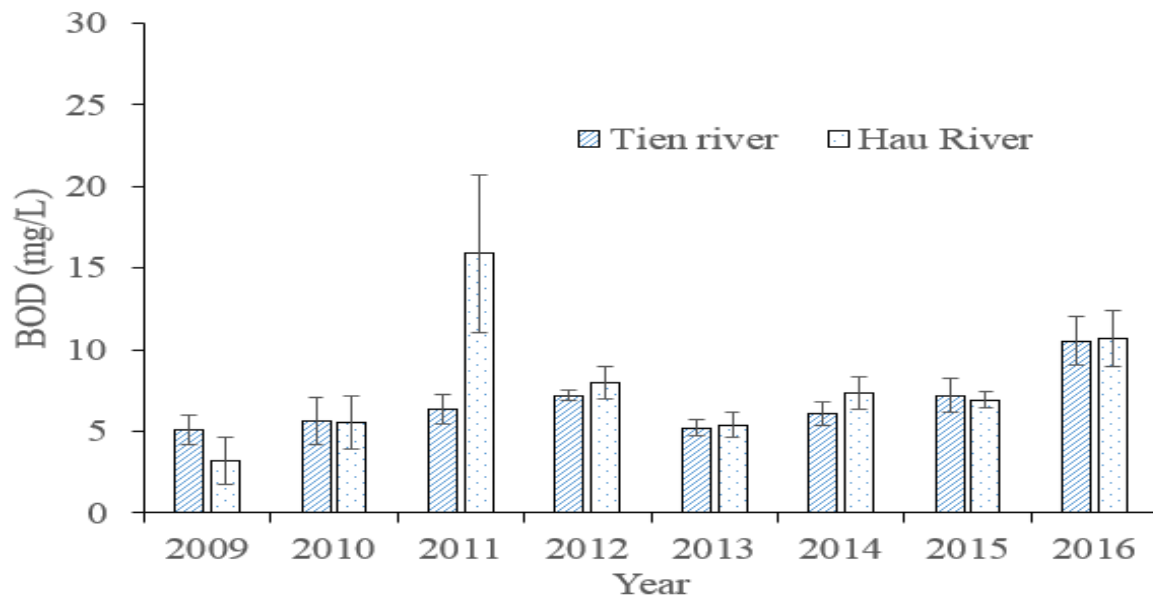


Figure 6. BOD in Tien and Hau rivers from 2009-2016

Nitrate and phosphate

Nitrate concentrations in Tien and Hau rivers were low and highly fluctuated (Figure 7). Generally, the results showed that the nitrate concentrations in Tien and Hau rivers

decreased from 2009 to 2016 and were within the allowable limits (2 mg/L NO_3^- -N) when comparing with national technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT).

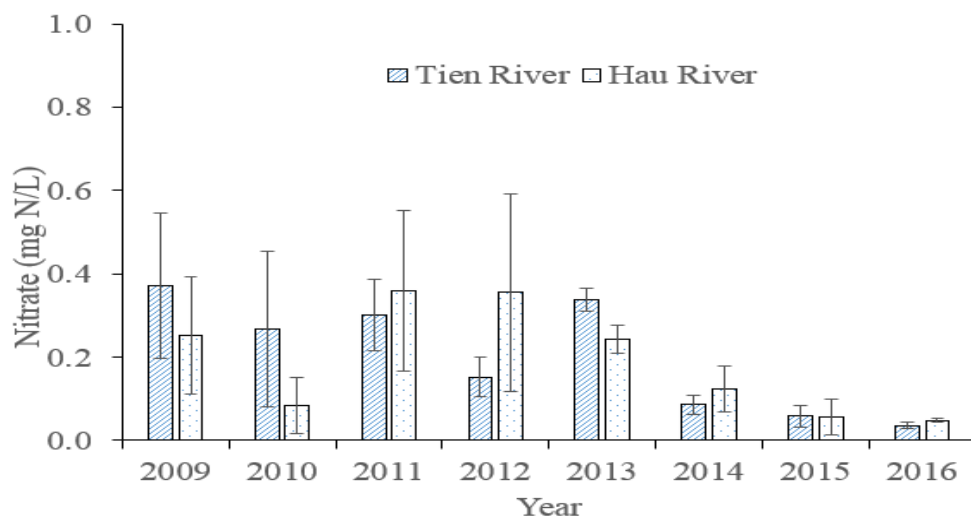


Figure 7. Nitrate in Tien and Hau rivers from 2009-2016

In Tien River, concentrations of ortho-phosphate was low and highly varied. This concentration would not pose a risk of nutrient pollution. Ortho-phosphate concentrations in Hau River were generally higher than those in Tien River. However, most of the ortho-phosphate concentrations were in the permissible level (0.2 mg PO_4^{3-} - P/L) as regulated in

national technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT) except in that of in Hau river in 2012 (Figure 8). As can be seen clearly that both nitrate and phosphate concentrations were low at all observed sites in the rivers and this would not likely to result in eutrophication.

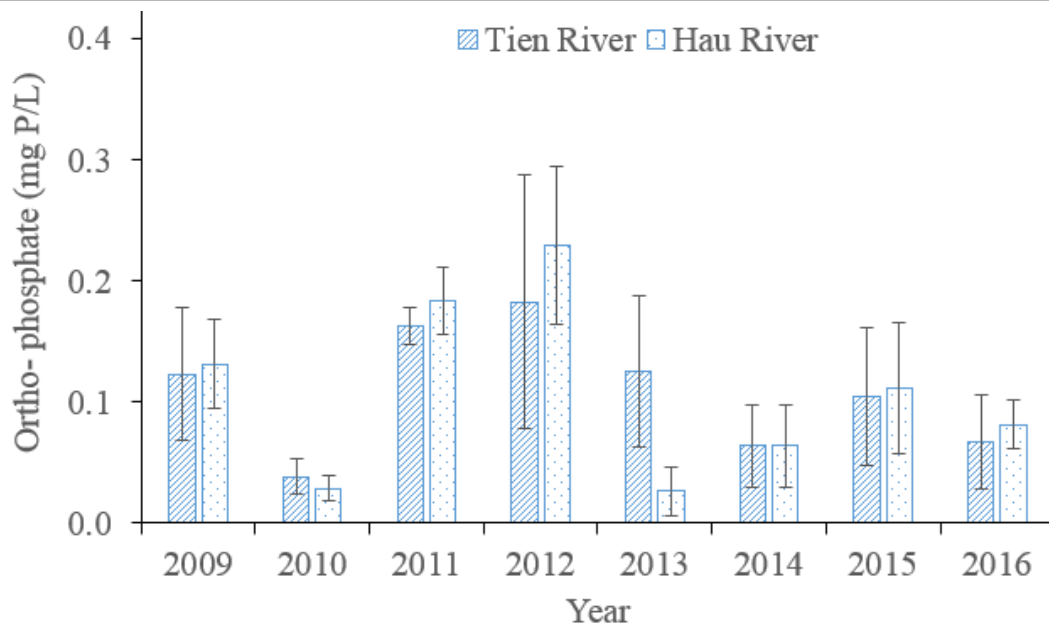


Figure 8. Phosphate in Tien and Hau rivers from 2009-2016

Coliforms

Total coliforms in Tien and Hau Rivers were higher than the permitted level of surface water quality standards (QCVN 08-MT: 2015/BTNMT), particularly total coliforms in Tien River exceeded the national standard (2500 MPN/100mL) by 92.1 times. Density of coliforms in Hau River exceeded the standard from 2.1 to 7.0 times over the period 2009-2016.

However, the mean values of coliforms in Tien and Hau rivers were not significantly different ($p > 0.05$) excepting for 2013. It could be concluded that the microbial pollution has long been existed in the rivers (Figure 9) and this could pose serious threats on water users. Measures should be taken to curb the pollution of microorganisms.

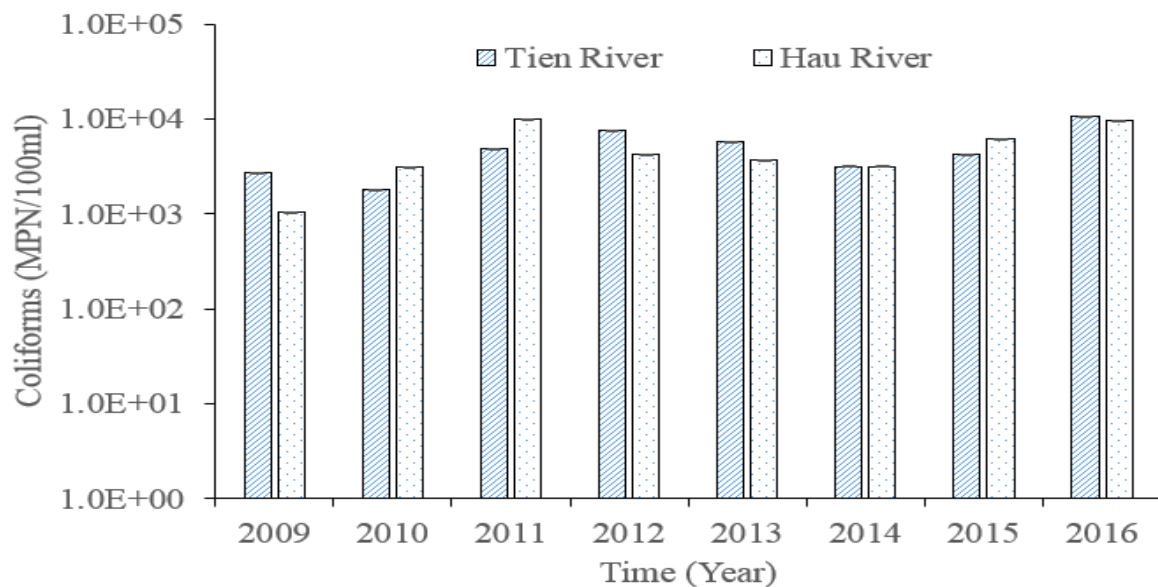


Figure 9. Coliforms in Tien and Hau rivers from 2009-2016

The water quality parameters including temperature, DO, pH, nitrate and phosphorus in Tien and Hau rivers were in the permissible limit. However, coliforms, TSS, and BOD exceeded National technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT) indicated that surface waters in these rivers were organically and microbially polluted. The reasons for the current pollution could

be because these rivers receive wastes from agricultural, aquacultural, industrial and commercial activities. The similar quality of water in the upper and lower parts of Tien and Hau rivers over An Giang province indicated that the problem of organic and microbial contamination is likely to be a common problem of surface water quality in the Mekong River.

3.2 Surface water quality management for Tien and Hau rivers

Tien and Hau rivers play pivotal roles in socio-economic development, especially in water supply for human consumption. Ensuring good water quality for different purposes of water use is a really challenging issue for the managers in environmental related sectors because the use of water of one sector could serious influence on the use of other sectors. The use of these waters as water sources for water supply, drinking, bathing, washing and other human use is particularly sensitive to water degradation. The strategy for water management should consider the following aspects:

For industrial sector: Careful consideration should be given to the highly polluted fields such as

production of chemicals, textile, dyeing, paper, batteries, etc. These types of factories must be placed in the well-designed industrial zones in which all wastes including solid, liquid and gas should be completely converted to non-harmful forms or meet the current environmental standards before they are permitted to release to the environments. The sustainable industrial zone model for the Mekong Delta based on recycling and recovery of wastes should be studied to minimize the introduction of wastes into the rivers.

For agricultural sector: Agriculture is the strength in the economy of the whole delta. This could mean that agricultural activities should be continuously

taking place in the region. Good agricultural practices are strongly recommended. Application of most recent scientific findings such as alternating wetting and drying, integrated pest management, using varieties that resistant to submergence, drought, and pests and diseases should be financed and enhanced. By-products in agriculture should be considered as sources of raw materials for ethanol and biogas production instead of indiscriminate dumping in the fields. Application of high technology in agriculture is a good strategy to increase profits in agricultural products and reduce scattered sources of environmental pollution resulting from agricultural activities. Greenhouse technology, agricultural films, disease-free and high yield and quality varieties, remote sensing technology to track origin of agricultural products are the technologies that have been currently applied in high-tech agriculture in Vietnam.

For the residential areas, urban centers, trade centers, and tourism: Attention should be paid to the locations, ecosystems and water sources. The operations of these areas should be linked to the excellent planning of environmental infrastructure to reduce environmental impacts.

The appropriate environmental planning should be made so that industrial, agricultural and service activities could take place without adversely damaging the environments. Government should also enact appropriate incentives for praising and rewarding for individuals, agencies, and organizations who are in excellent compliance with laws and regulations in environmental protection. Calculation of the capacity of Tien and Hau Rivers in assimilating the pollutants is urgently needed because this information could be effectively used to issue discharge permits for individuals, agencies, and organizations who discharged wastes into the receiving sources. Finally, the most important solution is to strictly enforce the laws, especially water resources and environmental laws.

Tien and Hau rivers are the lower parts of the Mekong river, therefore, international cooperation on water management of the Mekong river would significantly contribute to good management of water quality and quantity in Tien and Hau rivers.

Conclusion

Data analysis indicated that water quality in Tien and Hau rivers were organic pollution and microbial contamination. This pollution may pose serious

threats relating to water use for people along the rivers. It is necessary to enhance inventory of wastes, types and quantities of wastes associated with the study of wastes receiving capacity of the rivers as the basis for adjusting the discharge level taking into account for point sources and non-point sources. In addition, it is highly recommended to strengthen international cooperation on water conservation among Mekong countries, to share socio-economic activities hydropower operations and water quality from upstream nations to downstream countries to provide useful information for planning management to ensure water quality for sustainable socio-economic development.

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