

## Surveying causes of surface water pollution at Sao River, Binh Thuy district, Can Tho city, Vietnam

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### Abstract

Surface water sources play an important role in human and biological activities and the socio-economic development of the region. Therefore, the assessment of water quality and determination of the causes of water pollution in Sao river is essential for good management of the surface water environment. The study was conducted from July to December 2020. Water samples were collected at the time of low tide to evaluate the water quality indicators of temperature, pH, conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), total suspended solids (TSS), ammonium (N-NH<sub>4</sub><sup>+</sup>), orthophosphate (P-PO<sub>4</sub><sup>3-</sup>) and coliform. The source of pollution was determined by direct interviews with households living near Sao river. The results showed that surface water quality in Sao river had signs of organic pollution and microbiological pollution due to BOD, TSS, N-NH<sub>4</sub><sup>+</sup>, P-PO<sub>4</sub><sup>3-</sup>, coliform exceeded the allowable limits of National Technical regulation on surface water quality (QCVN 08-MT:2015/BTNMT, column A1). The results of the interview revealed that 70% of respondents said that water was seriously polluted and the main sources of pollution were domestic solid waste and domestic wastewater. Therefore, to improve surface water quality in Sao river, solid waste and wastewater management is urgently required. It is necessary to promote the monitoring and management of water quality with the participation of local authorities and communities.

**Keywords:** Surface water quality; Solid waste; Wastewater; Microbiological pollution; Sao river.

### 1. Introduction

Water is a valuable resource and plays a very important role in the life of humans and all living things on Earth. Currently, Can Tho city has a very fast economic growth rate, leading to a strong urbanization - industrialization, urban areas are increasingly formed and a concentrated residential place. In addition, the industrial activities, agriculture, services and the increasing demand for human goods have generated a large amount of domestic solid waste and domestic wastewater thus making the level of environmental pollution is getting worse in which water source is significantly affected. It can be seen that the consequences of water pollution are very serious. Firstly, it directly affects human health because when using contaminated water in daily activities, it will affect public health. Second, overcoming the consequences of water pollution is difficult and costly. Thirdly, water pollution directly threatens socio-economic development; existence and development of present and future generations. There have been many studies on quality of the surface water in the Mekong Delta. Surface water quality in Tien and Hau rivers in An Giang province for the period 2009-2016 was studied by Ly and Giao (2018) [1]. Thereby, it shows that the surface water has been polluted with organic matters and microorganisms. Water quality parameters including BOD, TSS and coliforms were much higher than the national technical standards for surface water quality (QCVN 08-MT: 2015/BTNMT) [2]. Water pollution can be caused by waste generated in agriculture, industry, service activities not being thoroughly treated, and water quality management from upstream and downstream governments is not very efficient. Appropriate measures are

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needed to manage surface water quality based on compliance with local environment and international management tools as these rivers are extremely important water resources for dependents on the water quality of the Mekong River.

In addition to sources of pollution such as domestic solid waste, industrial waste, wastewater from surrounding community activities, people's perceptions of water pollution were also reported by Tuan et al. (2019) [3] from the research conducted in Soc Trang and Bac Lieu provinces. The results showed that the river water resources in the Mekong Delta are being polluted. Pollution sources come from agricultural production from excessive use of fertilizers, pesticides, and pesticides, from domestic wastes and from industrial activities. With untreated wastewater, people in the study area are highly aware of this pollution problem. In social issues, education, poverty, and environmental pollution are the most concerned by the people. Almost all people believed that the river water where they live was of poor quality, was polluted and needed to be protected. Up to 62% of the people believed that everyone should be responsible for the use and protection of river water. The relatively high proportion of people willing to participate in river water protection programs suggested the possibility of socializing the protection of river water sources to avoid pollution. Previous studies only focused on water quality issues, few studies have focused on identifying sources of pollution. Therefore, to propose solutions to contribute to minimizing pollution of surface water sources in the study area, it is necessary to investigate the causes of surface water pollution in Sao River.

## 2. Material and methods

### 2.1. Water sampling and analysis

Water samples were collected in Sao River to analyze parameters including temperature, pH, conductivity (EC), dissolved oxygen (DO), biochemical oxygen demand (BOD), suspended solids (TSS), ammonium ( $\text{N-NH}_4^+$ ), orphosphosphate ( $\text{P-PO}_4^{3-}$ ) and coliform. The sampling locations are shown in Table 1. The parameters of temperature, pH, DO, EC were measured directly in the field while BOD, TSS,  $\text{N-NH}_4^+$ ,  $\text{P-PO}_4^{3-}$  and coliform parameters were analyzed at the Laboratory of Environmental Toxicity, College of Environment and Natural Resources, Can Tho University following standard methods [4]. Water quality indicators were presented in the form of average, then compared with national technical regulations on surface water quality QCVN 08-MT: 2015/ BTNMT, column A1 [2].

**Table 1** Description of sampling locations

No.	Code	Coordinate		Description
		Long	Lat	
1	D1	10.0588	105.7544	Markets, eateries, cafes and lots of solid waste on the river.
2	D2	10.0601	105.7513	Domestic wastewater discharge from the community, presence of solid wastes on the river
3	D3	10.0610	105.7462	Markets, river with lots of aquatic plants.

### 2.2. Surveying sources of water pollution

Information on the source of water pollution was collected through direct interviews with 30 households living along the Sao River. The interview questionnaire included questions about personal information of the respondents and 38 questions related to surface water quality, current water use, main sources of pollution, pollution levels, and potential impacts on people's health and solutions to minimize surface water pollution. Environmental management officers in the study area were also interviewed to collect information on how to solve future surface water problems through 15 questions, including 07 questions about personal information, 8 questions regarding the current state of surface water quality, main causes of pollution and local management.

### 3. Results and discussion

#### 3.1. Current status of surface water quality in Sao River

##### 3.1.1. Temperature

Temperatures at the three sampling locations were shown in Figure 1. There was not much difference in the temperature between the sampling locations, ranging from 27.3 °C to 28.7 °C. The lowest temperature at location D1 was 27.3 °C and the highest at position D3 was 28.7 °C and the average was 28 °C. The water temperature of the Hau River ranged from 27.1-32.0 [1; 5-6] and on the Mekong River was from 19.9-32.2 °C [7-8]. Temperature is closely related to the solubility of gases, especially oxygen, and higher temperatures lead to a decrease in dissolved oxygen in water [9]. According to Boyd (1998) [9], the suitable water temperature for fishes to grow from 25 - 32 °C. The temperature in the study area does not affect the aquatic life.

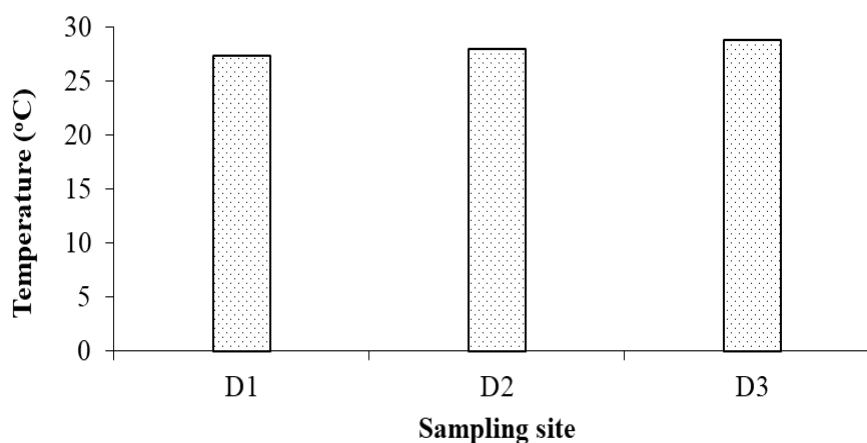


Figure 1 Temperature at Sao River

##### 3.1.2. pH

The pH values in water at the sampling sites were presented in Figure 2. pH in the study area ranged from 6.88 to 7.0. The lowest pH value was at D1 (6.88), highest at D3 (7.0) and average was 6.86. Previous study showed that pH in canals in An Giang 2006-2009 ranged from 6.9-7.1 [1], on main rivers and tributaries of Hau river in 2016 ranged from 6.3-8.0 [5] and Hau River, An Giang Hau Giang section, ranged from 6.7-7.12 [6]. In this study, pH was within the allowable value compared with the national technical regulations on surface water quality (QCVN 08-MT: 2015/BTNMT, column A1, pH = 6.0 - 8.5) [2].

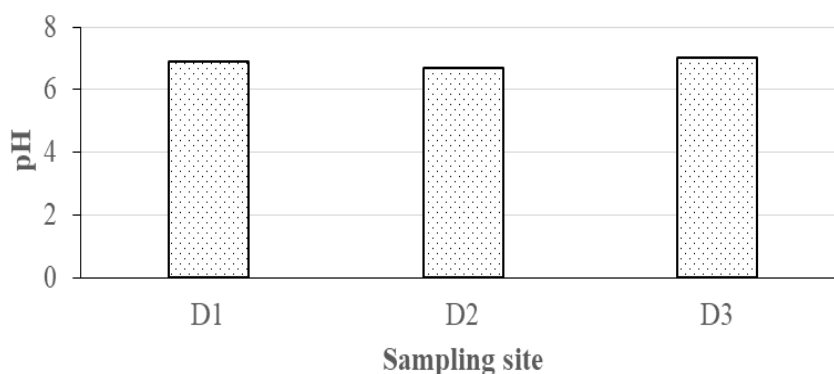
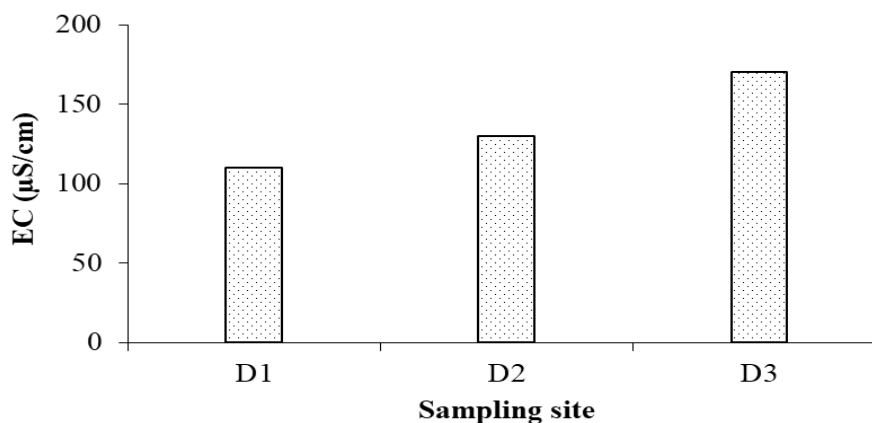


Figure 2 pH at Sao River

### 3.1.3. Electrical conductivity

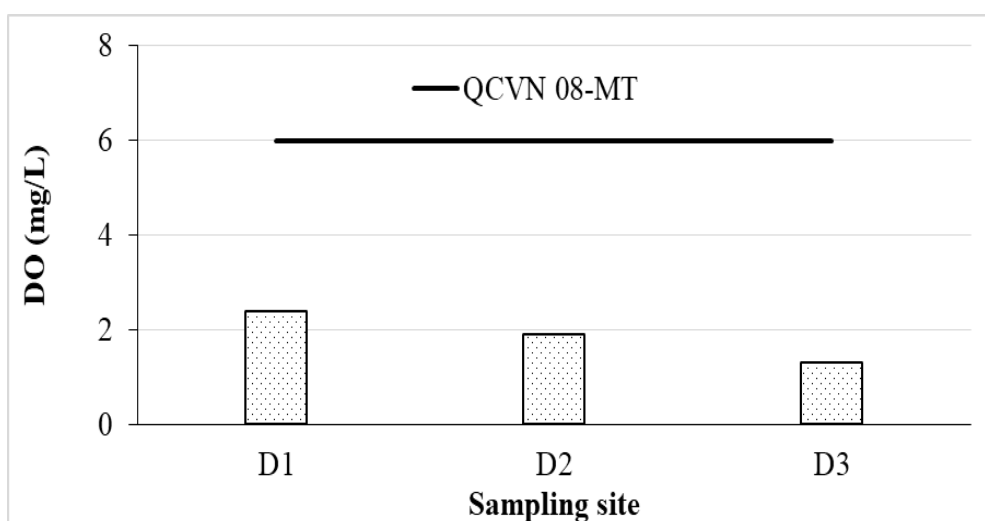
The results from Figure 3 showed that the electrical conductivity value increased gradually in the sampling location and ranged from 110  $\mu\text{S}/\text{cm}$  to 170  $\mu\text{S}/\text{cm}$ . Location D3 had the highest conductivity of 170  $\mu\text{S}/\text{cm}$ , which indicated that position D3 had the most dissolved ions among the positions. If the EC value in the water is too high, it can inhibit the uptake of nutrients to support the growth and development of aquatic organisms. Although there are no standards and regulations on the value of EC in Vietnam. However, according to MONRE (2012) [10] in freshwater, electrical conductivity for fish and large invertebrates is in the range 150-500  $\mu\text{S}/\text{cm}$ . Therefore, the EC value in the study area was relatively low and completely suitable for the development of aquatic animals.



**Figure 3** Electrical conductivity at Sao River

### 3.1.4. Dissolved oxygen

Figure 4 showed DO values at the sampling locations ranging from 1.3 to 2.4 mg/L, the lowest at D3 (1.3 mg/L), and the highest at D1 (2.4 mg/L) and the average was 1.87 mg/L. The reason for this difference was that at location D1, the connection point with the Tuc canal has a large water surface area, so the diffusion capacity of oxygen into the water was possibly high. On the other hand, there was disturbance in water at the sampling time (from D3 to D1). The average DO in the upstream waters of An Giang ranged from 4.0-5.2 mg/L [1], and Hau River in 2016 was  $4.8 \pm 1.1$ -  $5.5 \pm 0.7$  mg/L [5], Hau River in 2018 was  $5.29 \pm 0.33$ -  $5.56 \pm 0.56$  mg/L [6]. In canals in Soc Trang province, DO was lower than those in the other studies, ranging from 1.7-6.17 mg/L [3]. DO can be used as an indicator for the presence of organic contamination because microorganisms decompose organic matters in the presence of oxygen. Low oxygen in the water body can lead to the loss of the biodiversity of the water body.



**Figure 4** DO at Sao River

### 3.1.5. Total suspended solids

TSS in the study area was 30.9 mg/L (Table 2) exceeded the permissible limit of column A1 (20 mg/L) of QCVN 08-MT: 2015/BTNMT [2]. In the main rivers and tributaries of the Hau River, TSS ranged from  $41.2 \pm 33.7$  to  $89.57 \pm 31.31$  mg/L [5], in the canals of An Giang province in the period 2009-2016 TSS ranged from  $25.0 \pm 11.5$  mg/L to  $93.7 \pm 28.3$  mg/L [1]; Particularly for Hau river in the period 2009-2016, TSS was 40.1-68.0 mg/L [1] and TSS in Hau river in 2018 was  $41.16 \pm 35.81$ -  $48.67 \pm 9.07$  mg/L [6]. In canals in Soc Trang province, TSS was 16-176 mg/L [3]. The high TSS at the study site may be due to the presence of phytoplankton, and the disturbance of the bottom sediment due to the impact of water flow. High TSS causes serious deterioration of surface water quality, causing high cost for the treatment process.

**Table 2** Water quality parameters at Sao River

Parameter	Unit	Values	QCVN 08-MT:2015/BTNMT, A1
TSS	mg/L	30.9	20
BOD	mg/L	7.5	4
N-NH <sub>4</sub> <sup>+</sup>	mg/L	1.7	0.3
P-PO <sub>4</sub> <sup>3-</sup>	mg/L	0.81	0.1
Coliform	CFU/100 mL	4,200	2,500

### 3.1.6. Biological oxygen demand

BOD in the study area is 7.5 mg/L, which has exceeded the permitted limit of QCVN 08-MT: 2015/BTNMT, column A1 (Table 2), proving that the water environment was polluted with organic matters. BOD in rivers and canals including inland canals and Hau river of An Giang province were in the range of  $6.6 \pm 1.2$ -  $8.2 \pm 2.5$  mg/L [1], canals in Soc Trang province were in the range of 2.2-22.4 mg/L [3] almost surpassed QCVN 08-MT: 2015/BTNMT, column A1 [2]. Field survey results showed that the source of organic pollution was caused by people's waste indiscriminately thrown into the canals, accumulating over time and hindering the flow of the flow. In addition, the high BOD may be caused by the static flow and concentration of plant residues at the sampling sites which were under decomposition period and poor water exchange capacity due to aquatic plants. Furthermore, high BOD can also reduce DO, harm aquatic organisms and ecosystems.

### 3.1.7. Ammonium and orthophosphate

Ammonium was detected at a concentration of 1.7 mg/L, higher than the permitted limit of QCVN 08-MT: 2015/BTNMT, column A1 (Table 2) [2]. N-NH<sub>4</sub><sup>+</sup> in water at high concentrations would cause toxicity to fish and organisms [11]. Through practical observation showed that water in the canal was in a state of pollution due to the effects of waste accumulated on the canal for a long time. The high concentration of ammonium made aquatic plants like water hyacinth grow very strongly in Sao River, hindering the water transportation and water exchange. In addition, high concentration of N-NH<sub>4</sub><sup>+</sup> would affect water quality, self-cleaning ability of water sources.

The concentration of P-PO<sub>4</sub><sup>3-</sup> in the study area was 0.81 mg/L, exceeded the limit of QCVN 08-MT: 2015/BTNMT, column A1 (Table 2) [2]. The high concentration of P-PO<sub>4</sub><sup>3-</sup> may be due to the influence of waste from residential communities. The simultaneous presence of ammonium and dissolved phosphorus can lead to eutrophication. N-NH<sub>4</sub><sup>+</sup> concentration greater than 500 µg/L and dissolved phosphorus greater than 20 µg/L could cause eutrophication [10]. Thus, the concentration of nitrogen and phosphorus in Sao River can lead to occur eutrophication and is no longer suitable for the development of aquatic plants and animals. The concentration of P-PO<sub>4</sub><sup>3-</sup> in the water was high, causing the appearance of aquatic plants (for examples algae and water hyacinth), increasing suspended solids (TSS), organic matters [10]. Dissolved phosphorus values on inland canals and Hau river in An Giang province ranged from 0.02 to 0.47 mg/L [1], on Hau river An Giang-Hau Giang section 0.04-0.11 mg/L [6], canals of Soc Trang province 0.05-0.9 mg/L [3] showing that P-PO<sub>4</sub><sup>3-</sup> in surface water environment in the Mekong Delta has exceeded QCVN 08-MT : 2015/BTNMT, column A1 [2].

### 3.1.8. Coliform

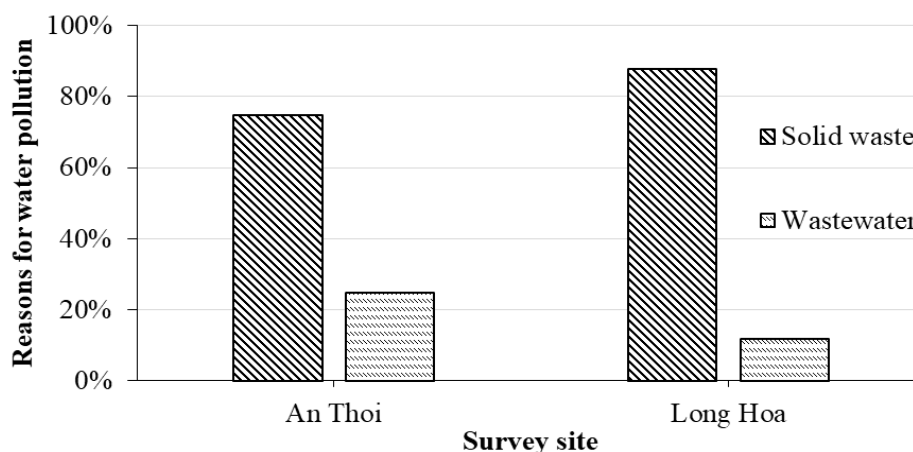
The coliform density at the sampling points was 4200 CFU/100mL, exceeding the permitted limit of QCVN 08-MT: 2015/BTNMT, column A1 [2] (2500 CFU/100mL) 1.68 times. This showed that the surface water had signs of organic matter pollution. Field survey showed that people's domestic waste was discharged directly to the river. Former study

by Ly and Giao (2018) [1] showed that coliforms in surface water of An Giang province in the period 2009-2016 exceeded the permitted limit by 2.14-7.02 times. In canals in Soc Trang province, coliforms exceeded 1 to 36 times [3]. Coliform is a common problem of many water bodies in the Mekong Delta.

### 3.2. Sources of water pollution in Sao river

The sources of water pollution was investigated and the results were presented in Figure 5. There were two main causes which were wastewater and domestic solid waste. There were 25% of people in An Thoi ward and 12% of people in Long Hoa ward supposed that the cause of pollution of surface water was from domestic wastewater because 46.67% of people live in An Thoi ward and 86.67% of people in Long Hoa ward discharged untreated wastewater into Sao River. Meanwhile, the majority of respondents in An Thoi ward (accounting for 75%) and Long Hoa ward (accounting for 88%) said that it was solid waste. The survey showed that there was a lot of waste floating in the river originated mainly from trading activities and from households.

The composition of solid wastes in An Thoi and Long Hoa wards was mainly compostable waste (including food scraps, vegetables, fruits ...) and persistent waste (including plastic, nylon bags, rubber...). The easily biodegradable solid waste in the appropriate time and at high temperature conditions would decompose and generate gases, especially  $H_2S$  and  $CH_4$ , causing odors that pollute the environment. In addition, the organic waste gathering place attracts and generates rats, flies, mosquitoes, cockroaches and other types of bacteria that infect health of humans and animals in the family. The study results also showed that 100% of households in An Thoi ward and 86.67% of households in Long Hoa ward directly disposed of easily-biodegradable waste into Sao river after use. Some households in Long Hoa ward use easily-biodegradable waste to make food for livestock (13.33%). Persistent components include plastic bottles, nylon wrap, straws, bottles, and plastic cups in which nylon bags are the majority. During the field visit, it was found that households doing business at Cau Ban market used a lot of nylon wrap. According to local people, nylon wrap is cheap, convenient and widely used. However, the decomposition time of nylon wrap is very long. There are 66.67% of households in two wards An Thoi and 93.33% households in Long Hoa ward to waste directly to Sao River after use. During the field survey at Sao River, there were many plastic wrap floating on the canal, which lost the beauty of the canal, hindered the flow and affected the decomposition speed. Therefore, at low tide, the amount of water in the canal was low and it often generates a bad smell. In addition, 33.33% of households in An Thoi ward and 6.67% of household in Long Hoa ward sell the wastes to the vendors.



**Figure 5** Reasons for surface water pollution at Sao River

Former study by Giaou et al. (2019) [12] also showed that domestic waste contributed 62% to the cause of surface water pollution. In addition, the research also showed that wastewater from production facilities and livestock activities also contributed to the cause of water pollution. The interview results revealed that 53.33% of people in An Thoi ward disposed of wastewater into the sewer system, but the sewer system is still incomplete. Therefore, the households still discharged wastewater directly to the canal accounting for 46.67% (An Thoi), and accounting for 86.67% (Long Hoa). The reason for the discharge was for the convenience and no cost. This indicated the awareness of the community on surface water quality protection is not good. Direct discharge of wastewater into Sao River increased the values of surface water quality indicators including TSS, coliform,  $N-NH_4^+$ ,  $P-PO_4^{3-}$  resulting in these indicators exceeded the allowable limits of QCVN 08-MT: 2015/BTNMT, column A1 [2]. Therefore, the water quality in Sao River could cause harm for human health and ecosystems.

Most of the people interviewed in Long Hoa ward said that the quality of surface water in Sao River was very seriously polluted (accounting for 80%), some people said that the water source was seriously polluted (accounting for 20%). There were 40% of households in An Thoi ward responded that the water pollution was serious and 60% said the water pollution was very serious. Some households living for a long time in Sao River said that the water source in Sao River has deteriorated over the past 5 years and this is manifested by sensory signs such as turbid water, occurrence of unpleasant odor, absence of fish and the amount of waste floating on the river. This could explain why all people living around the study area use tap water for daily use (accounting for 100%). The results of interviews with local management officials showed that the main cause of environmental pollution in surface water in Sao River were domestic solid waste and domestic wastewater, in accordance with local community's opinions. In fact, there are many other sources of pollution such as riverbank erosion, pollution source coming from elsewhere.

### 3.3. Surface water quality management at Sao River

There are 30/30 people (accounting for 100%) of the households of the two surveyed wards expressing that the management of surface water environment in the ward was not good, especially the law enforcement in the field of environmental protection. Many households still threw waste and discharged wastewater into the river in the study area. The survey results also showed that local authorities have not regularly propagated and mobilized people in environmental protection. To solve environmental problems, the study has conducted consultation with the people community' perspectives. The results showed that local people strongly suggested to sanction the polluters, propagate and educate to raise community's awareness of environmental protection, place more waste bins; regularly dredge the river and to smooth the water. At the same time, environmental taxes and fees should be applied to reduce waste generation and protect the environment. Community-based water quality management could be a good strategy for water management.

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## 4. Conclusion

The present study results showed that surface water in Sao River was polluted organically, nutritionally and microbiologically. The water parameters including BOD, TSS, N-NH<sub>4</sub><sup>+</sup>, P-PO<sub>4</sub><sup>3-</sup>, coliform did not meet the permitted standards of QCVN 08-MT: 2015/BTNMT, column (A1) - water used for the purpose of aquatic conservation. Specifically, BOD exceeded 1.88 times, TSS exceeded 1.5 times; N-NH<sub>4</sub><sup>+</sup>, P-PO<sub>4</sub><sup>3-</sup>, coliform were very high and DO was very low. The results of interviews with 30 households in the study area presented that their education level was quite low and their occupation was mostly trading, so this also affected their awareness of water quality protection. In addition, the interview results showed that the level of people's interest in understanding surface water quality was 73.3%. At the same time, up to 70% of respondents thought that the source of surface water quality in the river was seriously polluted and the management of the surface water environment in the study area was not good (accounting for 100%). However, the households commented that surface water quality in the river was polluted by two main reasons which were domestic wastewater and domestic solid waste. In which, the proportion of domestic wastewater was low (23.3%) and domestic solid waste accounted for a high proportion (76.7%). The local government of An Thoi ward has a future environmental management plan with economic and educational tools combined with the media. However, the most important factor in reducing pollution sources is the awareness of people living around, so the locality needs more solutions in managing surface water environment. To step up solid waste management, surface water quality monitoring and control must be done more frequently. Propagate and raise people's awareness of surface water quality protection, do not litter waste indiscriminately and throw it directly down Sao River.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

There is no conflict of interest to declare.

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