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Assessing the impact of flows into the Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province and some mitigation proposals

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ABSTRACT: The Kon River plays an important role in the basin, providing water and drainage for people's livelihood activities, being a waterway for boats to travel up and down, being an aquatic ecological environment favored by many aquatic species,... This study statistics and evaluates the impact of waste sources on the water quality of Kon River by water sample collecting and analyzing. Water samples from 11 sites in surface water layer of Kon River and 16 sites at wastewater sources were collected and analyzed parameters of water quality. The analyzed results show that at the beginning of the study river section - T1 site - Tay Giang village, the water quality was quite good, to meet the limit values of level A of QCVN 08:2023/BTNMT - good water quality. But from T2 site to downstream, the water quality of Kon River degrades gradually, at several study sites such as T3, T4 , water quality only meets the limit values of level B of QCVN 08:2023/BTNMT while at other study sites such as T5, T8, T9, T10, water quality meets the limit values of level D of QCVN 08:2023/BTNMT. This deterioration of water quality is due to receiving domestic, livestock, craft village,... wastewater from residential areas in the basin discharge to Dong Pho River, Dong Tre River, Ham Ho River, public sewers,... then discharged into the Kon River. This proves the deterioration of water quality in the studied river section due to the river section flow through a densely populated area with strong economic and social activities in livestock, production, services, ... without good management of wastewater discharge. Proposing solutions to protect and improve water quality of Kon River it is necessary to have a good managemental policy with each type of wastewater, especially livestock wastewater, domestic wastewater and noodle-making village wastewater.

Introduction

Kon River originates from the Annamit range in

Gia Lai and Quang Ngai provinces, has an altitude of 600 - 700 m, flows in the Northwest - Southeast direction to Thuong Giang, Binh Dinh province and then turns southwest to flow through An Nhon town, Tuy Phuoc, finally flows into the sea at Quy Nhon bay. The river is 171 km long, the river basin area is 3,102 km^2 with an average slope of about $0,2^o$. The coastal plain of the basin is relatively wide, mixed with sandy beaches along the river and coastal areas, from 2 to 20 m above sea level [1].

Carrying water from upstream to downstream and finally to the sea, the role of Kon River is to provide water and drainage for people's livelihood activities as well as agriculture, livestock farming, aquaculture rafts..., being a waterway for boats to travel up and down,... being an aquatic ecological environment favored by many aquatic species due to clear water environment flowing from the upstream,... Currently, the processes of exploiting and using water resources in the Kon River basin concentrated in the middle and lower reaches take place strongly in districts of Binh Dinh province including Vinh Thanh District, Tay Son District, An Lao District, An Nhon Town, Tuy Phuoc district, Van Canh district, Phu Cat district and Quy Nhon city [2]. The process of rapid urbanization and industrialization in this area in recent years has had a strong impact and put great pressure on the river system, especially the activities of 12 industrial clusters and vermicelli-making villages. - An Thai and My Thanh villages, Nhon Phuc commune, livestock activities, agricultural farming activities, ... have been operating at full capacity, causing the rising demand for clean water and the large amount of waste water. According to survey results, most wastewater from noodle-making villages, livestock wastewater and wastewater from residential areas, ... are not treated but discharged directly into canals connecting to the Kon River system causing the river more polluted by organic pollutants, plant protection chemicals, waste, ... These impacts lead to urgent problems in water resources management: the water environment is showing signs of degradation and pollution, natural aquatic ecosystems are gradually decreasing in number of species as well as number of individuals [3].

Protecting water quality and aquatic ecosystems, limiting pollution, degradation, and depletion of water resources is a regular, long-term and extremely urgent task. To protect the Kon River water source, it is necessary to evaluate and manage the effects of wastewater discharge into the river. This article "Assessing the impact of flows into the Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province some mitigation proposals " statistics and evaluates the impact of waste sources on water quality of Kon River, is a scientific basis providing information to help managers and policymakers in environmental management, protecting and planning.

Materials and methodology

Sample location, sampling time

The study river section is from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, 26km long. Figure 1 shows water sampling locations including sampling locations on the Kon River which are locations after receiving flows from rivers, streams, canals, ditches, and sewers with a flow of $5m^3$ per day or more from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province in rainy and dry seasons for 2 consecutive years 2021 and 2022. Besides, wastewater from main sewers of residential areas, wastewater from sewers of industrial activities, and wastewater from hospitals including 16 sampling locations (From X1 to X16) were also collected. Sampling point coordinates were determined by GPS global position device (Table 1). The water layer sampled on the river belongs to the surface water layer and at the discharge mouth of the discharge point.

Methods of collecting and analyzing water samples

Sampling procedures follow sampling standards in the "Guidelines for Sampling in Rivers and Streams - TCVN 6663 - 6: 2008" [4]. Samples were transported immediately to the Center for Technology and Experimental Analysis, Central Vietnam Division of Water Resource Planning and Investigation, stored at 4^0C, and conformed to TCVN 6663 - 1995. Samples were analyzed in the laboratory with the criteria and methods in Part 3 Determination method of QCVN 08:2023/BTNMT, refer to Determination method of APHA, AWWA, and WEF [5].

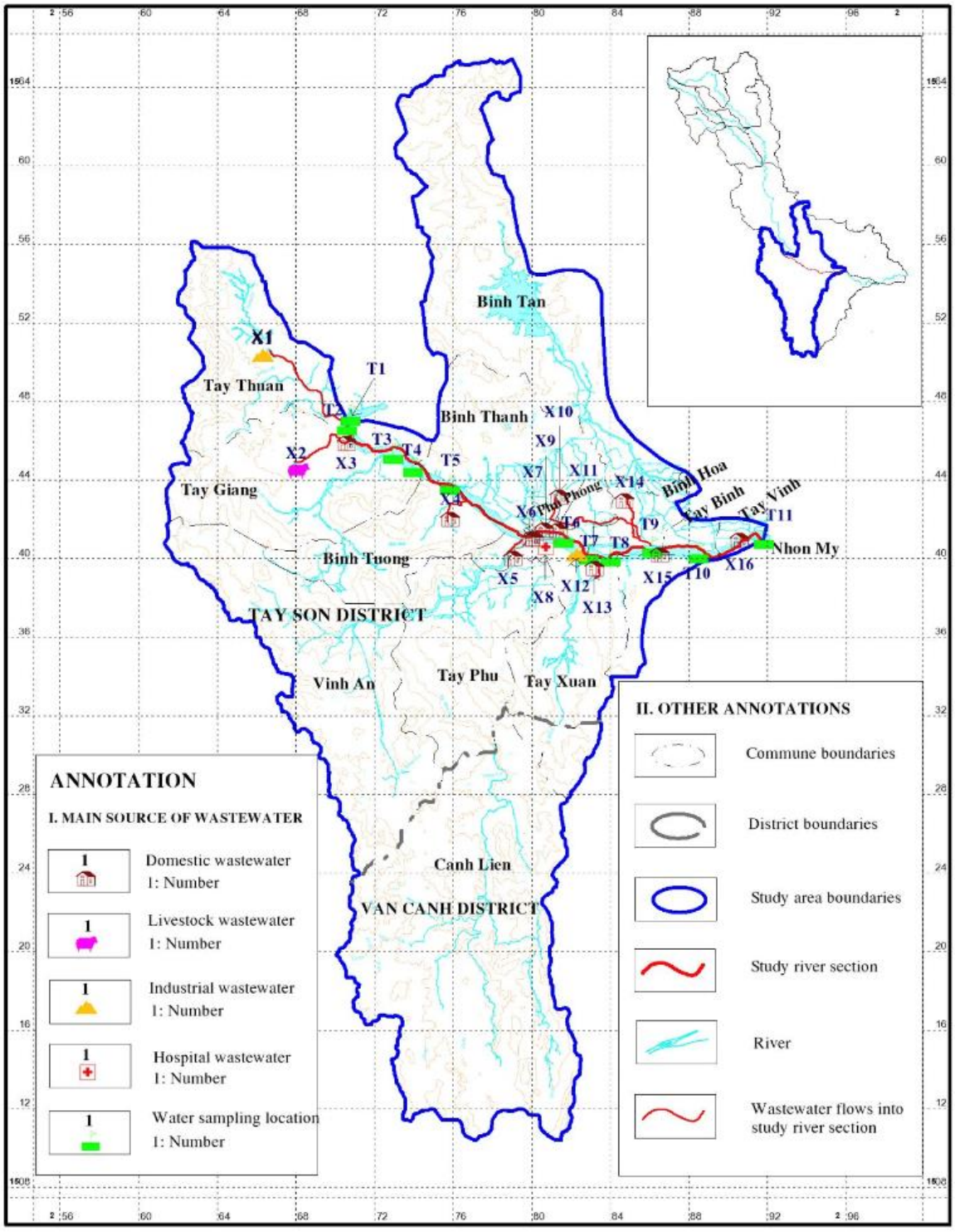

Figure 1. Water sampling locations

Table 1. Sampling site coordinates and sampling purposes

Water sampling sites	Sample signs	Coordinates		Sampling purpose
		Longtitude	Attitude	
Kon River, Tay Thuan commune, Tay Son district.	T1	154052'39"	26054'18"	Assessing the water quality of the Kon River at the beginning of the study river section.
Kon River, Tay Thuan commune, Tay Son district, after entering the Dong Pho River.	T2	$154^0$51'64"	$26^0$53'23"	Assessing the water quality of the Kon River after entering the Dong Pho River.
Kon River, Tay Thuan commune, Tay Son district, after entering the Dong Tre River.	T3	$154^0$33'25"	$26^0$68'59"	Assessing the water quality of the Kon River after entering the Dong Tre River.
Kon River, Tay Thuan commune, Tay Son district, after entering the Dong Pho River.	T4	$154^0$31'84"	$26^0$82'80"	Assessing the water quality of Van Phong lake on the Kon river after damming the river.
Van Phong Lake, Binh Tuong commune, Tay Son district.	T5	$154^0$19'82"	$27^0$06'19"	Assessing the water quality downstream of Van Phong Lake on the Kon river.
Kon River, Binh Thanh commune, Tay Son district, after receiving wastewater from residential areas and hospitals	T6	$153^0$91'28"	$27^0$68'35"	Assessing the water quality of Kon River after merging with Ham Ho River and receiving wastewater from residential areas 1, 2, Kien Long village, Thuan Nghia, Phu Phong Regional General Hospital.
Kon River, Phu Phong town, Tay Son district, after receiving water of the Dong Sim River.	T7	$153^0$83'96"	$27^0$74'78"	Assessing the water quality of the Kon River after the confluence of the Dong Sim River.
Kon River, Phu Phong town, Tay Son district, after receiving Kut River water.	T8	$153^0$87'35''	$27^0$54'87''	To assess the water quality of the Kon River after receiving wastewater from the residential area of Phu An village, Tay Xuan commune, Tay Son district.
Kon River, Binh Thanh commune, Tay Son district, after receiving Queo stream water.	T9	$153^0$88'02"	$28^0$08'77"	To assess the water quality of the Kon River after entering the Queo stream.
Kon River, Binh Nghi commune, Tay Son district	T10	$153^0$80'83"	$28^0$34'21"	To assess the water quality of Kon River after receiving wastewater from residential area of La Nghi village, Binh Nghi commune and discharging directly into the river

Water sampling sites	Sample signs	Coordinates		Sampling purpose
		Longtitude	Attitude	
Kon River, Nhon My commune, An Nhon town	T11	$153^0$91'71"	$28^0$65'39"	Assessing the water quality of the Kon River at the end of the study river section

Results and discussion

Current status of branch canals and waste sources flowing into Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province

In the studied river section of Kon River, there are flows such as branch canals and small streams that receive wastewater from residential areas, livestock farms, factories, enterprises, hospitals, ... That is Dong Pho River - confluence with Kon River in Tay Giang commune, Tay Son district, containing wastewater of Giang Dat Thanh company - specializing in producing microplastics, wastewater from pig and cow farms and domestic wastewater from villages; Dong Tre River - enters the Kon River in Tay Giang commune, Tay Son district, receiving domestic wastewater from villages of Thuong Giang 1, Thuong Giang 2; Dong Sim River - confluences with Kon River in Phu Phong Town, Tay Son District, Binh Dinh Province, containing wastewater from Tay Son Garment Joint Stock Company and domestic wastewater from residential areas in the town; Ham Ho River - confluence with Kon River at Phu Phong Town, Tay Son District, Binh Dinh Province receives domestic wastewater from residential areas of Binh Tuong, Tay Phu communes,... Queo stream - confluence with Kon river in Binh Thanh commune, Tay Son district - contains domestic wastewater in residential areas of Kien Long village, Binh Thanh commune and the residential area of Binh Hoa commune. In addition to the rivers and streams mentioned above, the study river section also receives wastewater from Phu Phong Regional General Hospital and many small sewers carrying domestic wastewater from households living near the river.

In the wastewater sources listed in Table 3.1, except for medical wastewater of Phu Phong Regional General Hospital, wastewater of Giang Dat Thanh Production and Trading Limited Company, Tay Son Garment Joint Stock Company has been licensed to discharge by the Ministry of Natural Resources and Environment, other wastewater sources of population here as sources of domestic wastewater, livestock wastewater, craft village wastewater, ... have not been licensed to discharge. About 60% of domestic wastewater in the basin has been treated through three-compartment septic tanks, then collected through sewers and flowed to small rivers and streams before being discharged into the Kon River [2]. Analysis results show that these domestic wastewater sources have quite high levels of suspended solids, organic substances, nutritional compounds of nitrogen and phosphorus, and coliform bacteria density, and many samples with high values exceed the allowable standard values of QCVN 14: 2008/BTNMT [6] in both using water purpose (discharged into water sources used for domestic water supply purposes) and (discharged into water sources not used for domestic water supply purposes). In detail, analysis results from domestic wastewater samples collected in the area showed that COD was in the range of 56 -390mg/l; BOD_5 is in the range of 38- 215mg/l; TSS (52-156mg/l); N-NH_4^+ (0,325 - 4,5mg/l); N-NO_3^- (0,018 - 0,630mg/l), N- NO_2^- (0,61-13mg/l); P - PO_4^{3-}(0,4-6,8mg/l); coliform density (1500.10^3 - 1200.10^9MPN/100ml).

Besides domestic wastewater, noodle production craft village wastewater about capacity of $380m^3$ per day from more than 200 households working in An Thai and My Thanh villages through the sewer system and then discharged directly to the Kon River. Wastewater from these vermicelli production facilities contains sour fermented starch, pH of 4,5-6, BOD_5 from 900-1200mg/l, COD from 1600-1900mg/l, high suspended solids concentration with TSS in a range from 110 - 450mg/l; high nutrients (TN 25-45mg/l; TP (10-12,5mg/l). In addition, the wastewater of the noodle-making village here also has

a high density of microorganisms (Total coliform $5,10^5$- $9,10^5$ MPN/100ml). It is mentioned here these craft villages have mainly family-scale production households and fragmented production, so it is difficult to apply modern wastewater treatment technologies due to low funding and lack of resources of operational expertise.

With livestock farms in the basin, solid waste is usually collected and buried or composted, while the liquid wastewater, which is concentrated in organic matter and suspended solids, is discharged directly to sewers, rivers, lakes, ponds,... Characteristics of these wastewaters are pH from 6,5 - 8,2, COD in the range of 1450 -3300mg/l; BOD_5 in the range of 868- 1615mg/l; N-NH_4^+ (250 - 280mg/l); N- NO_3^- (158 - 310mg/l), N- NO_2^- (111-230mg/l); P - PO_4^{3-}(180-420mg/l); total coliform (1900.10^9 - 1200.10^{12}MPN/100ml), TSS in a range from 350 - 950mg/l;. Though the amount of livestock wastewater is not large, but rich in organic substances and microorganisms and has been seriously polluting water bodies and the surrounding environment, creating a very unpleasant odor that spreads in the air. Table 3 statistics of pollution load contained in wastewater of the basin discharged into the study river section. The pollution load (L) discharged into the water environment is calculated follow to Vietnam Environment Administration (2019) as formula [7]:

$$L = W \times C \times 1/1000 \text{ (kg/per day)}$$

L: Pollution load

W: Wastewater discharge volume (m^3/day)

C: Pollutant concentration

Table 3. Pollution load contained in wastewater of the basin discharged into the study river section.

Wastewater types	Load of pollutants per day				
	TSS (kg)	BOD_5(kg)	COD(kg)	TN(kg)	TP(kg)
Domestic	52-156	38-215	56-390	5,5-18,1	0,4-6,8
Livestock farm	52,5-142,5	130,2-242,25	217,5-495	17-52	2,7-6,3
Noodle craft village	41,8-171	342-456	608-722	9,5-17,1	3,8-4,75

Current status of Kon River water quality and the impact of waste sources entering the Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province

The water quality analysis results of Kon River show that at the beginning of the study river section - T1 site - Tay Giang village, the water quality was quite good. In both dry and rainy seasons, dissolved oxygen concentration is high (≥ 6.78 mg/l), neutral pH (7,01 -7,03), low nutrient concentration ($TN_{dry\ season}$ 1,3mg/l; $TN_{Rainy\ season}$ 0,7mg/l; $TP_{Dry\ season}$ 1mg/l, $TP_{Rainy\ season}$ 0,8mg/l), low organic matter in both rainy and dry seasons (COD ≤ 5,9mg/l, BOD_5 ≤ 1,8mg/l). The water quality here meets the limit values of level A of QCVN 08:2023/BTNMT - good water quality, can be used for living, swimming, and playing underwater water supply purposes.

However, at location T2, after receiving Dong Pho River water, the water quality of Kon River has changed significantly. pH decreased slightly with a value at ranged 5,8-6,2, DO decreased significantly with DO values in the rainy season around 5,88 mg/l, DO in dry season 5,65 mg/l, total nitrogen increased with values in the rainy season around 1,3mg/l, in the dry season around 2mg/l; total phosphorus increased with values around 0,16 mg/l in the rainy season, around 0,19 mg/l in the dry season; Organic substances also increased with COD values in a range of 6- 6,5 mg/l in the rainy season, in ranges of 8-9 mg/l in the dry season, BOD_5 in rainy season is around 2,3mg/l, BOD_5 in the dry season is around 3,5 mg/l. Thus, at location T2, Kon River water quality only satisfies level B - of QCVN 08:2023/BTNMT-average water quality. The river ecosystem consumes a lot of dissolved oxygen due to pollutants such as nitrogen, phosphorus nutrients and organic substances in domestic wastewater in Tay Giang village, Tay Son district and wastewater from farms with about 3,300 pigs and 5,000 cattle discharges into Dong Pho River - the confluence with the Kon River in Tay Giang commune.

From position T2 to downstream, the water quality of Kon River continues to degrade due to receiving domestic, craft village wastewater from residential areas in the basin discharge to Dong Tre River, Ham Ho River, Queo Stream, or discharged directly into the Kon River from public sewers. Kon River water pH becomes lower, ranging from 6,0 to 6,3 in the rainy season, 5,5 to 5,7 in the dry season; DO in the rainy season is in the range of 4,9 - 5,18 mg/l while DO in the dry season in a range of 4,2-4,8 mg/l, DO reaches the lowest values at point T5 in both seasons; $TN_{Rainy\ season}$ is in range of 1,4- 3,9mg/l, $TN_{Dry\ season}$ in range of 2,7- 4,6mg/l, $TP_{Rainy\ season}$ in ranged of 0,13- 0,39mg/l, $TP_{Dry\ season}$ in range of 0,36- 0,5mg /l. In values of DO, the water quality of the Kon River at locations T5 and T11 even only meets limit value level C of QCVN 08:2023/BTNMT - Bad water quality, the domestic ecosystem has reduced dissolved oxygen strong due to containing a large number of pollutants, water can only be used for industrial production purposes after applying appropriate treatment measures [6]; In total nitrogen values, at locations T5, T8, T9, T10 only reach limit value level D of QCVN 08:2023/BTNMT - Water quality is very bad, can greatly affect fish and other living creatures in the river. Water environment due to high pollutant concentration, can be used for navigation purposes and other purposes with low water quality requirements [6]. Compared with the 2018 National Environmental Report, Kon River water quality has deteriorated significantly [3]. The discharge of untreated polluted water into Vietnam's rivers is a major reason why these water bodies are increasingly polluted and degraded in water quality [8]. This water source, due to being rich in nitrogen, phosphorus, and organic substances, easily faces the risk of eutrophication of the water source in the future without improving and protecting methods [9], [10], [11]..

It is easy to realize the deterioration of water quality in the studied river section. The reason due that the river section flows through a densely populated area with strong economic and social activities in livestock, production, and services,... with not very good management of wastewater discharge.

Proposing solutions to protect and improve the water quality of the Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province

To protect and improve the water quality of the Kon River from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province, it is necessary to have a good managemental policy for each type of wastewater.

For domestic wastewater, it is necessary to invest in three-compartment septic tanks to treat wastewater for 40% of the remaining residents who do not have a treatment tank.

For livestock farm wastewater, apply biofilter technology with constructed wetlands after biogas treatment by Phan et al to treat waste [12].

For noodle production craft village wastewater, it is necessary to collect wastewater into large tanks and treat wastewater with activated sludge supplemented with probiotics has been proven to be effective and suitable for both cost and operating techniques [13], [14], [15].

Currently on river basins, economic development activities along with the need to use water resources cause most river sections or rivers to use water for multiple purposes, from irrigation and aquaculture production, water supply, hydroelectricity, water transportation, tourism, ... However, activities of exploiting and using surface water resources in the river basin have been causing potential conflicts causing environmental conflicts [6]. Conflicts only end when the interests and goals of the parties are reconciled, people's lives are guaranteed, and nature conservation activities are combined with environmental protection. Only then activities to protect nature and the environment will be most effective.

Conclusions

The water quality of the Kon River analyzed result from Tay Thuan commune, Tay Son district to Nhon My commune, An Nhon town, Binh Dinh province proves the deterioration of water quality in the studied river section due to the river section flow through a densely populated area with strong economic and social activities in livestock, production, services,... with not very good management of wastewate discharge. Proposing solutions to protect and improve the water quality of Kon River, it is necessary to have a good managemental policy with each type of wastewater, especially livestock wastewater, domestic wastewater, and noodle-making village wastewater.

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Contributions of authors

Vu Thi Phuong Thao - contributes to the idea, analyzes, and writes the manuscript; Huynh Thi Thu Thuy - contributes to the idea and data acquisition.

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