



Journal of Mining and Earth Sciences

Website: <http://jmes.humg.edu.vn>

Water quality degradation in Sat River - the section flowing through Hai Duong province and some proposals to improve river water quality



Thao Phuong Thi Vu ^{1,*}, Thanh Thi Nguyen ²

¹ Hanoi University of Mining and Geology, Hanoi, Vietnam

² Hai Duong Department of Natural Resources and Environment, Hai Duong province, Vietnam

ARTICLE INFO

ABSTRACT

Article history:

Received 14th Jan. 2022

Revised 05th May 2022

Accepted 04th June 2022

Keywords:

Pollutant,
Proper treatment,
Sat River,
Water quality degradation.

This paper studies the water quality degradation of Sat river - the section flowing through Hai Duong province and waste sources pollute Sat river water. Five surveyed locations along Sat River were identified, and water samples were taken for five consecutive years from 2016 to 2020. Water samples were analyzed in the laboratory with the criteria and methods regulated by QCVN 08:2015/BTNMT. The analyzed results showed that the Sat river water had five parameters frequently exceeding the B1 limit value of QCVN 08 - MT: 2015 BTNMT consisting of DO, NH₄⁺, PO₄³⁻, COD, and BOD₅. Two main causes of Sat river pollution conclude of pollutants available in the river upstream and from many sources of domestic wastewater, industrial wastewater, and agricultural wastewater in Hai Duong province without proper treatment. To improve the water quality of Sat river, the collection and treatment of wastes at the source must be thoroughly treated with reasonable waste management.

Copyright © 2022 Hanoi University of Mining and Geology. All rights reserved.

1. Introduction

The Sat River is a natural river that takes water from the Red River through the Xuan Quan sluice in Hung Yen province. When building the Bac Hung Hai irrigation (BHHI) system, people renovated and connected many river sections, including Sat river. The Sat River is about 60 km

long, with an average width of 30÷50 m. The section flowing through Hai Duong is about 30 km long, starting from Cong Tranh, Luong Ngoc village, Thuc Khang commune, passing through Binh Giang, Cam Giang and Gia Loc districts, crossing Hai Duong city before emptying into Thai Binh river through Au Thuyen in Ngoc Chau ward. The Sat River has played the most critical role in the BHHI system, used to provide water for irrigation and domestic use for the districts of Binh Giang, Cam Giang, Gia Loc, Tu Ky and Binh Giang, Hai Duong city (Hai Duong Department of

*Corresponding author

E - mail: vuthiphuongthao@humg.edu.vn

DOI: 10.46326/JMES.2022.63(3).02

Natural Resources, 2020). Since December 2019, Hai Duong province has stopped exploiting water from the mainstream of Bac Hung Hai river, including the Sat River to supply domestic water production plants. The main reason for this decision is the water quality of the river system becoming seriously degraded due to receiving more and more wastewater from production, agriculture, domestic consumption, etc. (Hai Duong Department of Natural Resources, 2020).

This paper studies the water quality degradation of the Sat river - the section flowing through Hai Duong province and waste sources that pollute Sat river water.

2. Materials and method

2.1. Sample location, sampling time

River water samples were taken at five locations from Cong Tranh, Luong Ngoc village, Thuc Khang commune, Binh Giang district to Au Thuyen, Ngoc Chau ward, Hai Duong City in 2016÷2020. The location is 500 m to the river's end before pouring into the Thai Binh river (Figure 1). The coordinates of the sampling point are determined by a GPS device (Table 1).

2.2. Methods of collecting and analyzing water samples

Sampling procedures are per sampling standards in the "Guidelines for Sampling in Rivers and Streams - TCVN 6663 - 6: 2008" (Ministry of Natural Resources and Environment, 2008). Samples were transported immediately to the laboratory of Hai Duong Center for Environmental Monitoring and Analysis, stored at

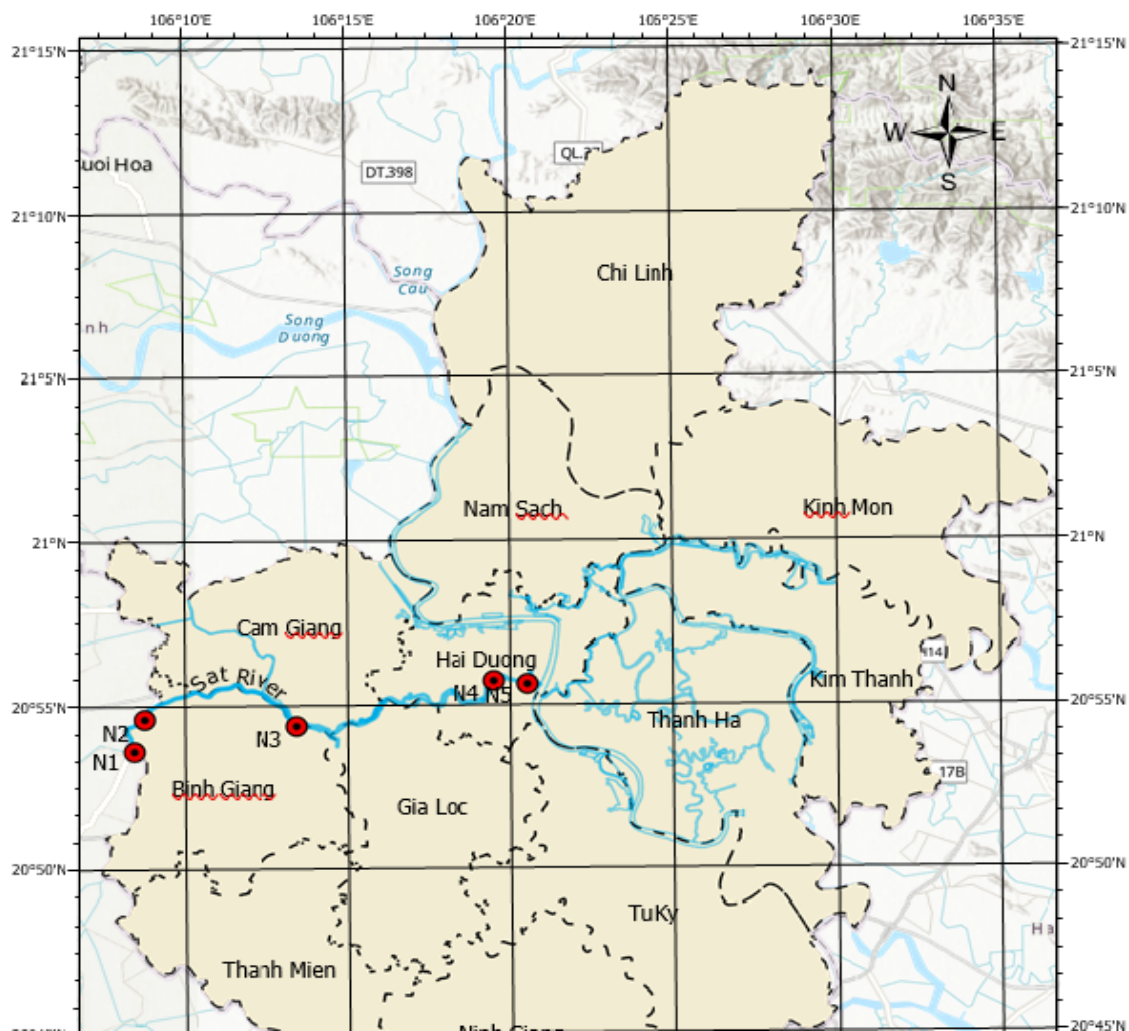


Figure 1. Water sampling locations in Sat River.

40°C, and conformed to TCVN 6663 - 1995. Samples were analyzed in the laboratory with the criteria and methods in Table 2 (Ministry of Natural Resources and Environment, 2015).

3. Results and discussion

3.1. Current status of Sat river water quality in the dry season in 2016÷2020

Analyzed results of Sat river water quality showed that from 2016÷2020, Sat river water quality in almost monitoring times does not meet the quality standard to supply water for daily life as the initial purpose when the government dug the BHHI system. The following is a detailed description of the water quality parameters of Sat River.

* pH and DO

PH in Sat river water is in the range of 7.0÷7.7, slightly alkaline in the dry season, and the range of 6.9÷7.3, almost neutral in the rainy season. This pH range is very close to the optimal pH of freshwater rivers, suitable for aquatic life. Unlike pH, DO has a deficient value which makes aquatic life in the Sat River become so risky. In both dry and rainy seasons, except for samples at sites N4 (Cat Bridge) and N5 (Au Thuyen) in 2018, N5 (Au Thuyen) in 2020 was satisfied the limit value B1 of QCVN 08 - MT: 2015/BTNMT, the remaining samples always give DO values in the range of 1.7÷3.6 mg/l, less than the standard of 4 mg/l. With these DO values, it is easy to explain the odor emitted from the anaerobic decomposition of organic matter in river water and the mass death of organisms floating on the river surface for many days people observed.

Table 1. Location of water sampling.

No	Study sites	Signs	Coordinates		Sampling purposes
			Latitude	Longitude	
1	Cong Tranh	N1	20°54'22"	106°13'20"	Assessment of water quality of Sat River upstream flowing from Hung Yen province to Hai Duong province at Cong Tranh
2	Sat Bridge	N2	20°54'35"	106°08'40"	Assessment of upstream water quality of Cau Luong river from Hung Yen province to Hai Duong province at Ke Sat town
3	Cay Bridge	N3	20°53'36"	106°08'21"	Assessing Sat River water quality after receiving wastewater from Tan Truong Industrial Park, Phuc Dien Industrial Park, residential, agricultural, and livestock
4	Cat Bridge	N4	20°55'44"	106°19'23"	Assessing Sat River water quality after receiving wastewater from Hai Duong city (receiving wastewater from the T2 canal)
5	Au Thuyen	N5	20°55'59"	106°20'52"	Assessing of Sat River water quality before flows into the Thai Binh River

Table 2. Water samples and analytical methods.

No	Parameters	Units	Method of analysis
1	pH	-	Quick test by TOA WQC - 22A
2	Dissolved oxygen (DO)	mg/l	
3	Total suspended solid (TSS)	mg/l	TCVN 6625 - 2000
4	Chemical oxygen demand (COD)	mg/l	TCVN 6491 - 1999
5	Biological oxygen demand after 5 days at 20°C (BOD ₅)	mg/l	TCVN 6001 - 1995
6	Ammonium (NH ₄ ⁺ - N):	mg/l	TCVN 5988 - 1995
7	Phosphorus (PO ₄ ³⁻ - P)	mg/l	TCVN 6494 - 1999
8	Total Coliform	MPN/100ml	TCVN 6187 - 1:1996

** Chemical oxygen demand (COD) and Biological oxygen demand after five days at 20°C (BOD₅)*

Figures 2 and 3 show the COD in the rainy and dry seasons in 2016÷2020, respectively. In contrast, Figures 4 and 5 show the BOD₅ in the rainy and dry seasons in 2016÷2020, respectively.

Analyzed results showed that in almost all water samples in 2017, 2019, and 2020, COD and BOD₅ in Sat river water are quite high and do not satisfy the limit value B1, especially at sites N2 (Sat Bridge), and N4 (Cat Bridge) in both seasons.

COD is in the range of 12÷102 mg/l, and 9÷90 mg/l in the dry and rainy seasons, respectively, in comparison with the B1 limit value of 30 mg/l. BOD₅ is from 6÷50 mg/l, and 6÷25 mg/l in the dry and rainy seasons, respectively, in comparison with the standard of 15 mg/l. Both COD and BOD₅ tend to decrease gradually along with the water flow, reaching the lowest value at Au Thuyen.

COD and BOD₅ also tend to decline gradually over the years. The ratio of BOD₅/COD always ranges from 0.61÷0.75, which shows that the organic matter content in Sat river water is mainly biodegradable organic substances, mainly derived from domestic wastewater. Therefore, it may be easily removed by biological methods.

** Content of nutrients in Sat river water*

+ Ammonium nitrogen (NH₄⁺ - N):

The values of NH₄⁺ - N in water samples are 2.7÷11.5 mg/l and 0.2÷6.5 mg/l in the rainy and the dry seasons, respectively. Except at the Au Thuyen site, NH₄⁺ - N values satisfying B1 limit values of QCVN 08 - MT: 2015/BTNMT in 2016, 2017, 2018, the remaining sites at all NH₄⁺ - N values consistently higher than B1 limit values from 1,1 to 13 times. The highest value is in the N4 (Cat Bridge) - where receiving wastewater from

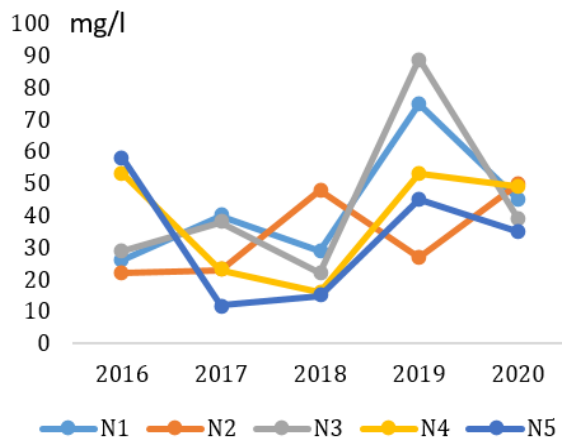


Figure 2. COD in rainy season in periods 2016÷2020.

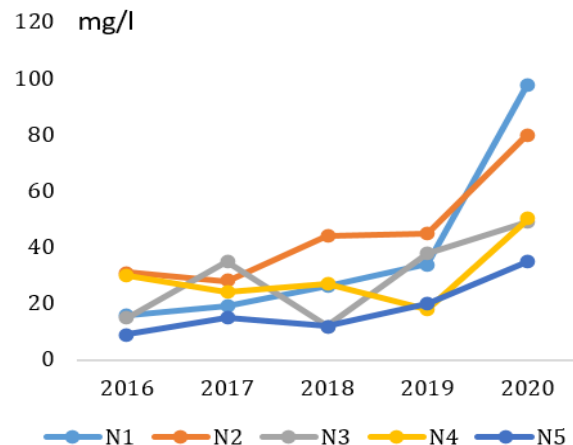


Figure 3. COD in dry season in periods 2016÷2020.

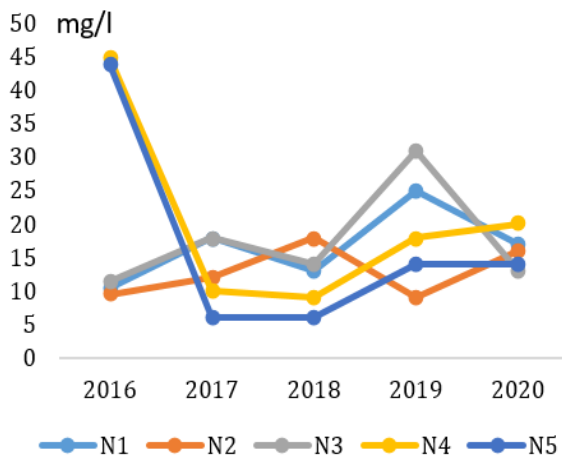


Figure 4. BOD₅ in rainy season in periods 2016÷2020.

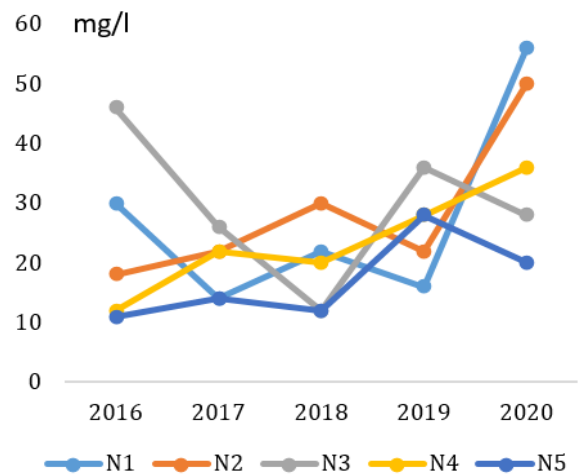


Figure 5. BOD₅ in dry season in periods 2016÷2020.

Hai Duong city through the T2 canal. The second high value was in the Sat Bridge site - where receiving river water from Hung Yen. The level of NH_4^+ - N pollution decreases gradually and reaches the minimum values at the last place of the river survey. Figures 6 and 7 illustrate NH_4^+ - N content in rainy and dry seasons during 2016 and 2020, respectively.

+ Phosphorus (PO_4^{3-} - P):

Values of PO_4^{3-} - P in the water samples were $0.2 \div 0.7$ mg/l in the rainy season and $0.2 \div 0.9$ mg/l in the dry season, 3 times higher than the B1 limit value of QCVN 08 - MT: 2015/BTNMT with the highest value in N1 (Cong Tranh) in dry season 2016 the site also get water from Cau Luong River of Hung Yen province to Hai Duong province.

The PO_4^{3-} - P pollution level was highest in the years 2016, and 2017 and tended to decrease in the following years. It satisfied the B1 limit values

of QCVN 08 - MT: 2015/BTNMT. Figure 8 illustrates PO_4^{3-} - P content in the rainy season, and Figure 9 shows PO_4^{3-} - P content in the dry season of 2016÷2020.

Nutrients are essential for living things, but the overabundance of nutrients in water can create harmful health and environmental effects. An excess of nutrients in water starts eutrophication, which would be detrimental to the biodiversity, creating dead zones with unpleasant color and smell (Abid et al., 2005). Therefore, removing these nutrients will be the main key in resolving the black color and odor in the river.

* Total coliform

Proper management has also been required for coliform bacteria in water sources because

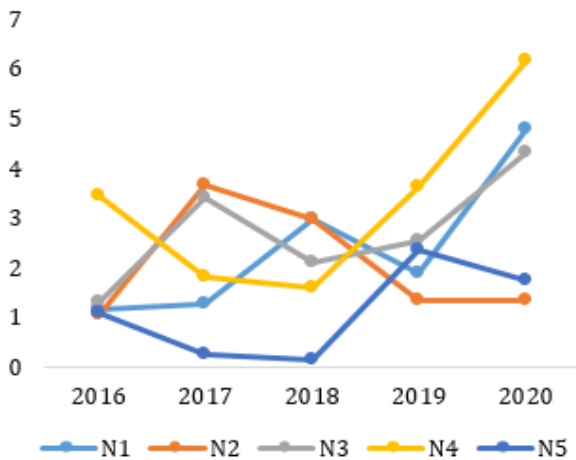


Figure 6. NH_4^+ - N in rainy season in periods 2016÷2020.

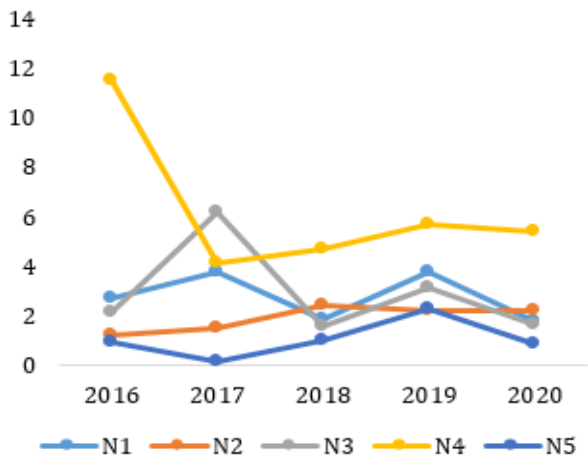


Figure 7. NH_4^+ - N in dry season in periods 2016÷2020.

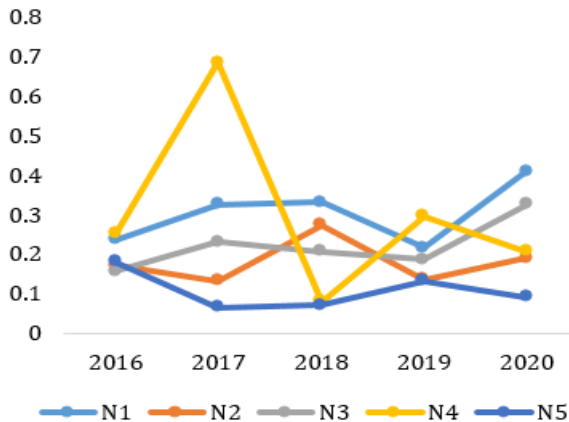


Figure 8. PO_4^{3-} - P in rainy season in periods 2016÷2020.

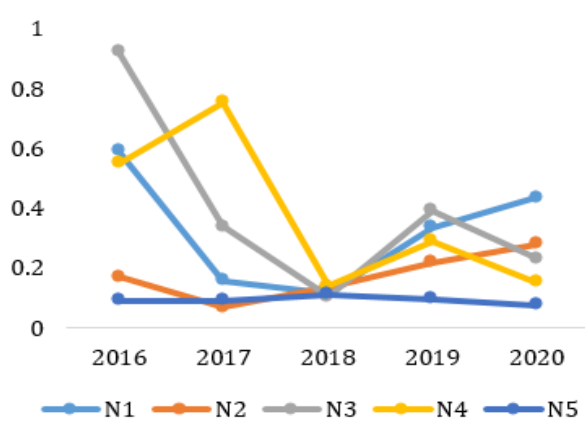


Figure 9. PO_4^{3-} - P in dry season in periods 2016÷2020.

these microorganisms can directly or indirectly impact human health. Coliform bacteria can cause serious illnesses, such as gastroenteritis and diarrhea, through polluted water from untreated sewage, septic tanks, etc. (Zeglin, 2015).

The distribution of total coliform at five sites in the Sat River is in Figures 10 and 11. Total coliforms showed a narrow distribution range in the rainy season and a wide range in the dry season. However, all coliform density values were satisfied with the B1 limit value of QCVN 08 - MT: 2015/ PO_4^{3-} - BTNMT. (Hai Duong Provincial Department of Natural Resources and Environment, 2019).

The results of water quality analysis showed that the Sat river water had five physicochemical parameters exceeding the B1 limit value of QCVN 08 - MT: 2015 BTNMT. It consisted of DO, NH_4^+ , PO_4^{3-} , COD, and BOD_5 in many monitoring times during 2016÷2020. The Sat river monitoring site at Sat Bridge, Binh Giang district receives polluted water upstream from Hanoi city, Hung Yen province, and at Cat Bridge - Hai Duong city. The water receiving area from the discharge of Hai Duong city from the T2 channel are the sites with a very poor concentration of parameters, exceeding the B1 limit value and occurs frequently. Water quality parameters have higher values in the dry season, tending to increase year by year, indicating that the pollution situation has not improved much.

3.2. Sources of discharge into the Sat River and some proposals to improve the water quality of Sat River

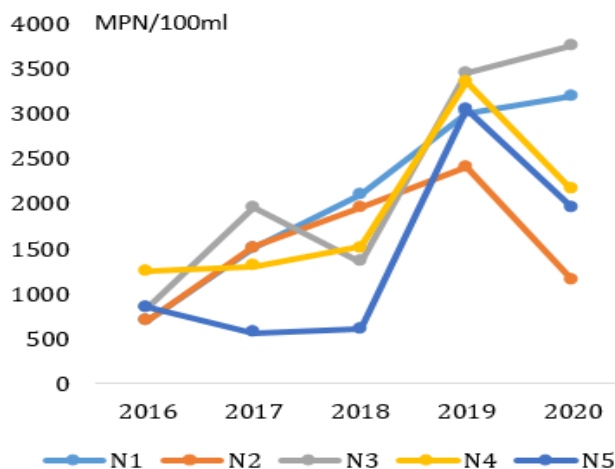


Figure 10. Total coliform in rainy season in periods 2016÷2020.

Nutrients, such as nitrogen and phosphorus, occur naturally, but most of the nutrients in our waterways come from human activities and sources - fertilizers, wastewater, automobile exhaust, and animal waste (Abid et al., 2011). Nutrients and pollutants in Sat river are not an exception. The main causes of river water quality degradation are discharge of domestic wastewater, agriculture, industry, and industrial zones which have not been properly treated and flow directly into canals leading to Sat river. The riverbed is full of sludge and garbage.

Sat River flowing through Hai Duong province is downstream of Sat River of BHHI river system, so the quality water of Sat River, when flowing to Hai Duong province, has withstood heavily polluted water flowing from the upstream provinces. It is the explanation for the higher concentration of pollutants at the beginning of the river flowing into Hai Duong province, at N1 (Cong Tranh) and N2 (Sat Bridge), in comparison with those of the survey sites in the province. In addition to receiving wastewater from upstream, Sat River also receives many domestic, industrial and agricultural wastewater in the province from the T2 channel at Au Thuyen, where the river flows through before pouring into the Thai Binh River. Sat river's water pollution source is mainly domestic wastewater from urban areas and concentrated residential areas, accounting for about 58.47% (Ministry of Natural Resources and Environment, 2019). Over the years, Hai Duong has had many solutions to overcome water pollution. The quality of water in the Sat River

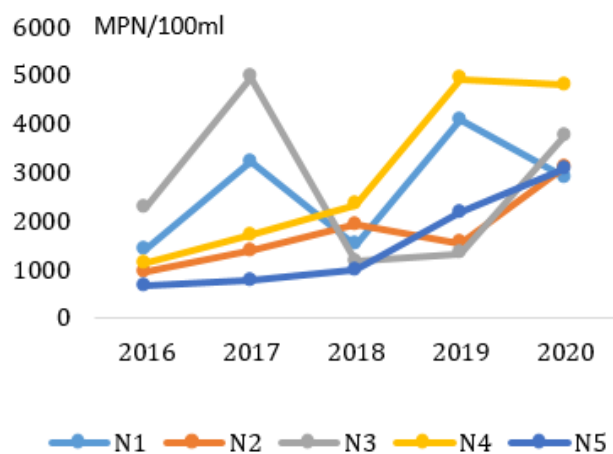


Figure 11. Total coliform in dry season in periods 2016÷2020.

through the province is further improved, ensuring water for agricultural production and people's living. However, in general, to minimize the pollution of the Sat River due to domestic wastewater from residential areas on the T2 canal, it is essential to improve the water quality, and landscape of this canal with the use of microbial products, stocking aquatic rafts (Mara, 2005).

Wastewater from domestic, animal husbandry, craft villages, etc., accounts for a large proportion, but no management measures have been taken. Responsibility for waste management in the wastewater treatment system is overlapping and unclear between the Ministry of Agriculture and Rural Development and the Ministry of Natural Resources and Environment. Therefore, to prevent waste streams with livestock waste, craft villages, etc., from reducing river water quality, it is necessary to have measures to manage livestock waste such as collection and processing into biofertilizers. Waste management in the wastewater treatment system should also be assigned to the Ministry of Natural Resources and Environment. The Ministry has complete discretion in making reasonable treatment measures for waste sources.

4. Conclusions

The results of water quality analysis showed that the Sat river water had five parameters exceeding the B1 limit value of QCVN 08 - MT: 2015 BTNMT consisting of DO; NH_4^+ ; PO_4^{3-} ; COD, BOD_5 in many monitoring times during 2016÷2020. There are two main causes of Sat river pollution. First, Sat River flowing through Hai Duong province is the downstream of Sat River of BHHI river system. Hence, its quality has withstood heavily polluted water flowing from the upstream regions. Second, Sat River also receives many sources of domestic, industrial wastewater, and agricultural wastewater without proper treatment from the T2 channel at Cat Bridge. The collection and treatment of wastes at the source of Sat River must be thoroughly treated

with proper waste management to improve the water quality.

Authors' contribution

Thao Phuong Thi Vu - contributes to the idea, data acquisition, analysis, and writes the manuscript; Thanh Thi Nguyen - contribute to collecting the data.

References

- Abid, A. A., Sarvajeet, S. G., Guy, R. L., & Walter, R. (2011), *Eutrophication: causes, consequences and control*. Springer, Neitherland. 394 pages.
- Hai Duong Department of Natural Resources and Environment. (2020). *Report on solving and overcoming environmental pollution in Bac Hung Hai river*. (in Vietnamese).
- Hai Duong Provincial Department of Natural Resources and Environment. (2019). *Report on the verifying information on the situation of water pollution in Sat river in Hai Duong province*. (in Vietnamese).
- Mara, D. (2005). *Domestic wastewater treatment in developing countries*. Routledge Publisher, London, 310 pages.
- Ministry of Natural Resources and Environment. (2008). *Guidelines for sampling in rivers and streams - TCVN 6663 - 6:2008*. (in Vietnamese).
- Ministry of Natural Resources and Environment. (2015). *QCVN 08:2015/BTNMT - National Technical Regulation on surface water quality*. (in Vietnamese).
- Ministry of Natural Resources and Environment. (2019). *Report on the situation and solutions to solve water pollution in Bac Hung Hai river system*. (in Vietnamese).
- Zeglin, L. H. (2015). Stream microbial diversity in response to environmental changes: review and synthesis of existing research. *Frontiers in microbiology*, 6, 454.