

**ASSESSMENT OF SURFACE WATER QUALITY AFFECTED  
BY DOMESTIC WASTEWATER FROM RESIDENTIAL  
AREA OF DI AN CITY, BINH DUONG PROVINCE:  
CASE STUDY ON SIEP STREAM FLOWING THROUGH DI AN CITY**

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**DOI: 10.37550/tdmu.EJS/2024.02.550**

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### Article Info

**Volume:** 6

**Issue:** 02

**June** 2024

**Received:** April 5<sup>th</sup>, 2024

**Accepted:** April 22<sup>nd</sup>, 2024

**Page No:** 229-240

### Abstract

Siep Stream is a first-level tributary flowing into Dong Nai River, the main source of domestic water supply for the provinces of Binh Duong, Dong Nai, and Ho Chi Minh City. The water quality of Siep stream contributes to affecting the surface water quality of Dong Nai river in general and the downstream area of Dong Nai river in particular. The Siep stream basin currently receives wastewater from most residential areas in Di An city, a fast-growing area of Binh Duong province, according to forecasts, by 2025 the total pollution load entering the Siep stream will be mainly domestic wastewater. Research to evaluate surface water quality of Siep stream from 2022 to 2023, shows that most pollution parameters tend to increase and exceed standards QCVN 08-2023/BTNMT (level A) and QCVN 08: 2015/ BTNMT (column A2) specifically: about 86.9% COD exceeding the standard  $1.0 \div 7.8$  times, 95.6% SS parameters exceeding the standard  $1.8 \div 30.4$  times, 95.6% N-NH<sub>4</sub> number exceeds the standard of  $0.16 \div 21.8$  times, 52.1% of N-NO<sub>2</sub> parameters exceed the standard by  $0.52 \div 8.9$  times, 65.2% of P-PO<sub>4</sub> parameters exceed the standard by  $0.35 \div 6.25$  times, 91.3% of Coliform parameters exceeded the standard of  $1.0 \div 3.3$  times. The WQI (water quality index) results show that the surface water quality of Siep stream is mostly average, this result is not suitable for domestic water supply purposes, there needs to be solutions to improve water quality at the area Siep Stream.

**Keywords:** Binh Duong, pollution wastewater, Siep stream, water quality

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### 1. Introduction

In 2017, Di An was recognized as a type III urban area (Thien Ly, 2023) and within just 6 years later, in 2023 Di An was recognized as a type II urban area (Tran Hong Ha, 2023). In the first 9 months of 2023, total retail sales of goods and service revenue increased by 9.4% over the same period; Industrial production value increased by 3.9% over the same period (Ngoc Thanh, 2023). This shows that Di An city always has rapid growth, is one of the central urban areas, and is the most dynamic and bustling land of development in Binh Duong province, with strengths in industry and commerce, service (Thanh Hau, 2023).

Siep Stream is one of the stream with a large basin in Di An city, with a stream basin area reaching 25.69km<sup>2</sup>. Siep stream sub-basin includes 5 wards (Di An city has 7 wards): Binh An, Binh Thang,

Di An, Dong Hoa, Tan Dong Hiep, limited from the beginning of the stream to the toll station area of National Highway 1K, Siep Stream is level 1 tributary flowing into Dong Nai river. Siep Stream has a length of over 6km, the stream has 3 small branches to drain rainwater and wastewater naturally (Department of Science and Technology of Binh Duong province, 2018).

Pollution load due to domestic wastewater: By the end of 2018, the population of the Siep stream sub-basin was about 112,943 people. The calculation results show that the flow of domestic wastewater draining into the Siep stream sub-basin is  $8,132\text{m}^3/\text{day.night}$ . The Siep stream sub-basin has a total number of about 28,236 households, of which there are no households within the collection scope of the project "Improving the water environment of South Binh Duong". Results of calculating the total domestic load discharged into Siep stream sub-basin is 4.83 tons/day (Department of Natural Resources and Environment of Binh Duong Province, 2018).

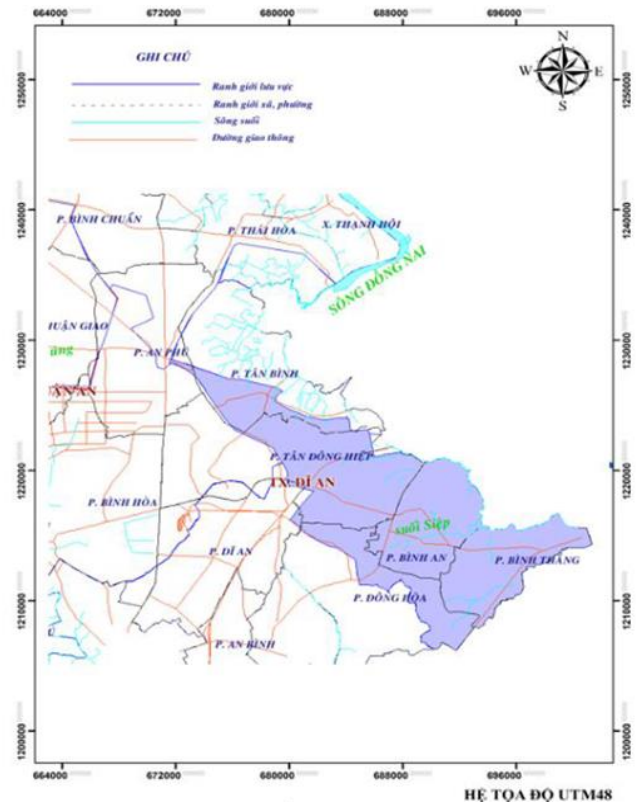
Pollution load due to industrial, commercial and other service wastewater: As of the end of 2018, the Siep stream sub-basin and its tributaries are currently receiving wastewater from 105 industrial, industrial, commercial and service establishments. with a total flow of  $10,707\text{m}^3/\text{day}$ . The calculation result of the total industrial load discharged into the Siep stream sub-basin is 1.33 tons/day (Department of Natural Resources and Environment of Binh Duong Province, 2018).

Load of rain water: Siep stream sub-basin according to calculations receives rainwater runoff with a flow of about  $11,154\text{m}^3/\text{day.night}$  with a total load of 1.3 tons/day (Department of Natural Resources and Environment of Binh Duong Province, 2018).

In short, the total load of the Suoi Siep system basin is 9,866 tons/day. Currently, the main source of pollution in Suoi Siep is domestic activities, accounting for 73.38%, the cause is that domestic wastewater has not been collected and treated to meet allowed standards; Industrial and service waste sources contribute 13.48% of the load and stormwater runoff sources account for 13.14% (Department of Natural Resources and Environment of Binh Duong Province, 2018).

It is forecast that by 2025 the area will have a total population of 165,685 people with a total domestic wastewater flow of about  $14,912\text{m}^3/\text{day.night}$ . Other industrial, commercial and service waste sources are about  $25,704\text{m}^3/\text{day.night}$ . The flow of rainwater runoff is  $10,997\text{m}^3/\text{day.night}$  (Department of Natural Resources and Environment of Binh Duong Province, 2018). Thus, the total pollution load into Siep stream is still mainly domestic wastewater.

Siep Stream is a first-level tributary flowing into Dong Nai River, the main source of domestic water supply for the provinces of Binh Duong, Dong Nai, and Ho Chi Minh City. Therefore, protecting the surface water source of Dong Nai River is extremely important. Water quality of Siep stream contributes affecting the quality of surface water of Dong Nai river in general and the downstream area of Dong Nai river in particular. Therefore, the control of wastewater quality at points and sources discharged into Siep stream is necessary, therefore the topic "assessment of surface water quality affected by domestic wastewater from residential area of Di An city, Binh Duong province: case study on siep stream flowing through di an city" to determine the quality and trend of surface water quality



**Figure 1.** Siep stream sub-basin (Department of Natural Resources and Environment of Binh Duong Province, 2018)

in Siep stream and thereby propose some solutions to contribute to controlling surface water quality in Siep stream and Dong Nai river.

## 2. Research content and methods

### 2.1. Research content

#### *Research content*

Content 1: Statistics and analysis to assess surface water quality

Implementations: Statistics on analysis results of pH, DO, COD, N-NH<sub>4</sub>, N-NO<sub>3</sub>, N-NO<sub>2</sub>, P-PO<sub>4</sub>, coliform from January 2022 until November 2023. Export graphs and trends of pollution parameters over time.

Content 2: Assessing surface water quality of Siep stream

- How to do it : Calculate WQI parameters Decision 1460/QD-TCMT dated November 12, 2019 (Ministry of Natural Resources and Environment, 2019) from January 2022 to November 2023. Export WQI performance and trend charts.

Content 3: Propose solutions to manage and control water quality

- How to do it: Provide technical and management solutions to control surface water quality of Siep stream.

### 2.2. Research area

In order to evaluate the surface water quality of Siep stream affected by residential areas in Di An city, the research location is at the culvert on National Highway 1 K in Tan Dong Hiep, Di An, Binh Duong.

### 2.3. Research Methods

#### *Methods of data collection and analysis*

Data are collected from monitoring results of the Binh Duong Technical-Environmental Monitoring Center to calculate the WQI index. Data is collected continuously in the period from January 2022 to November 2023. Monitored water quality parameters include: pH, suspended solids (SS), dissolved oxygen content (DO), chemical oxygen demand (COD), Ammonium (N- NH<sub>4</sub>), nitrate (N- NO<sub>3</sub>), nitrite (N-NO<sub>2</sub>), Coliform, temperature, phosphate (P-PO<sub>4</sub>) (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023).

Methods are carried out according to (TCVN 6663-1:2011, TCVN 6663-3:2008, TCVN 6663-6:2008); sample preservation and transportation (TCVN 6663-14: 2000) (Department of Natural Resources and Environment of Binh Duong Province, 2023).

The Center for Natural Resources and Environmental Monitoring of Binh Duong Province collects monitoring samples continuously with a frequency of once a month) (Department of Natural Resources and Environment of Binh Duong Province, 2023).

*WQI calculation method (Ministry of Natural Resources and Environment, 2019)*

Method for calculating water quality index (WQI): Formula for calculating WQI value according to Decision 1460/QD-TCMT dated November 12, 2019 of the Ministry of Natural Resources and Environment (Ministry of Natural Resources and Environment, 2019).

$$WQI = \frac{WQI_I}{100} \times \frac{\left( \prod_{i=1}^n WQI_{II} \right)^{1/n}}{100} \times \frac{\left( \prod_{i=1}^m WQI_{III} \right)^{1/m}}{100} \times \left[ \frac{1}{k} \sum_{i=1}^k WQI_{IV} \times \frac{1}{l} \sum_{i=1}^l WQI_V \right]^{1/2}$$

In there:

WQI<sub>I</sub>: Calculation results for group I parameters: pH parameters.

WQI<sub>II</sub>: Calculation results for group II parameters : Not available.

WQI<sub>III</sub>: Calculation results for group III parameters: Not available.

WQI<sub>IV</sub>: Calculation results for parameters group IV: Parameters DO, COD, N-NH<sub>4</sub>, N-NO<sub>3</sub>, N-NO<sub>2</sub>, P-PO<sub>4</sub>.

WQI<sub>V</sub>: Calculation results with group V parameters: coliform.

The water quality assessment scale is specified by a color palette specific to each level of water source pollution, clearly shown and easy to understand.

TABLE 1. Water quality assessment scale

WQI value	Water quality	Suitable for intended use	Color
91-100	Excellent	Excellent for domestic water supply purposes	Blue
76-90	Good	Used for domestic water supply purposes but requires appropriate treatment measures	Green
51-75	Medium	Use for irrigation and other similar purposes	Yellow
26-50	Least	Used for water transportation and other similar purposes	Orange
10-25	Heavy pollution	The water is heavily polluted and needs treatment measures in the future	Red
<10	Pollution is very heavy	Water is contaminated and requires remedial and treatment measures	Brown

(According to Decision 1460/QĐ-TCMT dated November 12, 2019 of the Ministry of Natural Resources and Environment)

Data processing methods

- Synthesize statistical data using Microsoft Excel 2016 software.
- Export charts using Minitab 20, Microsoft excel 2016.

3. Results and discussion

3.1. Assess surface water quality

a. Influence of pH parameter

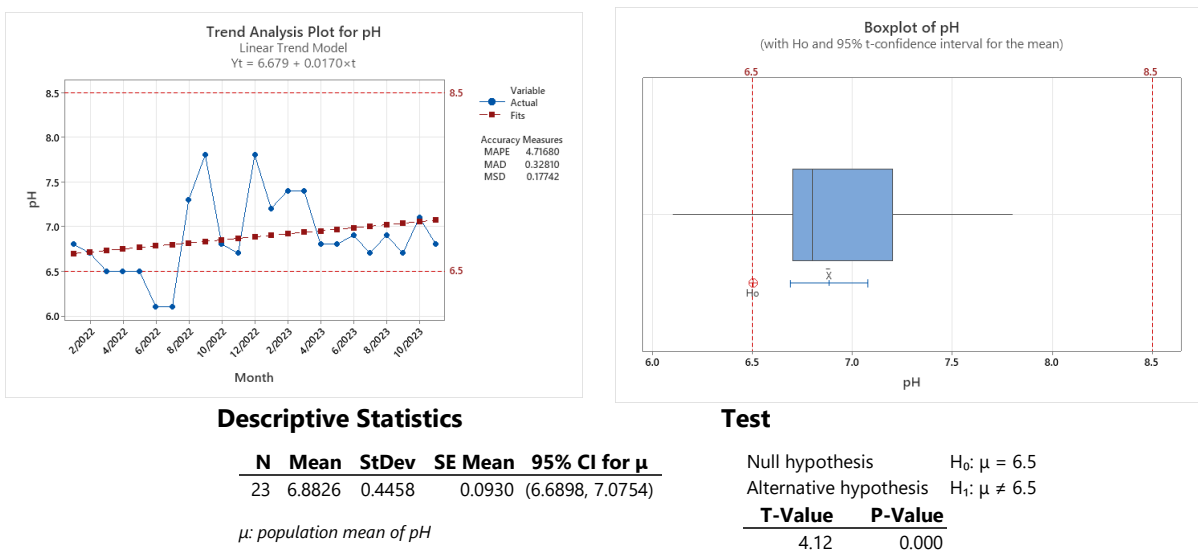


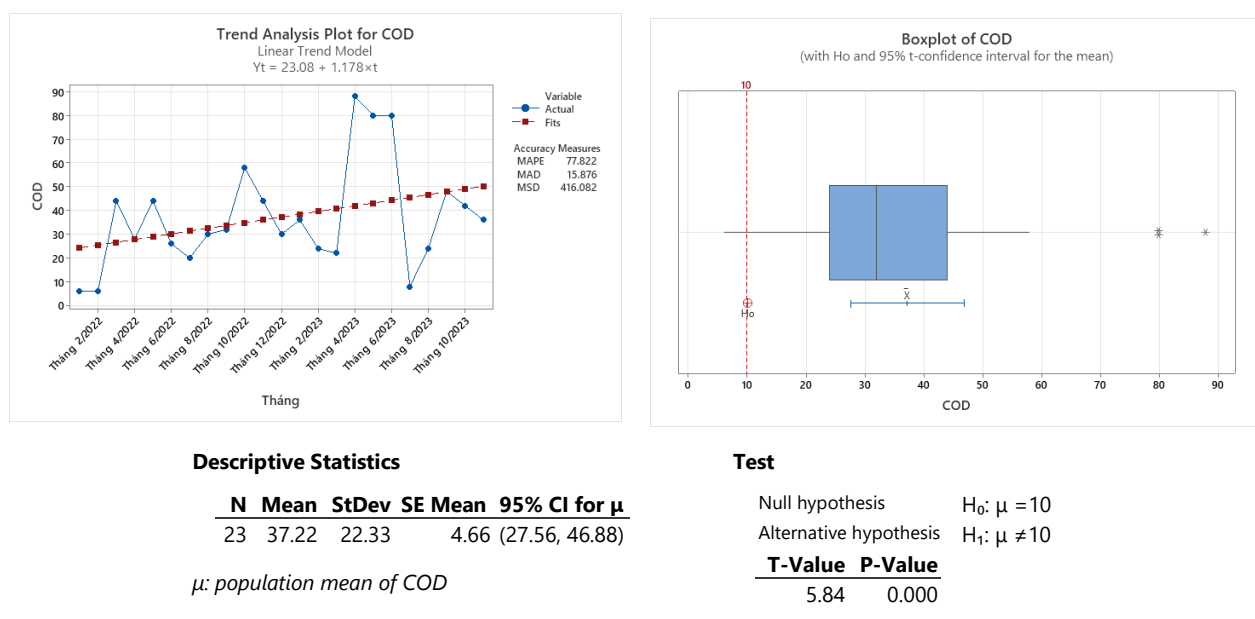
Figure 2. Box plot chart and trend chart of pH parameter

Based on the chart in Figure 2, it shows that most pH parameter results from January 2022 to November 2023 are within the allowable limits of QCVN 08:2023/BTNMT (level A) ranging from  $6.1 \div 7,8$  and pH parameters tend to increase over time.

With P- Value =  $0.000 < 0.05$ , it shows that the pH parameter is unstable. Average results of 23 months are available pH = 6.88, the value is within the standard QCVN 08:2023/BTNMT (level A) and the pH parameters of the months have deviations within  $\pm 0.4458$ . Statistical results according to Minitab software show that 95 % of pH parameters fluctuate between 6.68 and 7.05, thereby showing that this fluctuation range is not too large compared to QCVN 08:2023/BTNMT (level A).

When comparing the pH results ( $6.1 \div 7.8$ ) of Siep stream, they show similarities with the results at Cat stream, Trang bridge, Thu Dau Mot with pH ( $6.2 \div 7.6$ ) and at Cai stream, Ba Kien bridge, Tan Uyen, pH ( $6.6 \div 7.9$ ) at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the pH parameter at Siep stream have similar results with the comparison results at Cat stream and Cai stream.

**b. Influence of COD parameter**



**Figure 3.** Box plot chart and trends chart of COD parameter

Based on the chart in Figure 3, it shows that most of the COD parameter measurement results from January 2022 to November 2023 exceed QCVN 08:2023/BTNMT (level A) ranging from  $8 \div 88\text{mg/l}$ , 86.9% of COD exceeds the standard by  $1.0 \div 7.8$  times and COD parameters have a clear tendency to increase over time. Especially from April 2023 to July 2023, COD parameters increase, exceeding 7 to 8 times the allowable threshold. This result may be because this is the beginning of the rainy season, pollutants on the ground are released following the surface water flowing into the stream.

The result P-Value =  $0.000 < 0.05$  shows that the COD parameter are unstable. The average result of 23 months COD =  $37.22\text{mg/l}$  is 2.7 times greater than standard and COD of the months has deviations within  $\pm 22.33\text{mg/l}$ . Statistical results according to Minitab software show that 95 % of COD parameters range from  $27.56\text{mg/l}$  to  $46.88 \text{mg/l}$ , exceeding the standard by  $1.7 \div 3.6$  times.

When comparing the results of COD parameters ( $8 \div 88\text{mg/l}$ ) of Siep stream, it is lower than COD at Cat stream, Trang bridge, Thu Dau Mot, COD ( $4 \div 114\text{mg/l}$ ) and higher at Cai stream and Ba Kien bridge, Tan Uyen, COD ( $4 \div 50\text{mg/l}$ ) at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the COD parameters at Siep stream have results that are not similar to the comparison results at Cat stream and Cai stream, the quality of Siep stream has better COD parameters than Cat stream and is not good compared to Cai stream.

c. Influence of DO parameter

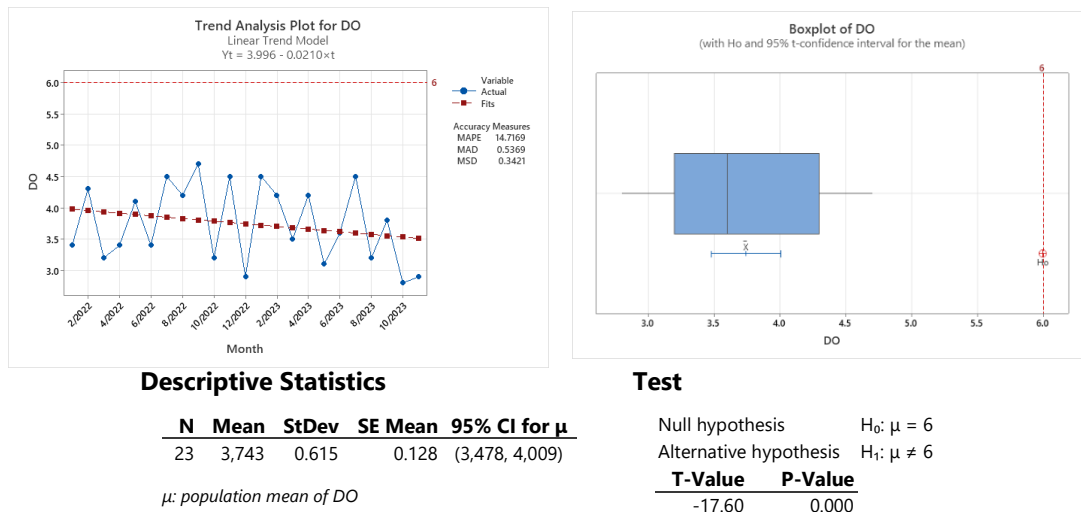


Figure 4. Box plot chart and trend chart of DO parameter

Based on the chart in Figure 4, it shows that all DO parameter measurement results from January 2022 to November 2023 do not meet the allowable threshold compared to QCVN 08:2023/BTNMT (level A) ranging from 2.8 ÷ 4.7mg/l, and DO parameters have a clear tendency to decrease over time. With P-Value = 0.000 < 0.05, it shows that DO parameters are unstable. The average result of 23 months DO = 3.74mg/l did not meet QCVN 08:2023/BTNMT (level A) and DO of the months had deviations within +/- 0.615mg/l. Statistical results according to Minitab software show that 95% of DO parameters fluctuate between 3.47 ÷ 4.0mg/l, not meeting standards.

When comparing the results of DO parameter (2.8 ÷ 4.7mg/l) of Siep stream, it is better than that of Cat stream, White bridge, Thu Dau Mot, DO (0.8 ÷ 3.5mg/l), worse Compared to DO at Cai stream, Ba Kien bridge, Tan Uyen, DO (2.6 ÷ 5.7mg/l) at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the DO parameters at Siep stream have results that are not similar to the comparison results at Cat stream and Cai stream. The quality of Siep stream has better DO parameters than Cat stream and is not good compared to Cai stream.

d. Effect of SS parameter

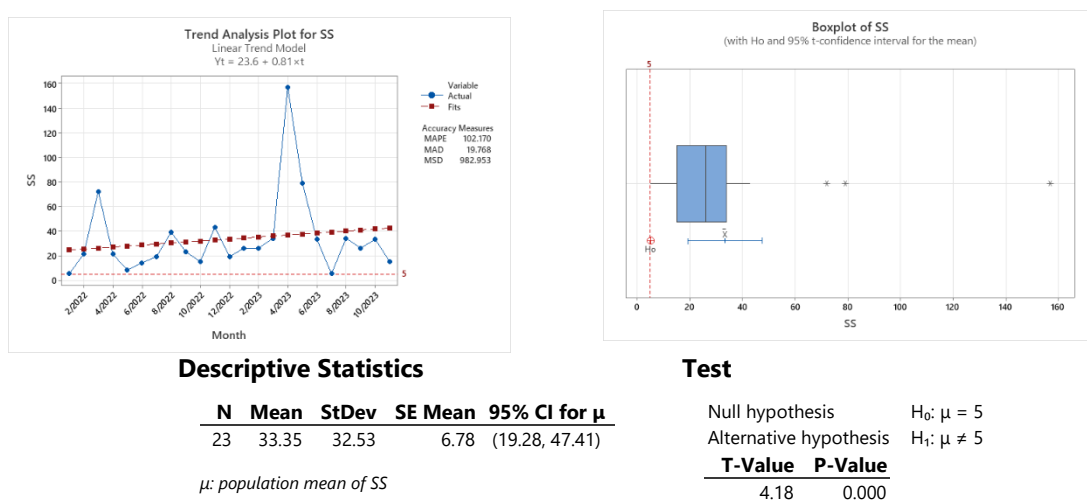


Figure 5. Box plot chart and trend chart of SS parameter

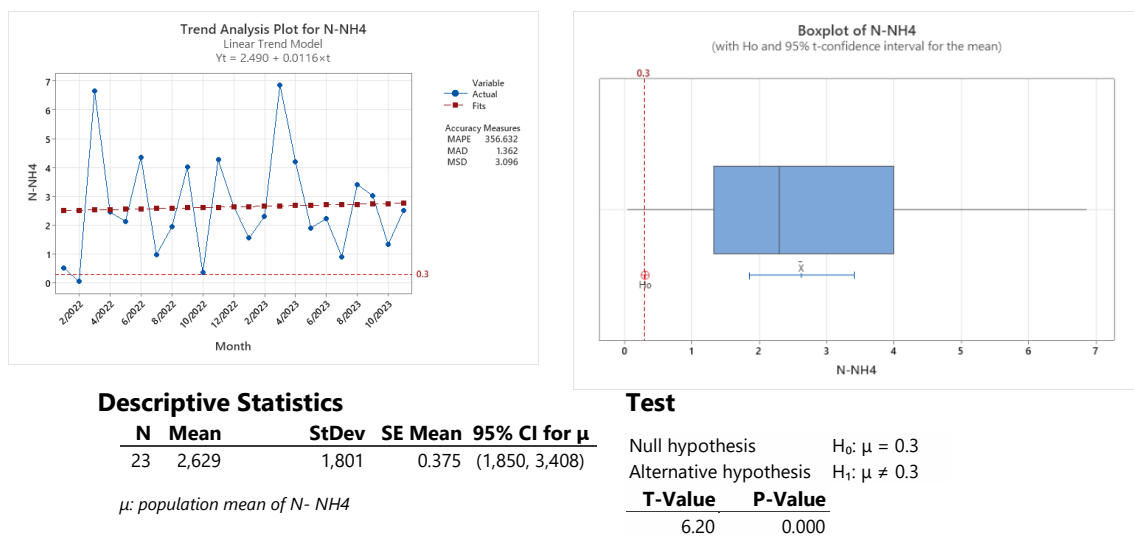
Based on the chart in Figure 5, it shows that the SS parameter measurement results from January 2022 to November 2023 all exceed QCVN 08:2023/BTNMT (level A) ranging from 5 ÷ 157mg/l, 95, 6% of SS parameters exceed the standard by 1.8 ÷ 30.4 times and SS parameters tend to increase slightly

over time. In April every year, SS parameters increase, SS parameters in April 2023 increase higher than April 2022 and exceed the standard by 30,4 times. This result may be due to this being the beginning of the rainy season pollutants on the ground are carried into streams by surface water.

The result P-Value = 0.000 < 0.05, shows that the SS parameters are unstable. The average result of 23 months of SS = 33.35mg/l exceeded the standard by 5.6 times and the SS of the months had deviations within +/- 6.78mg/l. Statistical results according to Minitab software show that 95% of SS parameters range from 19.28mg/l to 47.41mg/l, exceeding the standard by 2.8 ÷ 8.4 times.

When comparing the results, SS parameters (5 ÷ 157mg/l) of Siep stream at the same time were higher than those of Cat stream, Ba Kien bridge, Thu Dau Mot with SS (10 ÷ 123mg/l). When compared with the results at Cai stream, Ba Kien bridge, Tan Uyen with SS (8 ÷ 61mg/l), it shows that SS is much higher, the reason may be because the Siep stream basin has a dense population and more factories than the Cai stream basin (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the SS parameters at Siep stream have results that are not similar to the comparison results at Cat stream and Cai stream, the quality of Siep stream has higher SS parameters.

e. Effect of N-NH<sub>4</sub> parameter



**Descriptive Statistics**

N	Mean	StDev	SE Mean	95% CI for $\mu$
23	2,629	1,801	0,375	(1,850, 3,408)

$\mu$ : population mean of N- NH4

**Test**

Null hypothesis  $H_0: \mu = 0.3$   
Alternative hypothesis  $H_1: \mu \neq 0.3$

T-Value	P-Value
6.20	0.000

**Figure 6.** Box plot chart and trend chart of N-NH<sub>4</sub> parameter

Based on the chart in Figure 6, it shows that most N-NH<sub>4</sub> parameters from January 2022 to November 2023 exceed QCVN 08:2015/BTNMT (column A2) ranging from 0.04 ÷ 4,35mg/l, 95.6% of N- NH<sub>4</sub> parameters exceed the standard by 0.16 ÷ 21.8 times and N- NH<sub>4</sub> tends to be quite stable. In March 2022 and March 2023, the high parameters exceeded the standard by 21.2 ÷ 21.8 times. This result may be due to this being a hot and dry time, causing flow to decrease, increasing pollution concentration infected.

The result P-Value = 0.000 < 0.005, shows that the N-NH<sub>4</sub> parameter is unstable. Average results 23 months of N- NH<sub>4</sub> = 2,629mg/l exceeded the standard by 7.6 times and N- NH<sub>4</sub> in each month had deviations within +/- 1,801mg/l. Statistical results according to Minitab software show that 95% of N-NH<sub>4</sub> parameters range from 1,850mg/l to 3,408mg/l, exceeding the standard by 5.0 ÷ 10.3 times.

When comparing the results of parameters N-NH<sub>4</sub> (0.04 ÷ 4.35mg/l) of Siep stream is lower than the N-NH<sub>4</sub> parameter (0.01 ÷ 8.75mg/l) at Cat stream, Cau Trang, Thu Dau Mot, higher than at Cai stream, Ba Kien bridge, Tan Uyen with N-NH<sub>4</sub> (0.01 ÷ 3.05mg/l) at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the N-NH<sub>4</sub> parameter at Siep stream has results that are not similar to the comparison results at Cat stream and Cai stream, the quality of Siep stream has N-NH<sub>4</sub> parameter better than Cat stream and not good compared to Cai stream.

f. Effect of parameter N-NO<sub>2</sub>

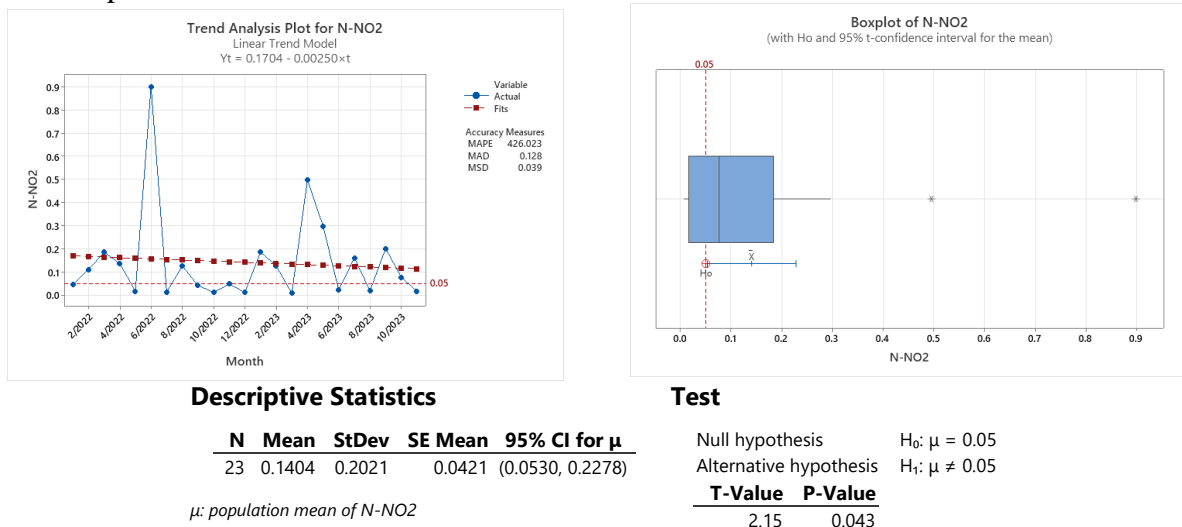


Figure 7. Box plot chart and trend chart of of N-NO<sub>2</sub> parameter

Based on the chart in Figure 7, it shows that the results of measuring the N-NO<sub>2</sub> parameter from January 2022 to November 2023 range from 0.01 ÷ 0.9mg/l, about 52.1% exceeding QCVN 08:2015/ BTNMT (column A2) is from 0.52 ÷ 17 times and the N-NO<sub>2</sub> parameter tends to decrease slightly over time. In June 2022, N-NO<sub>2</sub> exceeded the standard 17 times, a result that may be due to discharge from some factories in the basin.

The result P-Value = 0.043 < 0.05, shows that the parameters N-NO<sub>2</sub> unstable. Average 23-month results of N-NO<sub>2</sub> = 0.14mg/l exceeds the standard 1.8 times and N-NO<sub>2</sub> of the months has deviations within +/- 0.20mg/l. Statistical results according to Minitab software show that 95% of N-NO<sub>2</sub> parameters range from 0.053mg/l to 0.22mg/l, exceeding the standard by 0.1 ÷ 3.4 times.

When comparing the results of N-NO<sub>2</sub> parameters (0.01 ÷ 0.9mg/l), Siep stream is higher than N-NO<sub>2</sub> (0.01 ÷ 0.143mg/l) at Cat stream, Trang Bridge, Thu Dau Mot and also higher than N-NO<sub>2</sub> (0.02 ÷ 0.133mg/l) at Cai stream, Ba Kien bridge, Tan Uyen at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the N-NO<sub>2</sub> parameter at Siep stream has results that are not similar and are higher than the comparable results at Cat stream and Cai stream.

g. Effect of N-NO<sub>3</sub> parameter

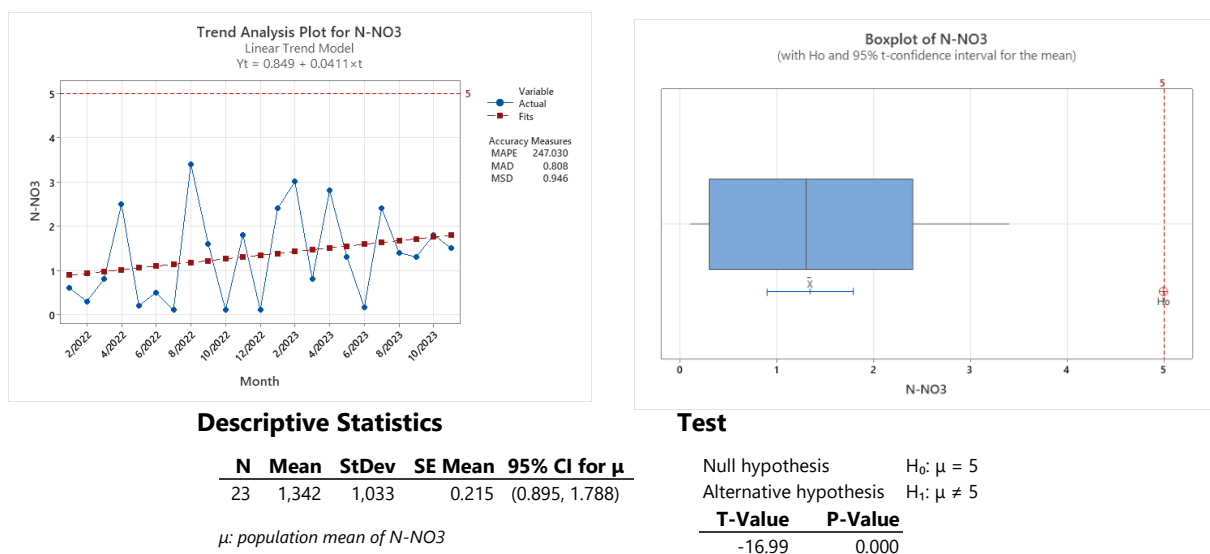


Figure 8. Box plot and trend chart of N-NO<sub>3</sub> parameter

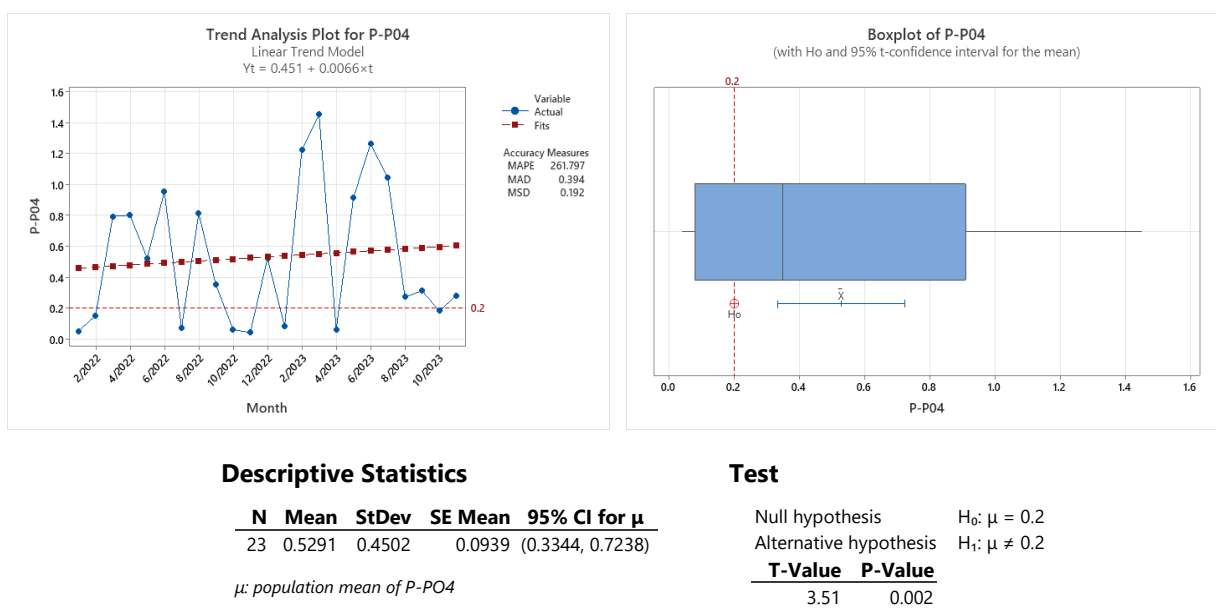


Based on the chart in Figure 8, it shows that the N-NO<sub>3</sub> parameter measurement results from January 2022 to November 2023 all meet QC 08:2015/BTNMT (column A2) ranging from 0.1 ÷ 3, 4mg/l and N-NO<sub>3</sub> parameters tend to increase over time.

Results P-Value = 0.000 < 0.05, showing the N-NO<sub>3</sub> parameters are unstable. Average results for 23 months, N-NO<sub>3</sub> = 1.34mg/l exceeded the standard 1.6 times and N-NO<sub>3</sub> of the months had deviations within +/- 1.03mg/l. Statistical results according to Minitab software show that 95% of N-NO<sub>3</sub> parameters range from 0.89mg/l to 1.78mg/l, much lower than the standard.

When comparing the results of N-NO<sub>3</sub> parameters (0.1 ÷ 3.4mg/l) in Siep stream is higher than N-NO<sub>3</sub> (0.1 ÷ 2.3mg/l) in Cat stream, Cau Trang, Thu Dau Mot and also higher than N-NO<sub>3</sub> (0.09 ÷ 1.6mg/l) at Cai stream, Ba Kien bridge, Tan Uyen at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the N-NO<sub>3</sub> parameter at Siep stream has results that are not similar and are higher than the comparable results at Cat stream and Cai stream.

**h. Influence of P-PO<sub>4</sub> parameter**



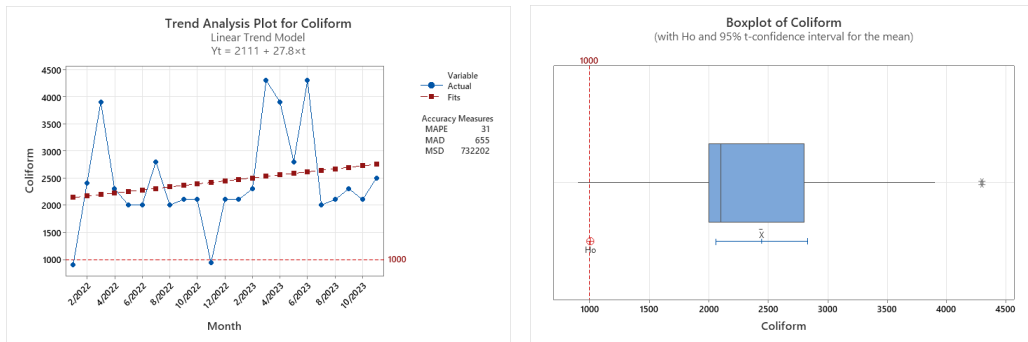
**Figure 9.** Box plot chart and trend chart of P-PO<sub>4</sub> parameter

Based on the chart in Figure 9, it shows that most of the P-PO<sub>4</sub> parameter measurement results from January 2022 to November 2023 exceed QCVN 08:2015/BTNMT (column A2) ranging from 0.04 ÷ 1.45mg/l, 65.2% of P-PO<sub>4</sub> parameters exceed the standard by 0.35 ÷ 6.25 times and P-PO<sub>4</sub> parameters tend to increase over time. In February 2023, March 2023, June 2023 and July 2023, pollution parameters exceeded the standard 5 ÷ 6 times.

Results P-Value = 0.002 < 0.05, showing the P-PO<sub>4</sub> parameters are unstable. The average result of 23 months, P-PO<sub>4</sub> = 0.52mg/l exceeded the standard 1.6 times and parameters P-PO<sub>4</sub> of the months had deviations within +/- 0.45mg/l. Statistical results according to Minitab software show that 95% of P-PO<sub>4</sub> range from 0.33mg/l to 0.72mg/l, respectively exceeding the standard by 0.65 ÷ 2.6 times.

When comparing the results of parameters P-PO<sub>4</sub> (0.04 ÷ 1.45mg/l) in Siep stream is lower than P-PO<sub>4</sub> (0.03 ÷ 1.95mg/l) in Cat stream, Trang bridge, Thu Dau Mot and higher than P-PO<sub>4</sub> ( 0.02 ÷ 0.41mg/l) at Cai stream, Ba Kien bridge, Tan Uyen at the same time (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that the P-PO4 parameters at Siep stream are not similar to the comparison results at Cat stream and Cai stream. The quality of Siep stream has P-PO4 parameters better than Cat stream and much higher than Cat stream. with Cai stream.

i. Influence of Coliform parameter



**Descriptive Statistics**

N	Mean	StDev	SE Mean	95% CI for $\mu$
23	2445	895	187	(2058, 2832)

$\mu$ : population mean of Coliform

**Test**

Null hypothesis  $H_0: \mu = 1000$   
 Alternative hypothesis  $H_1: \mu \neq 1000$

T-Value	P-Value
7.74	0.000

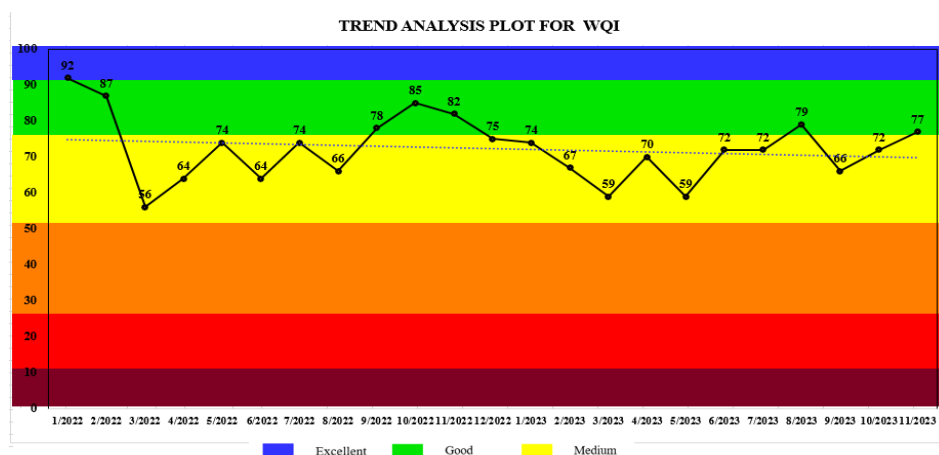
**Figure 10.** Box plot chart and trend chart of Coliform parameter

Based on the chart in Figure 10, it shows that most of the Coliform parameter measurement results from January 2022 to November 2023 are higher than QCVN 08:2023/BTNMT (level A) ranging from 900 ÷ 4,300 MPN/100ml. 91.3% of Coliform parameters exceed the standard by 1.0 ÷ 3.3 times and Coliform tends to increase over time. In which, March 2022, April 2023, June 2023 had Coliform parameters exceeding the standard 2.9 ÷ 3.3 times. This high result can have many causes, such as in March and April, dry times dry up the flow, increasing pollution levels, along with often the first rains of the season, bringing pollutants to the ground. According to surface water flowing into the stream, in June 2023 it may be due to discharge of wastewater from livestock units or factories in the basin.

The result P-Value = 0.002 < 0.05, shows the teacher that the Coliform parameters are unstable. Average results for 23 months, Coliform = 2445 MPN/100ml exceeded the standard 1.6 times and Coliform of each month had deviations within +/- 895 MPN/100ml. Statistical results according to Minitab software show that 95% of Coliform parameters range from 2058 ÷ 2832 MPN/100ml, exceeding the standard 1 ÷ 1.8 times.

Coliform parameters (900 ÷ 4,300mg/l), Siep stream is higher than Coliform (1200 ÷ 3900mg/l) at Cat stream, Trang Bridge, Thu Dau Mot and also higher than Coliform (750 ÷ 4300 MPN/100l) at Cai stream, Ba Kien bridge, Tan Uyen at the same time but not much (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). Thereby, it shows that Coliform parameters at Siep stream have similar results compared to comparable results at Cat stream and Cai stream.

**3.2. Assessing surface water quality of Siep stream**



**Figure 11.** WQI trend chart of Siep stream from 1/2022 to 11/2023

From the chart figure 11 shows, the results The amount of surface water of Siep stream in 23 months through the WQI index ranges from 56 ÷ 92, of which 16 months are at the average level. (WQI 51 ÷ 75), 58.4% in 2022, 82% in 2023; 6 months is at a good level (WQI from 76 ÷ 90, 2022 accounts for 33.3%, higher than 2023 accounts for 18%); 01 month is at a very good level, (WQI from 91 ÷ 100, in 2022 accounts for 8.3%). WQI at Siep stream is trending down. Surface water quality of Siep stream becomes worse in the months of March, April, May, June and better in the months of September, October, November, December, and January. Thus, it shows that the surface water quality of the stream is also affected by season, whereby at the beginning of the dry season the water quality is better than at the end of the dry season and the beginning of the rainy season. Figure 11: WQI trend chart of Siep stream from 1/2022 to 11/2023

WQI at Siep stream in 2022 (41% good and very good, 58.4% average) is higher when compared to WQI at Cat stream, White bridge, Thu Dau Mot city (33% good and 67% of the average level) and lower when compared with WQI at Cai stream, Ba Kien bridge, Tan Uyen city (83% of good level and 17% of average level) (Department of Natural Resources and Environment of Binh Duong Province, 2022, 2023). The surface water quality of Siep stream is higher when comparing the surface water quality of Ba Lua canal, Thu Dau city with WQI (83 ÷ 89) in 2018 (Ngoc Thanh, 2023) and higher than the surface water quality of Dong Nai river at this location. Bien Hoa water plant WQI= 96 (June 2023) (Department of Natural Resources and Environment of Dong Nai province, 2023).

### **3.3 Proposing solutions**

*In terms of management:*

Strengthen inspection, supervision, and sanctioning of administrative violations in the field of management, exploitation and use of water resources, especially for businesses with production stages that generate wastewater containing many substances. organic and heavy metals.

Capacity building and professional training for local specialized officials in water resource management.

Encourage businesses to produce cleaner and apply advanced science to limit wastewater generation.

*Technically:*

Promote the application of technical and technological achievements in domestic wastewater treatment in wastewater treatment stations of residential areas and clusters. Additional centralized treatment stations for residential areas and clusters that do not have domestic wastewater treatment stations. Accelerate the process of implementing domestic wastewater collection systems in the area.

Invest in completing and connecting the rainwater and wastewater drainage systems in the area, gradually ensuring the collection and treatment of domestic wastewater. Dredge and clear the flow of a number of rainwater and wastewater collection routes in the area, and at the same time research and deploy a system of mixing and aerating canals to increase dissolved oxygen and improve water quality.

Implement a plan to relocate polluting factories to industrial parks and industrial clusters. Applying advanced, modern and effective treatment technology in wastewater treatment.

## **4. Conclusion**

Research shows that pH parameters meet QCVN 08:2023/BTNMT (level A), N-NO<sub>3</sub> meets QC 08:2015/BTNMT (column A2). The remaining parameters SS, COD, N-NO<sub>2</sub>, N-NH<sub>4</sub>, P-PO<sub>4</sub>, Coliform all do not meet standards and tend to increase over time.

The WQI index fluctuates from 56-92 and tends to decrease, showing that surface water pollution at Siep stream is increasing. Therefore, to improve the surface water quality of Siep stream, it is necessary to specifically control and reduce the pollution load of SS, COD, N-NO<sub>2</sub>, N-NH<sub>4</sub>, P-PO<sub>4</sub> parameters with management and technical solutions.

Evaluation results from January 2022 to November 2023, about 2 years, so a long-term study, 5 to 10 years, is needed to determine factors affecting water source quality. Siep stream surface, thereby determining comprehensive and optimal control solutions and tools.

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