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Surface Water Quality Influenced by Industrial Wastewater Effluent in An Giang Province, Vietnam

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Abstract

The study was conducted to evaluate the impact of wastewater from industrial zones on surface water quality in water bodies of An Giang province in 2020. Surface water samples were collected at three locations (S1-S3) where it was affected by wastewater from the industrial park. The parameters of pH, temperature, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonium ($N\text{-}NH_4^+$), total oil and grease, and coliform were analyzed for water quality evaluation. Surface water quality is assessed by comparing each water parameter with the National Technical Regulation on Surface Water Quality (QCVN 08-MT:2015/BTNMT), column A1 and water quality index (WQI). The research results showed that the water quality was polluted because TSS, COD, BOD, $N\text{-}NH_4^+$ and coliform parameters exceeded the permissible limits. The parameters of temperature, pH, oil and grease are still within the allowable limits. WQI index ranges from heavy pollution to the level of use for domestic water supply, but appropriate treatment measures should be applied, most of which are suitable for irrigation. The current finding shows that wastewater from industrial activities has an adverse impact on surface water quality, requiring timely treatment solutions to ensure safe water use.

1. Introduction

An Giang province has a relatively dense system of rivers and canals. Two major river routes passing through the province are Hau River (100 km long) and Tien River (80 km long) belonging to the lower Mekong River, which govern the hydrological regime of surface water in the province. The structure of the industrial economy in the province's GRDP shifted in a positive direction (the structure of the region II in 2015 accounted for 10.7% of the GRDP; by 2019 it increased to 15.13%) [1]. The industrial production index has grown year by year (in 2016 it increased by 5.75%; in 2017 it increased by 6.79%, in 2018 it increased by 8.93%, in 2019 it increased by 8.39 and in 2020 it is estimated to increase by 9.72). %); The average growth of the industrial production index in the period 2016 - 2020 is estimated at 7.89% (the period 2011 - 2015 is 5.66%/year); The processing and manufacturing industry has always been a strength, accounting for over 90% of the total industrial production value, with an average growth rate of 7.98%. The industrial sector, especially the processing industry, grew. stable, there are many enterprises investing in processing rice and seafood up to export standards with new technology and large capacity [1]. Industrial parks and clusters have gradually improved their infrastructure to meet the needs of project implementation, expand production of enterprises, attract investors, and create jobs for local workers. The occupancy rate of Binh Long Industrial Park is 100%, there are 10 investment projects with a total investment

capital of 1,053 billion VND. Binh Hoa Industrial Park, the occupancy rate is 84%, there are 16 projects that have been granted investment certificates with a total registered capital of 4,095 billion VND. The whole province has 16/32 industrial clusters which are detailed planning with a total area of over 450/1,355 ha; there are 14 industrial zones with operating enterprises (there are 06 industrial parks with establishment decisions) with a total industrial land area for lease of about 200 ha, attracting 22 domestic and foreign enterprises to invest in production and business with the fields of seafood processing, food, polishing, construction materials. Total investment of enterprises is about 4,031 billion VND, creating jobs for about 8,000 workers [1]. Currently operating industrial zones do not have a centralized wastewater treatment system, but projects and facilities operating in industrial zones and industrial zones have invested in building wastewater treatment systems before discharging sewers. general [1]. Industrial development has put great pressure on water quality [1-2] because wastewater treatment systems are often inefficient [3]. Environmental monitoring at the receiving water source in the industrial park is a necessary task [4]. This study was conducted to assess the impact of industrial wastewater on surface water quality in some areas of An Giang province.

2. Materials and methods

Surface water quality samples were collected at 3 locations. Location S1 on Hau River in Binh Long Industrial Park, Binh Chanh Hamlet, Binh Long Commune, Chau Phu District is heavily affected by industrial park wastewater. Location S2 is the location on Hau River that is affected by wastewater from My Qui industrial cluster, Long Xuyen city. Location S3 is the location on Hau canal (before emptying into Hoi Dong canal at Binh Hoa Industrial Park, in Phu Hoa hamlet, Binh Hoa commune, Chau Thanh district, where it is subject to wastewater movement.Samples were collected in March, June, September and November of 2020 to analyze the parameters of pH, temperature, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonium nitrogen ($N\text{-}NH_4^+$), total oil and grease, and coliform. pH and temperature were measured by hand-held instruments in the field while TSS, BOD, COD, $N\text{-}NH_4^+$, oil and grease, coliform were analyzed in the laboratory experiment using standard methods [5]. Water quality indicators were evaluated using national technical regulations on surface water quality (QCVN 08-MT:2015/BTNMT, column A1) [6] and water quality index [7].

3. Results and discussion

3.1 Evaluating surface water quality using national regulations

The temperature in surface water in industrial zones and clusters through 4 monitoring periods in 2020 ranges from 28 to 31.5^{o}C, with an average of 29.6^{o}C (Figure 1). The average temperature between months ranges from 28.4 to 30.8^{o}C. This temperature range is within the tolerance limit of aquatic organisms [6,8]. Previous studies have shown that water temperature is less volatile and often within the tolerance limits of organisms [9-11].

The measurement results of pH value in surface water in the study area are presented in Figure 2. The pH at the locations fluctuates in the range of 7.1-7.2 while the pH between months is in the range of 7.0-7.3. Research results show that the pH is in the neutral range. The results of this study are also consistent with previous studies that reported that surface water in the Cuu Long River Delta has a neutral pH value [9-11]. The pH value in this study at all 4 monitoring periods in industrial zones and clusters in 2020 is within the allowable limits of QCVN 08-MT: 2015/BTNMT, column A1 (6 - 8.5) [6].

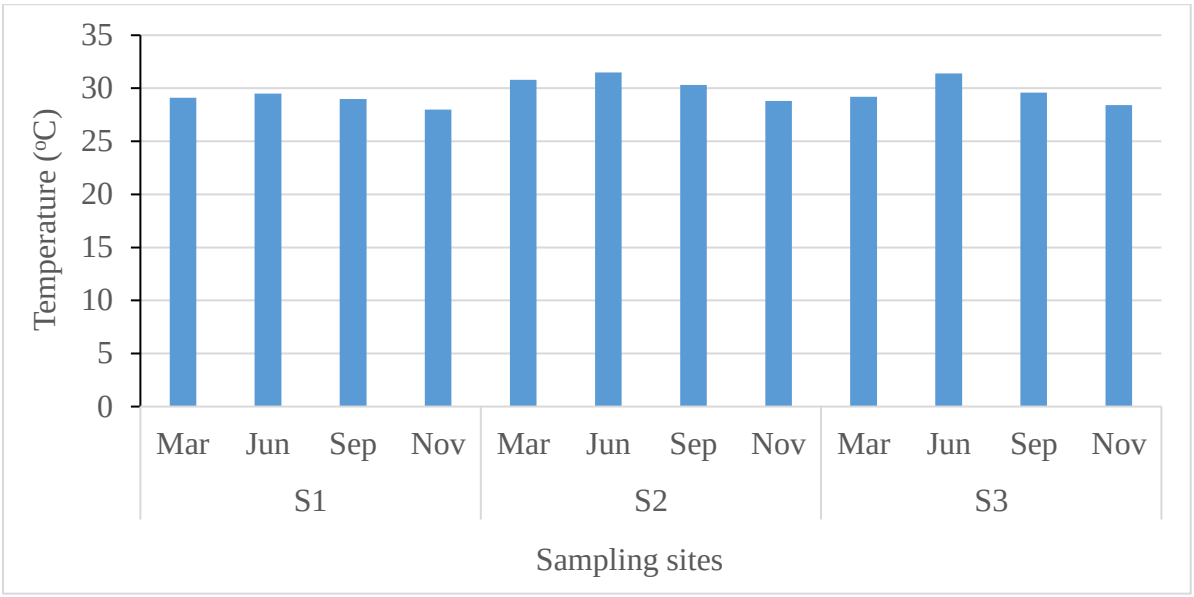

Figure 1. Temperature in the water bodies influenced by industrial wastewater effluent

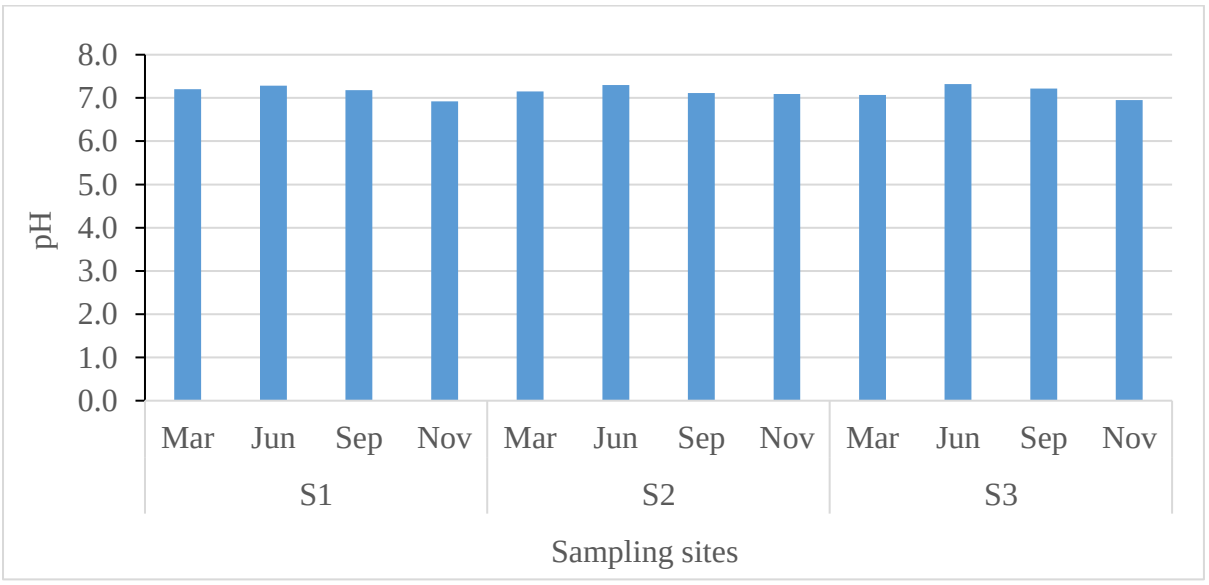

Figure 2. pH in the water bodies influenced by industrial wastewater effluent

TSS concentration in water bodies affected by wastewater after treatment from industrial zones and clusters ranges from 38 - 63 mg/l (Figure 3). Mean TSS at the sites ranged from 49.3-56.0 mg/L while between months of sampling was in the range of 46.7-58.7 mg/L. TSS in March was lower than TSS in the remaining months. TSS in the study area exceeded the allowable limit of QCVN 08-MT:2015/BTNMT, column A1 (20 mg/L) from 1.90 to 3.15 times, the highest in My Quy-S2 industrial cluster in September and the lowest in Binh Long-S1 industrial park in March. In general, TSS concentration in industrial clusters tends to increase gradually with each monitoring period of the year. TSS in rivers in the Mekong Delta is high due to the impact of erosion, stormwater runoff, and phytoplankton. High TSS causes deterioration of water quality and loss of biodiversity [10-15].

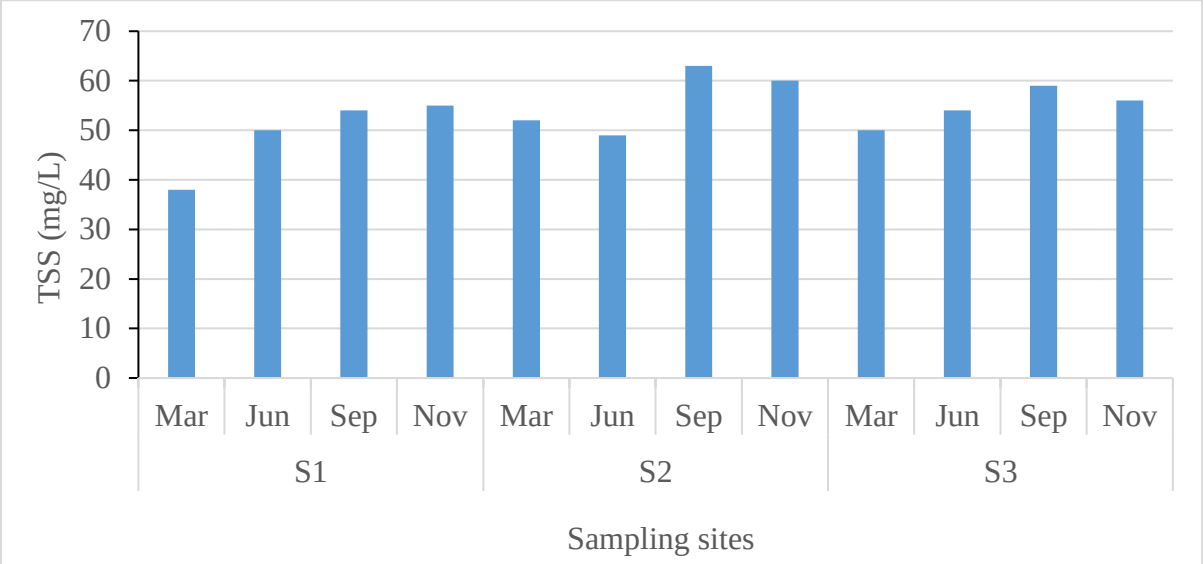

Figure 3. TSS in the water bodies influenced by industrial wastewater effluent

The COD concentration in the study area ranged from 14 - 45 mg/l (Figure 4). COD was found to be highest in My Quy-S2 industrial cluster in March and November and lowest in Binh Long-S1 industrial park in March. The average TSS value between months is in the range of 21.7-36.0 mg. /L. The mean COD at the sampling sites ranged from 22.8 to 32.5 mg/L. The evolution of COD content is quite complicated between locations during the year, specifically, in Binh Long industrial zone, COD concentration tends to increase gradually with each monitoring period of the year; especially My Quy industrial cluster tends to decrease in the middle of the year and increase again at the end of the year; Binh Hoa industrial park tends to decrease in the last 2 phases of the year. The COD concentration in the study area has exceeded the permitted standards of QCVN 08-MT:2015/BTNMT, column A1 (10 mg/l) from 1.40 to 4.50 times. The water quality in the study area is contaminated with organic matter. TSS is one of the major water quality problems in the Mekong Delta [11-17].

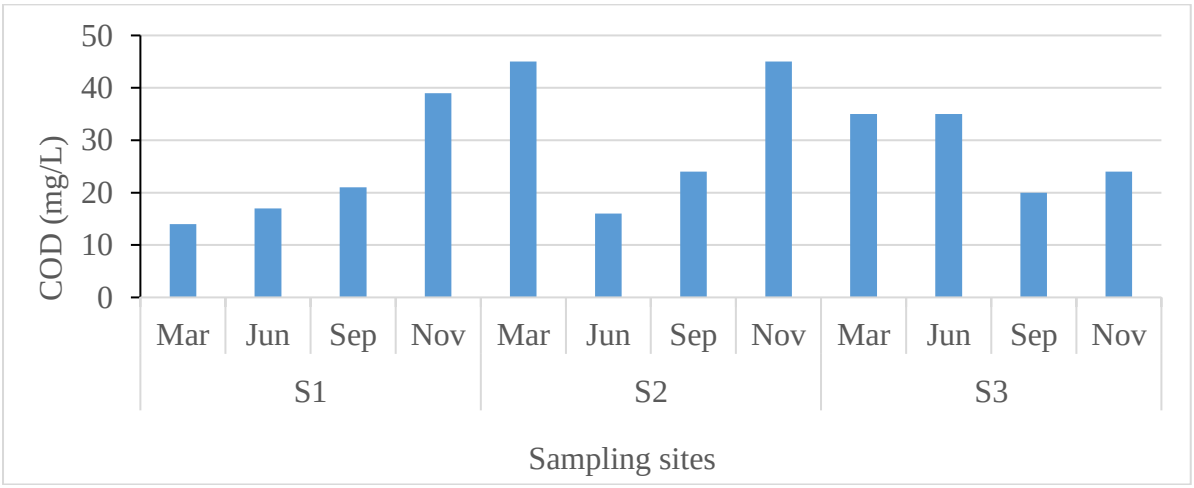

Figure 4. COD in the water bodies influenced by industrial wastewater effluent

The results showed that the BOD content ranged from 9 to 29 mg/l (Figure 5). The COD content at the sites ranged from 14-21 mg/L while the BOD between samples ranged from 14.7-23.3 mg/L. BOD exceeded the allowable limit of QCVN 08-MT:2015/BTNMT, column A1 (4 mg/l) from 2.25 to 7.25 times in all 4 monitoring periods. The value of BOD was highest in My Quy-S2

industrial cluster in March and November and lowest in Binh Long-S1 industrial park in March. The evolution of BOD in 2020 is similar to that of COD. High BOD and COD indicate that surface water quality is affected by organically polluted industrial wastewater. COD is 1.5 times higher than BOD, indicating that surface water contains many substances that are difficult to biodegrade. These compounds can endanger the use of water by organisms and humans [10-11]. Further studies need to clarify the composition of persistent compounds present in the surface water environment in the study area.

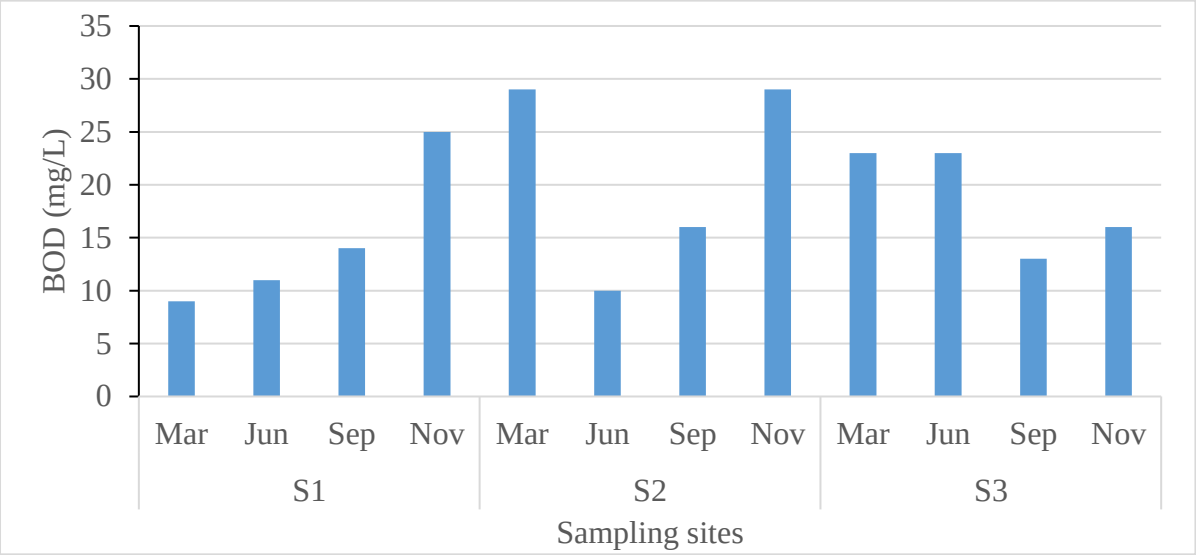

Figure 5. BOD in the water bodies influenced by industrial wastewater effluent

The evolution of concentration ($N\text{-}NH_4^+$) in industrial zones and clusters through 4 monitoring periods in 2020 has a value ranging from 0.088 to 3.290 mg/l (Figure 6), exceeding the standard QCVN 08-MT: 2015/BTNMT, column A1 (0.3 mg/l) from 1.12 to 10.97 times. $N\text{-}NH_4^+$ has a large variation between sampling locations. $N\text{-}NH_4^+$ in the water in Binh Long-S1 industrial park exceeded the permitted standards in the last two phases of the year (September and November) by 1.20 and 9.80 times, respectively; $N\text{-}NH_4^+$ in surface water at My Quy-S2 industrial cluster exceeded the standards in the sampling periods in March, September and November, respectively, by 1.14; 7.73 and 10.97 times; $N\text{-}NH_4^+$ in Binh Hoa-S3 industrial park exceeded the allowed standards in all 4 periods of the year from 1.12 to 6.53 times. The concentration of $N\text{-}NH_4^+$ in surface water in industrial zones and clusters in November was higher than in other periods of the year, the highest in My Quarter-S2 industrial cluster, possibly due to increased production activities leading to higher concentrations of $N\text{-}NH_4^+$. Wastewater treatment facilities often face difficulties when treating $N\text{-}NH_4^+$ because this group of microorganisms is sensitive to the operating conditions of the treatment system and has a slow growth rate [14-16]. Therefore, the water bodies in the Mekong Delta often face pollution problems due to $N\text{-}NH_4^+$ [9-14]. The presence of $N\text{-}NH_4^+$ can be toxic to aquatic organisms at high pH and can cause eutrophication [8].

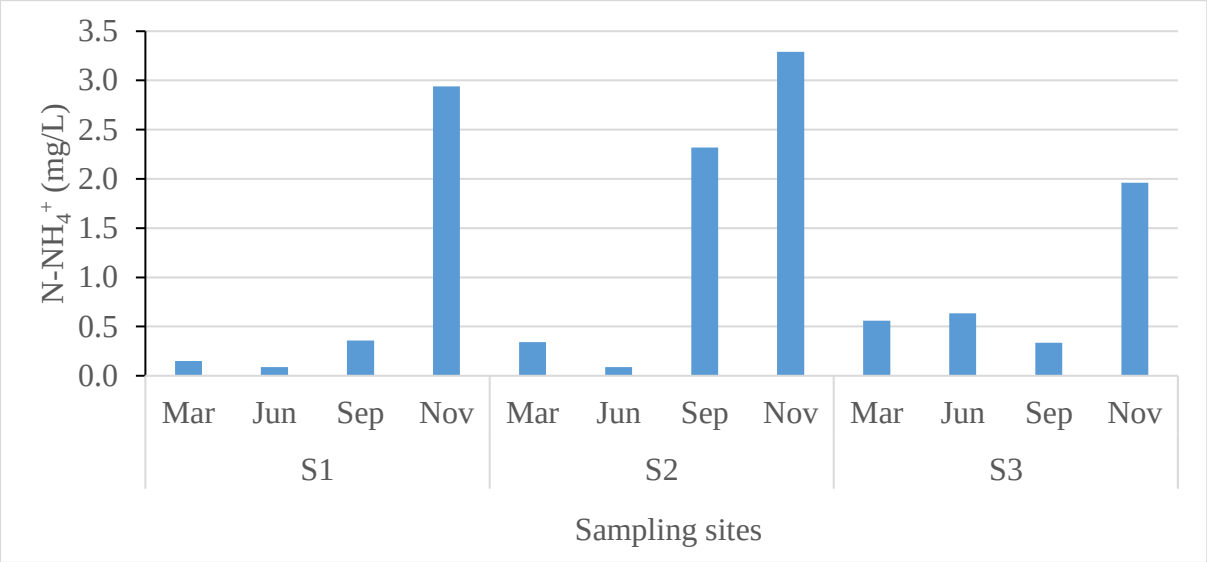

Figure 6. N-NH_4^+ in the water bodies influenced by industrial wastewater effluent

The density of coliforms in the surface water environment in industrial zones and clusters through monitoring in 2020 ranges from 4,300 to 46,000 MPN/100 ml (Figure 7). Coliforms at sites and between samples had values of 8,050-21,700 MPN/100 mL and 5,366-33,766 MPN/100 mL, respectively. Coliform has exceeded the allowable limit of QCVN 08-MT:2015/BNTMT, column A1 (2,500 MPN/100 ml) from 1.72 to 18.4 times. The coliform density on Tien and Hau rivers over the years 2011-2019 tended to increase, ranging from 2621±2379 to 11968±5615 MPN/100 mL [17] exceeding QCVN 08-MT:2015/BTNMT, column A1 from 1.1 to 6.5 times. The mean coliform value over 9 years exceeded the limit by 2.2 to 5.7 times. Former study by [18] showed that coliform in surface water of An Giang province in the period of 2009-2016 exceeded the allowable limit 2.14-7.02 times. In canals of Soc Trang province, coliform exceeded from 1 to 36 times [16]. The results show that the study area is contaminated with microorganisms and the water must be treated appropriately before use. The presence of coliform shows that river is receiving excreta from humans and animals [19].

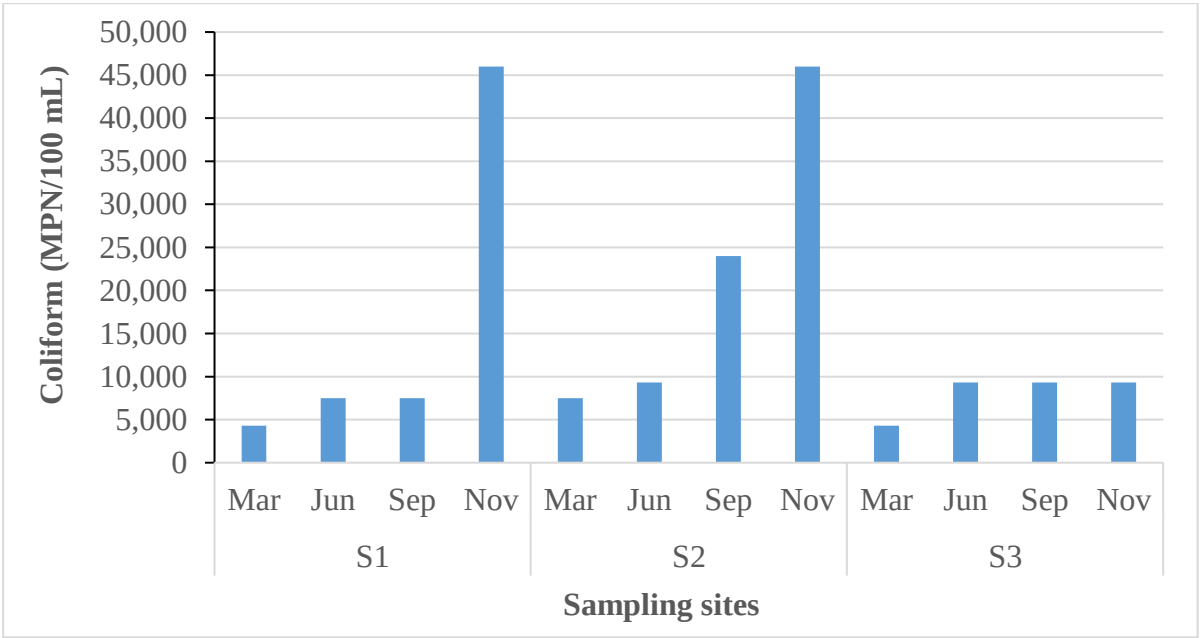

Figure 7. Coliform in the water bodies influenced by industrial wastewater effluent

3.2 Evaluating surface water quality using water quality index

The values of WQI is in the range of 0-100 classifying surface water quality into five levels. Level 1, WQI from 91-100, presents very good water quality that is considered good for domestic water supply purposes; Level 2, WQI from 76 to 90, shows good water quality suitable for use for domestic water supply but need suitable treatment measures; Level 3, WQI between 51-75, indicates moderate water quality to be used for irrigation and other equivalent purposes; Level 4, WQI values from 26 to 50, shows bad water quality used for navigation and other equivalent purposes; Level 5, WQI values from 10 to 25, shows poor quality so the water is heavily polluted, needing treatment measures in the future. Level 6, WQI value <10, shows very heavily contaminated water, and needs to be remedied and treated [7].

The results show that the WQI values on the water bodies in the study area range from 18-82 (Figure 7). The WQI classifies water quality from poor to good, with moderate water quality on average. Water quality affected by wastewater from industrial zones and clusters in 2020 according to the WQI index ranges from heavy pollution to the level of use for domestic water supply, but appropriate treatment measures are required. Most of the water quality is suitable for irrigation. Surface water quality in Binh Long-S1 industrial park and My Quy-S2 industrial cluster tends to decrease gradually through each monitoring period of the year and especially in November – water quality is heavily polluted and needs to be continued. continue to monitor and monitor regularly to detect and promptly handle incidents that occur. The reason that the water quality according to the WQI index at the monitoring location falls into a heavy pollution level is due to the high concentration of coliform in the water, the parameters participating in the WQI calculation such as COD, BOD, N-NH_4^+ and WQI. coliform has an excess value resulting in a very low WQI value ($10<WQI\leq25$). With this water quality, people should not directly use the water source for drinking, but need to take measures to treat it before using or use another water source to replace it.

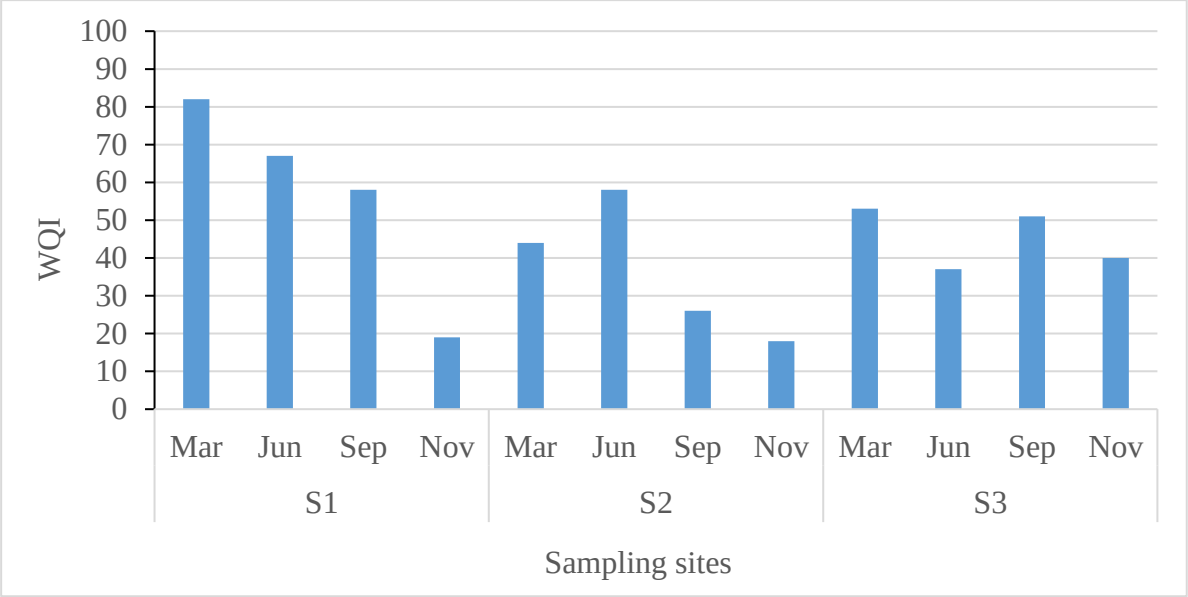

Figure 8. WQI in the water bodies influenced by industrial wastewater effluent

4. Conclusion

In summary, surface water quality in industrial zones and clusters in 2020 is not guaranteed well according to QCVN 08-MT: 2015/BTNMT, column A1 - National technical regulation on surface water quality. The current results showed that the water quality was polluted because the parameters TSS, COD, BOD, N-NH_4^+ and coliform exceeded the permissible limits. The parameters

of temperature, pH, oil and grease are still within the allowable limits. The WQI index (18-82) ranges from the level of heavy pollution to the level of use for domestic water supply, but appropriate treatment measures should be applied, most of which are suitable for irrigation. The finding shows that wastewater from industrial activities has an adverse impact on surface water quality, requiring timely treatment solutions to ensure safe water use. From the research results, the author recommends that people should not directly use river water in this area for domestic purposes, but need to have appropriate measures and water treatment technology to ensure health safety.

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