



Water quality assessment using water quality index: a case of the Dong Nai river- sections flow through Bien Hoa city

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ABSTRACT

Over the past few years, there are many activities had negative impacts on the surface water of the Dong Nai river such as industry, agriculture, and service development activities; Therefore, river water quality is significantly relieved. This study was conducted to evaluate the effect of elements on the water quality in Bien Hoa City, Dong Nai Province. Analyze the parameters of pH, temperature, DO, BOD₅, COD, N-NH₄⁺, P-PO₄³⁻, TSS, turbidity, and total Coliform on 54 samples from Jan to Dec in 2022. The water quality index (WQI) and statistical analysis were applied to explore and determine the water quality in Bien Hoa City. The results of the study indicated that the water quality of Dong Nai river is not quite good, most parameters reach the limit value B1 according to QCVN 08:2015/BTNMT; however, the values of parameters DO, total coliforms, TSS exceed the limit value B1 significantly. WQI values fluctuate at a fairly high level from 17 to 68, and the average WQI of the river reaches is quite low, so the authority should have promulgated the law to protect the water surface of this river; Therefore, water quality assessment is significant for better control and management of the surface water environment in Vietnam.

Keywords: Dong Nai river, WQI, surface water quality, Bien Hoa city, water quality index

1. Introduction

Water resources play an essential role in the living environment, determining the existence and sustainable development of all production and living activities of people.

Rivers are one of the critical channels for human survival that have a unique role in the origin and development of human societies. They have always been well thought-out as valuable freshwater resources for life because most of the activities under development depend on them to date. Additionally, ancient people have thrived along with them. Rivers supply water for different uses, including industry, agriculture, drinking, aquaculture, public water supply, and transportation, among others. Currently, under the pressure of population growth and the demand for socio-economic development which has negative effects on the water resources such as increasing flow of flash floods, the depletion of water in the dry season, deterioration of water quality and wastewater contamination will tend to be increasingly depleted if it is not protected. (Ackah, 2011)

Recently, The Dong Nai River is a source of supplying water for Ho Chi Minh City, Bien Hoa City, and industrial areas. However, the status of the Dong Nai river has been seriously polluted which was caused by emission sources from urban areas, industrial zones, etc. Dong Nai River not only has the basic function of draining floods from upstream but also plays a very important role in water supply for hydropower, and economic-social activities for the entire Southeast region. However, according to many research results on the water quality of Dong Nai River in recent years, the pollution of the river section is increasing which seriously threatens the water supply capacity for economic development. Society. Bien Hoa City is an industrial city located near Dong Nai River where wastewater generated from public, agricultural and domestic activities is mostly discharged directly or indirectly into the Dong Nai River. According to experts, Bien Hoa City is one of the areas with the most important influence on the water quality of the Dong Nai River, especially the section of the Dong Nai River flowing through this city.

Water Quality Indices (WQI) are widely used as convenient parameters for the assessment of the quality of surface water. This is a simple method which helps to reduce a large set of data to a single value which can be further applied to determine the general water quality status (Wu et al., 2018). Usually, major inorganic chemical parameters such as total phosphorous, nitrates, chlorides, alkalinity, total dissolved solids or total hardness are taken into consideration together with physical parameters (pH, electrical conductivity, dissolved oxygen, turbidity), as well as organic matter indicators (biological oxygen demand, chemical oxygen demand). WQI is used to evaluate the quality of water in rivers streams or even lacustrine water bodies (Zotou et al., 2020). In Vietnam, WQI is selected to calculate and assess water quality for Hau River (Ut Ngoc Vu et al., 2021), Ray River (Phan Thi Thanh Thuy et al., 2021), Sai Gon River (Nguyen Thong et al., 2022) with parameters like DO, BOD₅, COD, NH₄⁺, PO₄³⁻, TSS, Tur, Coli, and pH.

This study will provide an effective method for rapid, quantitative, and sustainable water quality management in Dong Nai river. These results reflect the current status of the river's water source and help the authorities to take timely measures to prevent and deal with the pollution problem.

2. Materials and methods

2.1. Sample collection and analysis

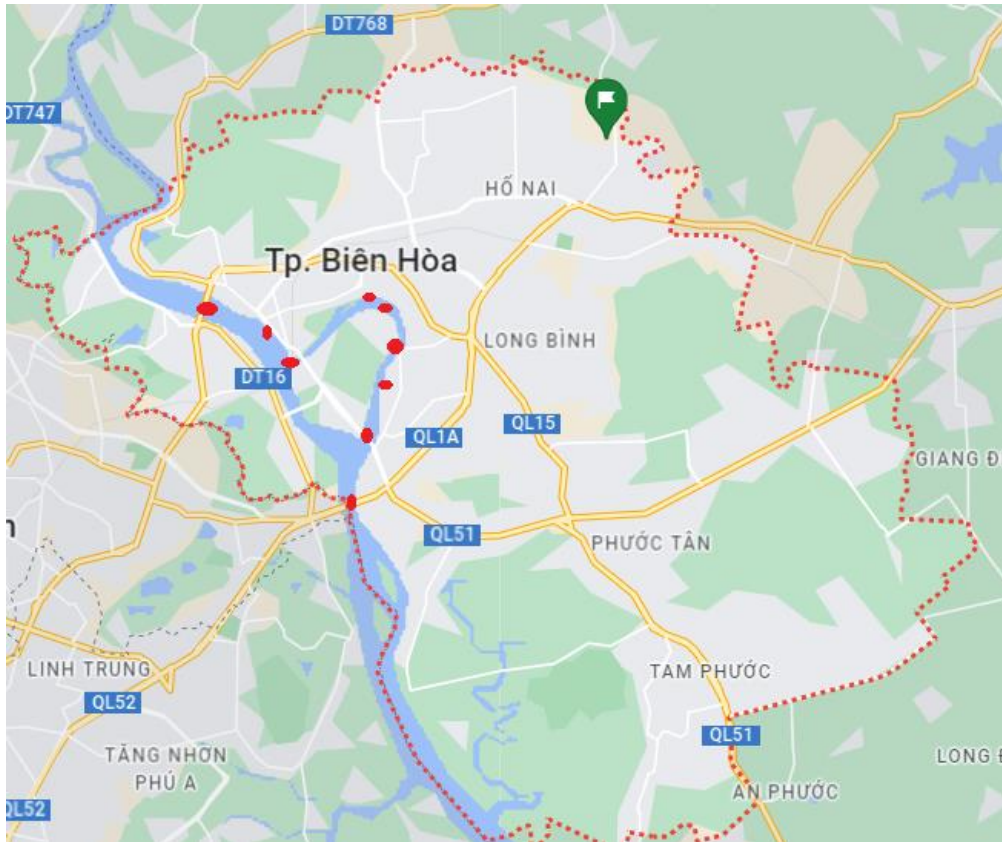


Fig 1. Water sampling location in the Dong Nai river in Bien Hoa city

The water quality parameters were taken once a month from January to December 2022. Water samples were collected from the first 20-30 cm of the water column along the Dong Nai River in Bien Hoa city at each site using a pre-sterilized two-liter plastic bottle, repeatedly washed with water from those sites and tested for some physical and chemical water quality parameters which are required for this study according to TCVN 6663-6 : 2008 (ISO 5667-6 : 2005) and TCVN 6663-3 : 2008 (ISO 5667-3 : 2003). Nine monitoring sites of the Dong Nai river (abbreviated to VT1- Hoa An Bridge, VT2- Dowaco Bien Hoa plant, VT3-Rach Cat Bridge, VT4-In the middle of Tan Mai village, VT5-At the sewage drain of Tan Mai paper company, VT6- Confluence of San Mau Stream and Song Cai River, VT7- Confluence of Linh Stream and Song Cai River, VT8- An Hao wharf, and VT9-Dong Nai Bridge) with 10 parameters including water temperature, pH, TSS, DO, BOD₅, COD, N-NH₄⁺, P-PO₄³⁻, turbidity, and total Coliform were analyzed in 2022. All samples were kept at 4⁰C prior to analysis. Values used for each parameter are the mean value of the three sites under this investigation. Parameters like surface water temperature, pH, and DO were measured by the water quality checker WQC 22A (TOA, Japan) while BOD₅, COD, N-NH₄⁺, P-PO₄³⁻ were determined by UV spectrophotometer Jasco V770.

2.2. Application of the WQI

In the formulation of WQI, the importance of various parameters depends on the intended use of water; here, water quality parameters are studied from the point of view of suitability for human consumption. The ‘standards’ (permissible values of various parameters) for the irrigation water used in this study are those recommended by the QCVN08:2015/BTNMT. Among 13 physicochemical, the development of WQI for the Dong Nai River was based upon ten water quality parameters such as temperature, pH, TSS, DO, BOD₅, COD, N-NH₄, P-PO₄, turbidity, and total Coliform (Wu, Z et al., 2018; Pham Thi Thanh Thuy, 2021) using the following formula:

$$WQI = \frac{WQI_{pH}}{100} \left[\frac{1}{5} \sum_{a=1}^5 WQI_a \times \frac{1}{2} \sum_{b=1}^2 WQI_b \times WQI_c \right]^{1/3}$$

Where

- BP_i: The lower limit concentration of the observed parameter value specified in the table corresponding to level i.
- BP_{i+1}: The upper limit concentration of the observed parameter value is specified in the table corresponding to the level i+1.
- q_i: The WQI value at level i given in the table corresponds to the BP_i value.
- q_{i+1}: WQI value at i+1 level given in table corresponds to BP_{i+1} value.
- C_p: The value of the observed parameter is included in the calculation.
- WQI receives the value between 1 (the worst water quality) and 100 (the best water quality).

The computed WQI values could be classified as 91-100 = Excellent; 76 -90 = Good; 51-75 = Medium; 26-50 = Poor; 0-25 = Bad.

3. Results and discussion

3.1. Water quality analysis results in Dong Nai River at Bien Hoa City

The results of water quality analysis results from January to December for ten parameters showed that an indication of the water quality deterioration was observed in the Dong Nai river at Bien Hoa city as parameters did not meet the Vietnamese regulation for surface water QCVN 08:2015 type B1 such as TSS, DO, and Total Coliform while the remaining parameters are within the limit value B1 which is well used for irrigation purposes of the citizens.

The values of pH from all the sampling sites in Dong Nai river at Bien Hoa city ranged from 6,0 to 67,4; N-NH₄ and P-PO₄ were not high from January to December due to little impact on domestic wastewater; to be specific, the range of ammonium levels was

between 0.101 and 0.283 mg/L; the phosphate values varied from 0.012 to 0.081 mg/L, phosphate enters the river ecosystem mainly through domestic wastewater, and agricultural runoff containing fertilizers; In general, the phosphate levels were found in very low concentrations in this river. The organic pollution was also relatively severe in surface water, with the mean value of COD being 7.0 mg/L and 25 mg/L while the value of COD at the sewage drain of Tan Mai paper company is the highest (25,3 mg/L); the BOD₅ values ranged between 4 and 14 mg/L; These parameters were within the allowable range of QCVN 08-MT: 2015/BTNMT type B1.

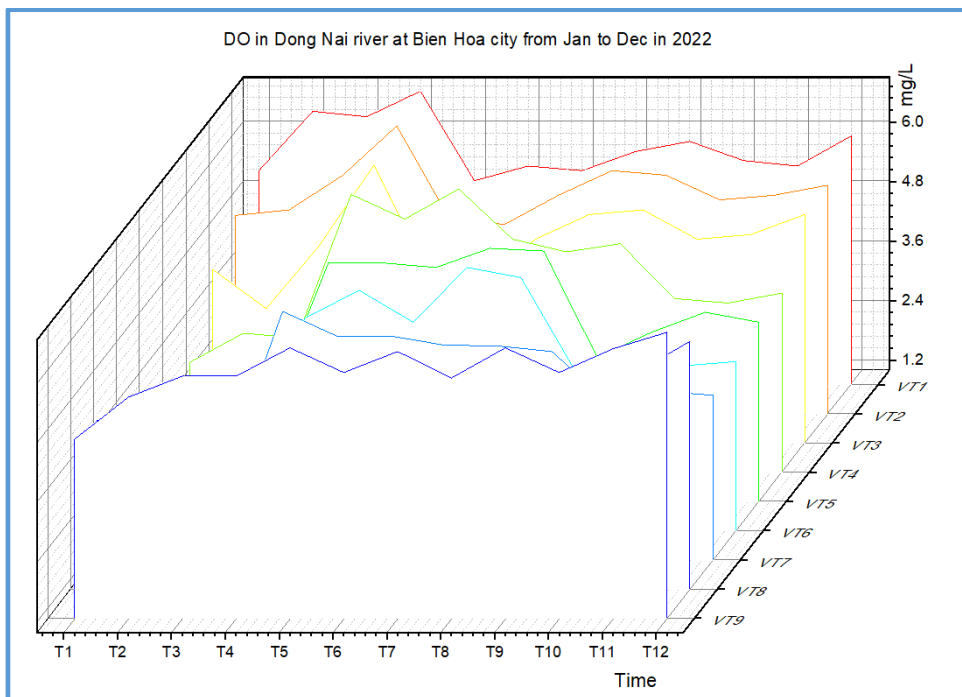


Fig 2. DO in Dong Nai river, sections flow through Bien Hoa city

The results of The Dissolved oxygen analysis results once a month at Dong Nai river, sections flow through Bien Hoa city (Fig 2) showed that:

The Dissolved oxygen values varied from 3,1 to 6,9 mg/L, the low values of the dissolved oxygen at sampling site VT5- At the sewage drain of Tan Mai paper company, and VT8- An Hao wharf, especially in March-April can be attributed to organic waste, and mainly the untreated sewage from the industrial activities. Any release of raw sewage into a river is accompanied by a decrease in dissolved oxygen content because bacteria, which use the sewage as a food source, grow in number and respire. This respiration rapidly uses up oxygen in the water and can lead to fish kills. In addition, DO of a water body depends on numerous factors like temperature, photosynthetic activity, wind action, the respiratory process of the life's creature, and pollution load. The reduction in dissolved oxygen along the Dong Nai river indicates that the deoxygenation rate caused by the biological decomposition of organic matter is higher than the re-oxygenation rate from the atmosphere.

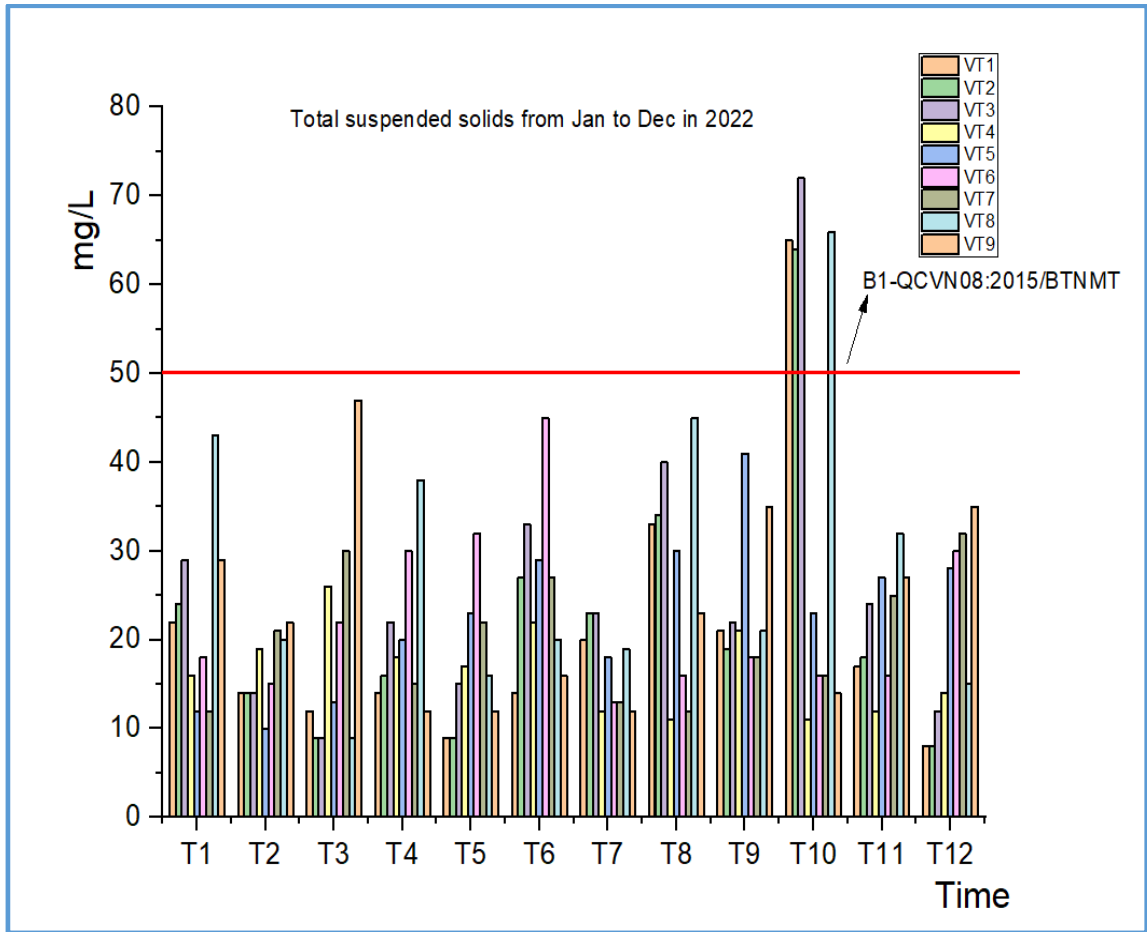


Fig 3. Total suspended solids from Jan to Dec 2022

The results of Total suspended solids results in analysis from Jan to Dec 2022 at Dong Nai river, sections flow through Bien Hoa city (Fig 3) showed that:

The TSS was relatively high in the selected locations, the TSS values were between 9 and 66 mg/L, and most of the samples were within the allowable range of QCVN 08-MT: 2015/BTNMT type B1, without sampling site VT1-Hoa An Bridge, VT2-Dowaco Bien Hoa plant, VT3-Rach Cat Bridge and VT8- An Hao wharf in October. Total suspended solids are a measure of water clarity and are affected by the amount of material suspended in water. As more material is suspended, less light can pass through, making it less transparent. Suspended materials may include soil, algae, plankton, and microbes. TSS are the most visible indicators of water quality. These suspended particles can come from soil erosion, runoff, discharges, stirred bottom sediments, or algal blooms. While it is possible for some streams to have naturally high levels of suspended solids, clear water is usually considered an indicator of healthy water. A sudden increase in TSS in a previously clear body of water is a cause for concern. Excessive suspended sediment can impair water quality for aquatic and human life, impede navigation and increase flooding risks.

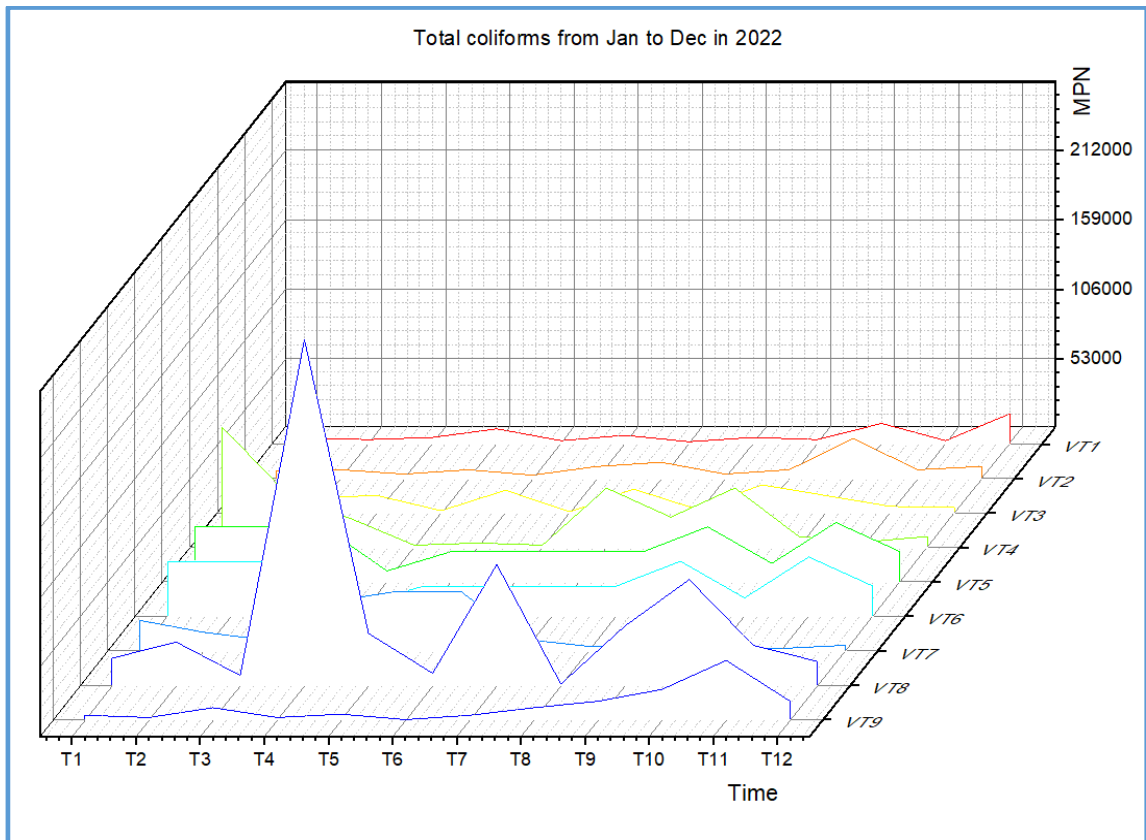


Fig 4. Total coliforms from Jan to Dec in 2022

The results of Total coliforms results in analysis from Jan to Dec 2022 at Dong Nai river, sections flow through Bien Hoa city (Fig 4) showed that:

Regarding the Coliform whose standard of surface water is quite high, it is found that the surface water samples were over the maximum allowance in most samples. The total coliform values ranged between 930 and 260000 MPN/100 mL. Total coliform counts give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste.

The result of the fuzzy comprehensive evaluation model (FCE) based on the Entropy weight method was built to calculate pollution levels for 18 monitoring sites of the Dong Nai River with 7 parameters in the period 2005 – 2012 showed the water quality Dong Nai River is ranking – as medium pollution. (Le Hoang Bao Tran et al., 2014)

The results of the water quality status and evaluation of wastewater receiving capacity in Dong Nai river (2012-2016) showed that polluted concentrations such as TSS and Fe exceeded the river’s wastewater receiving capacity. Almost all of the parameters were exceed available wastewater receiving loads of TSS, COD, BOD₅, NH₄⁺, coliform bacteria, and Fe (Nguyen Thi Hang et al., 2018).

3.2. Calculation of water quality index (WQI) of the

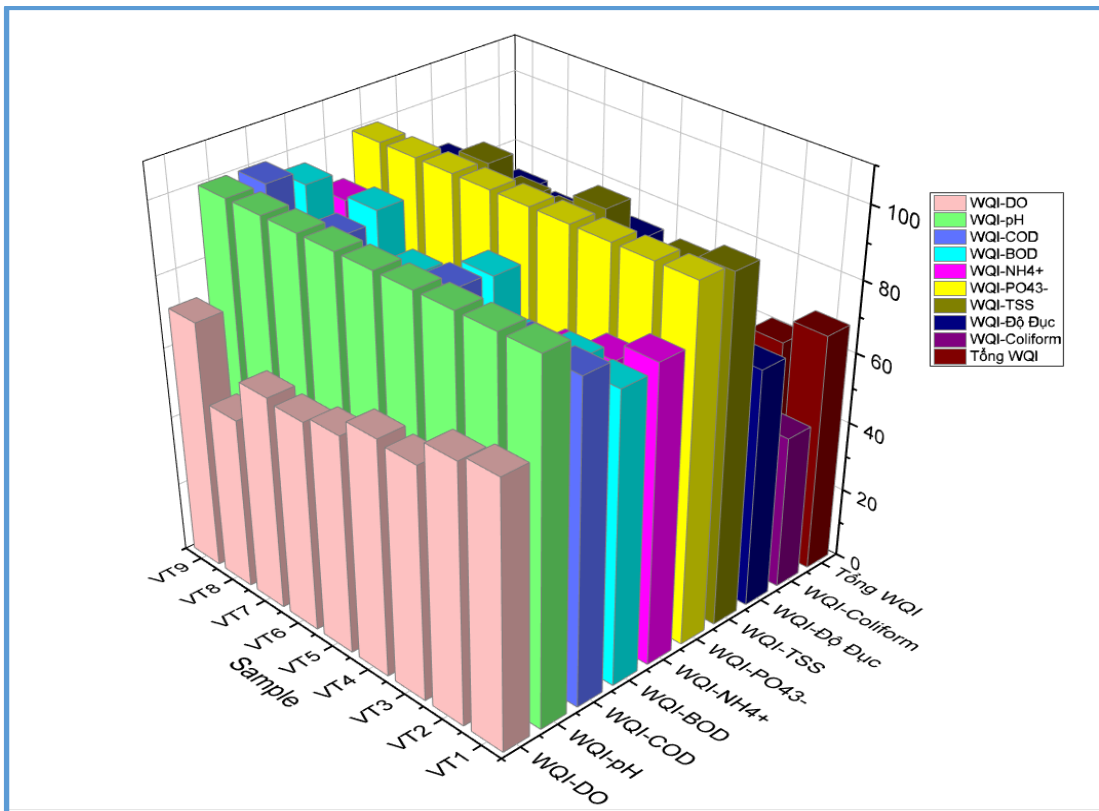


Fig 5. Water quality index (WQI) of the Dong Nai river, sections flow through Bien Hoa city. Water quality indices (WQIs) were calculated for the samples using the concentration of 10 parameters such as temperature, pH, DO, COD, BOD5, TSS, N-NH₄⁺, P-PO₄³⁻, turbidity, total Coliform. The WQI value (Fig. 5) of Dong Nai river ranges from 17 to 68 and reflects not good water quality in different location samples during the entire study period. The low value of WQI in 2022 indicates the deterioration of this river’s water quality. The sample collected at locations VT1 and VT2 was of medium and was classified as “III” category. Besides, all the sampling areas at VT3-VT9 of the Dong Nai River were the most polluted since their WQI has the lowest value (Figure 5). This is due to the results of the expansion of industrial activities, agricultural activities, and the increased use of fertilizers, agrochemicals. On the other hand, the high organic load from domestic and livestock wastewater has seriously polluted the Dong Nai River.

The results of calculating the WQI (Water Quality Index) from the water quality monitoring data on the Dong Nai River from the Nam Cat Tien ferry terminal to mui Den Do during different periods from 2014 – 2016 showed that the WQI ranged from 46 to 100, usually from 79 to 100, especially low in residential and industrial areas, showing many variations in water quality. Based on this result, the interpolation map of surface water quality in the studied area was created, creating more data sources for the management of surface water resources in Dong Nai. (Chau Hong Tham et al, 2020).

4. Conclusion

This study aims to assess the water quality once a month at the Dong Nai River and to determine ten parameters main parameters that influence water quality, which is considered for the prediction of the WQI at the nine locations. The WQI values of Dong Nai River, water ranged from 17 to 68; in which, most of the water samples fell in medium and bad water quality (class III, IV, and V) because of industrial wastewater and domestic wastewater in this area. Accordingly, the Dong Nai River water quality needs to be treated for public water supply. Water quality in the study area is gradually reaching an alarming stage so proper planning is essential to this venture to preserve the source water quality. The formula for calculating WQI for Dong Nai River only evaluates some parameters, so it does not accurately represent the real quality of river water; therefore, further studies are needed to accurately assess the water quality here.

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