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## MONITOR CHANGES IN THE QUALITY OF DONG NAI RIVER WATER DURING THE SEASONS

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**ABSTRACT**

The method of using WQI index to assess water pollution is used by many researchers. values of BOD5, COD, N-NH4, P-PO4, TSS, turbidity, total coliform, DO, pH, were used to calculate WQI index. Based on the value of WQI obtained, water quality is assessed in the study area. The method of determining WQI is based on the guidelines of the Ministry of Natural Resources and Environment of Vietnam. The results determine the extent and distribution of surface water pollution in the study area. At heavy polluted water levels (WQI≤25), pollutants are mainly caused by Coliform and Turbidity. At a lower level of pollution, water is only used for waterway purposes with pollution of many factors including turbidity, coliform, TSS, COD, DO, N-NH4. At the level of water only for agricultural usage, there are factors causing pollution. At the water level for drinking water, additional cleaning is required, the order of pollution decreases in the order of COD> Turbidity> DO> BOD5.

**Keywords**: Water pollution, WQI, Surface water, Dong Nai River, water quality.

### Introduction

Water is an important component for the existence of flora and fauna in the biosphere (Kakar et al., 2010). Two-thirds of the earth's area is covered by water. This is an extremely valuable resource for people. However, people are not really aware of the value of this resource. One way or another, they are polluting the water more and more seriously with domestic waste, industrial and urban wastewater (Mahmood, 2006). The river plays a major role in assimilating or carrying industrial and urban wastewater (Stroomberg et al., 1995; Ward and Elliot, 1995). The river forms the main water supply for drinking, irrigation and industrial purposes. Agricultural, industrial, domestic and urban wastes can penetrate river and lake water through leachate, runoff, wastewater and dry deposition (Biney and Christopher 1991; Okoye et al. 1991). Water pollution not only affects water quality, but also threatens human health, economic development and social prosperity. According to World Health Organization (WHO), about 80% of all human diseases are caused by water (WHO, 2004). Concentrations of pollutants in which the system has led to bioaccumulation of toxic metals and serious environmental problems, threatening aquatic organisms and human health (Sasmaz et al., 2008).

The use of contaminated water in large city surroundings for growing vegetables is a common habit. Although it is considered a rich source of organic matter and plant nutrients, it also contains enough soluble salts and metals such as iron, manganese, copper, zinc, etc. Water is used to irrigate crops for a long time, these metals can accumulate in the soil and that could be toxic to plants and also cause soil degradation (Perveen et al., 2006). A variety of contaminants including toxic metals, especially copper and zinc are reported to be ubiquitous in rivers and reservoirs and are detrimental to aquatic organisms (Olsson, 1998). Monitoring of surface water pollution is meaningful in the context of human health is increasingly affected because of polluted water.

Dong Nai province is a province with many industrial parks and residential areas with high density (1060 people/ $km^2$). Therefore, the amount of wastewater discharged into the environment is huge. According to the statistical report of Dong Nai Department of Natural Resources and Environment, the total amount of industrial wastewater in the province is about 129,000 $m^3$/day. The total amount of domestic wastewater is about 190,000 $m^3$/day, particularly in Bien Hoa City, about 80,000 $m^3$/day. Wastewater flow of medical facilities is about 5,076 $m^3$/day (environmental report of Dong Nai, 2015). Therefore, the current study is an attempt to monitor the water quality of Dong Nai River (Vietnam).

### Materials and methods

21 samples of river water were collected. Sampling locations were scattered along the length of the river, especially the river section through Bien Hoa

city, the sampling points were enhanced. River water samples were collected by taking water from three locations: Left bank, right bank and middle river. It will then be mixed with the water obtained from these three locations and this used as a model for analyzing water samples. Sampling time was in early February; April; June; September and December of the year.

Sample collection method: use 1000 ml plastic bottle. Before sampling the bottles are washed with water to sample and the sample is preserved by acidifying to pH*2 with HNO3 and kept at 4°C until analysis.

According to analytical data on the frequency of selection of parameters to assess surface water quality of some researchers on surface water quality in the world. It can be seen that the DO, BOD, pH, N-NH4, Temperature, TSS, Coliform, Turbidity indexes are most commonly used.

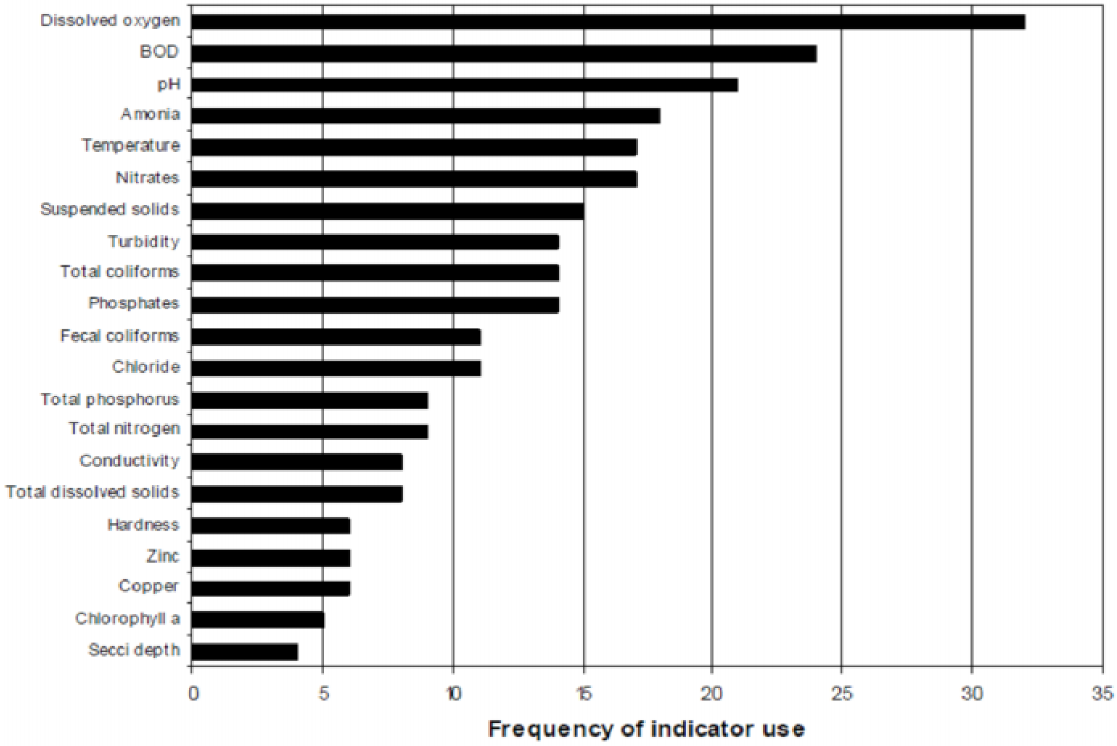


*Figure 1. Frequency of using parameters in surface water quality assessment (P.M.Hanh 2009).*

According to monitoring data from 1998 to 2016 in Vietnam, the frequency of parameters is: 7.25% of samples with pH measurement; DO: 64.17%; TSS: 50.25%; Turbidity: 73.84%; BOD5: 43.65%; COD: 45.54%; Total coliform: 68.02%; N-NH4: 65.62%; P-PO4: 36.27%; Fe: 46.52% (P.M.Hanh 2009; N.T. Loc, 2014; T..Tang, 1998, 2007; L.Trinh, et all, 2016; The Mekong river card on water quality, Volume 2).

Based on the above analysis, we selected 8 parameters including dissolved oxygen index (DO); BOD (Biochemical oxygen Demand) biochemical demand; Chemical oxygen demand COD (Chemical Oxygen Demand); Total suspended solids TSS (turbidity & suspendid solids); Turbidity (Turbidity); N-NH4; P-PO4; Total coliform. These parameters are analyzed in the laboratory. In addition, the pH and temperature of the sample are measured by a handheld meter at the sampling position.

**Method of pollution assessment**:

Using surface water quality assessment method (WQI) according to the standards of Vietnam Environment Administration, is implemented as follows:

Step 1: calculate the pollution index of each parameter ($WQI_{SI}$)

$WQI_{SI}$ is calculated for parameters BOD5, COD, N-NH4, P-PO4, TSS, turbidity, total coliform by the following formula:

$$WQI_{SI} = \frac{q_i - q_{i+1}}{BP_{i+1} - BP_i}(BP_{i+1} - C_p) + q_{i+1}$$

(Formula 1)

In which: $BP_i$: The lower limit concentration of the observed parameter values is specified in table 1 corresponding to level i.

$BP_{i+1}$ The upper limit concentration of the observed parameter values is specified in table 1 corresponding to the i + 1 level.

$q_i$: WQI value at level i given in the table corresponds to $BP_i$ value.

$q_{i+1}$: WQI value at i + 1 is given in the table corresponding to $BP_{i+1}$ value.

Cp: value of monitoring parameters

Table 1

**Specifies the qi and BPi values**

| i | $q_i$ | BOD5 (mg/l) | COD (mg/l) | N-NH4 (mg/l) | P-PO4 (mg/l) | Turbility (NTU) | TSS (mg/l) | Coliform (MPN/100 ml) |
|---|---|---|---|---|---|---|---|---|
| 1 | 100 | ≤4 | ≤10 | ≤0.1 | ≤0.1 | ≤5 | ≤20 | ≤2500 |
| 2 | 75 | 6 | 15 | 0.2 | 0.2 | 20 | 30 | 5000 |
| 3 | 50 | 15 | 30 | 0.5 | 0.3 | 30 | 50 | 75000 |
| 4 | 25 | 25 | 50 | 1 | 0.5 | 70 | 100 | 10000 |
| 5 | 1 | ≥50 | ≥80 | ≥5 | ≥6 | ≥100 | >100 | >10000 |

In case the $C_p$ value of the parameter coincides with the $BP_i$ value given in the table, the $WQI_{SI}$ of the main parameter can be determined by the corresponding qi value.

Step 2: calculate WQI value for DO parameter ($WQI_{DO}$): calculated parameter through saturation DO value (DOBH) [Elmore & Hayes, 1960]:

$$DO_{BH} = 14.652 - 0.41022T + 0.0079910T^2 - 0.000077774T^3$$

Where T is the water environment temperature at the time of monitoring. The the value of DO percent saturation ($DO_{\%\,BH}$) is calculated as follows:

$$DO_{\%\,BH} = \frac{DO_{HT}}{DO_{BH}} * 100$$

where $DO_{HT}$ is the value of observed DO (in mg / l).

Table 2

**Defines $BP_i$ and qi values for $DO_{\%\,BH}$**

| i | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| $BP_i$ | <20 | 20 | 50 | 75 | 88 | 112 | 125 | 150 | 200 | >200 |
| $Q_i$ | 1 | 25 | 50 | 75 | 100 | 100 | 75 | 50 | 25 | 1 |

If the value $DO_{\%\,BH}$ <20 then $WQI_{DO}$ = 1

If 20 <$DO_{\%\,BH}$ <88 then $WQI_{DO}$ is calculated according to formula 2 and using table 2

If 88 <$DO_{\%\,BH}$≤112 then $WQI_{DO}$ = 100

If 112 <$DO_{\%\,BH}$≤200 then $WQI_{DO}$ is calculated according to formula 1 and using table 2

If the value $DO_{\%\,BH}$> 200 then $WQI_{DO}$ = 1.

$$WQI_{SI} = \frac{q_{i+1} - q_i}{BP_{i+1} - BP_i}(C_p - BP_i) + q_i \quad \text{(Formula 2)}$$

Step 3: calculate $WQI_{pH}$

Table 3

**Defines $BP_i$ and qi values for pH parameters**

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| BPi | <5.5 | 5.5 | 6 | 8.5 | 9 | >9 |
| qi | 1 | 50 | 100 | 100 | 50 | 1 |

If the pH value is <5.5, then $WQI_{pH}$ = 1.

If 5.5≤ pH <6 then WQIpH is calculated according to formula 2 and uses BPi and qi values in table 3.

If 6≤pH≤8.5 then $WQI_{pH}$ = 100.

If 8.5 <pH≤9 then $WQI_{pH}$ is calculated according to formula 1 and uses $BP_i$ and $q_i$ values in table 3.

If pH> 9 then $WQI_{pH}$ = 1.

Step 4, calculate the WQI composite pollution index

After calculating WQI for each parameter if above, the calculation of WQI is applied according to the following formula:

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

$WQI_a$ value WQI calculated for 5 parameters: DO, BOD5, COD, N-$NH_4$, P-$PO_4$

$WQI_b$ value WQI calculated for 2 parameters TSS, turbidity

$WQI_c$ WQI value of the total coliform parameter

$WQI_{pH}$ value $WQI_{pH}$

The value of WQI after calculation will be rounded to an integer.

Step 5

**Classify water quality level according to Table 4**

| WQI | Water quality level | color |
|---|---|---|
| 91-100 | Good to use for drinking water | Blue |
| 76-90 | Use for domestic water supply, but additional cleaning measures are required. | Green |
| 51-75 | Used for agricultural purposes | yellow |
| 26-50 | Use for waterways | Orange |
| 0-25 | Heavily polluted | Red |

**Results**

In February, about 33.3% of the sampling points had heavy pollution levels (7/21 sampling points have a value of WQI ≤25). Pollution points are mainly found in the river sections that flow through urban areas. According to the analysis of the results, all pollution points (WQI≤25) are caused by coliform (7/7 points have WQI-coliform ≤ 25). The remaining parameters have a high WQI index. The origin of coliform is mainly from domestic wastewater and wastewater from industrial zones. The number of monitoring points of WQI value within the water level for agriculture and aquaculture is 9.5% (2/21 monitoring points are worth WQI from 51-75). Pollution locations are mostly sample points located in transition areas from heavily polluted river sections. This is even more evident when most parameters are of high value (WQI> 75), only WQI-coliform values are relatively low (WQI = 27). Water quality that is good for domestic use accounts for about 57.14% of sampling points. Of which about 66% (8/12 points) is water at the level of domestic use but need additional treatment measures.

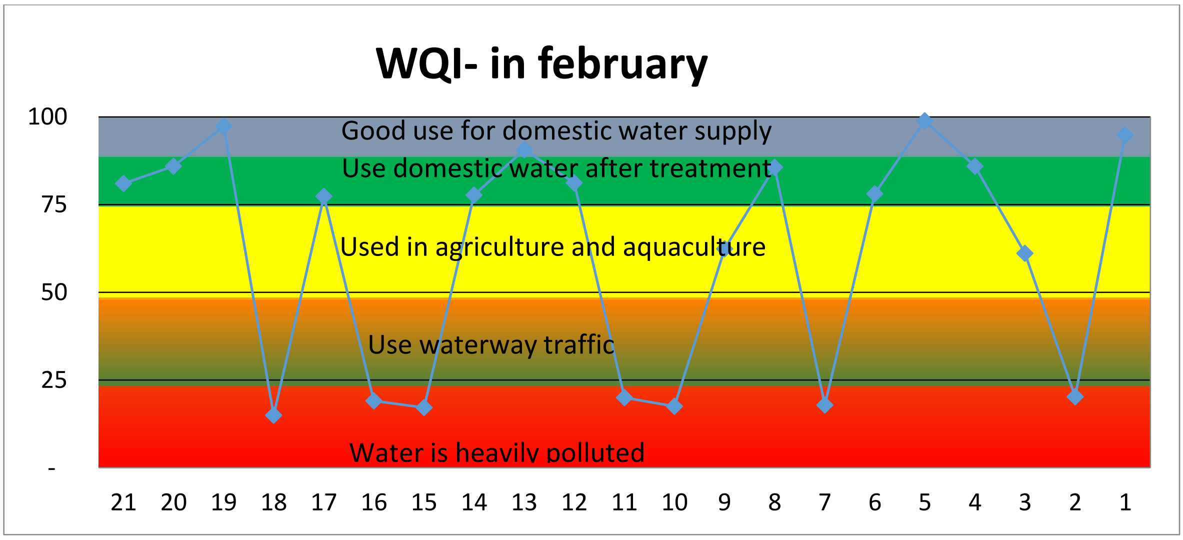


*Figure 2. Water quality at monitoring points in February*

Water pollution in April. About 23.8% of sampling points have very high pollution levels in April (5/21 sampling points have a value of WQI <25). All samples detected very heavy coliform contamination (WQI coliform <25). The remaining parameters are good. The number of monitoring points with WQI at the water quality level used for agriculture and fisheries accounts for 19.05% of the total sampling points (4/21 points). This level of pollution is mainly in the downstream of Dong Nai river. The cause of pollution is also due to the number of coliforms exceeding the permitted level (4/4 points with WQI-coliform = 27). The water quality is at a good level, using for domestic use accounts for about 58% of the sampling points (12/21 points). In which about 41.6% (5/12 points) is water at the rate of daily use but need additional treatment measures. This shows that, in April, water quality is better than in February. This could be explained by April being the dry season, the turbidity is reduced, and the water is cleaner.

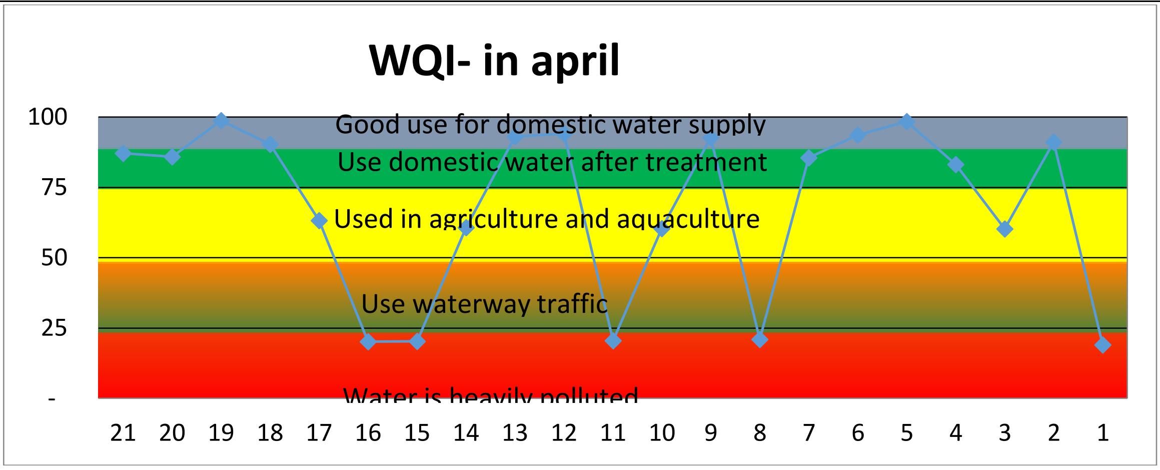


*Figure 3. Water quality at monitoring points in April*

Water pollution in June, about 47.6% of sampling points have very high pollution levels in June (10/21 sampling points have a value of WQI <25). These pollution points are mainly due to coliform levels of 10/10 points with coliform levels> 10000 MPN / 100 ml; 9/10 points have WQI turbidity <50. The quality of water used for agriculture and fisheries accounts for about 33.3% of the total sampling points (7/21 points 50 <WQI <75). Pollution is mainly caused by turbidity, coliform and TSS (7/7 points with WQI turbidity <50; 4/7 points of WQIcoliform <50, 3/7 points of WQIDO <50). Water quality is good, drinking water accounts for about 19.4% of sampling points (4/21 points). Of which 50% (2/4 points) is the water used for drinking water, but additional measures are needed. Pollution is mainly detected 2/4 points with WQIDOduc <75; 2/4 WQITSS points <75.

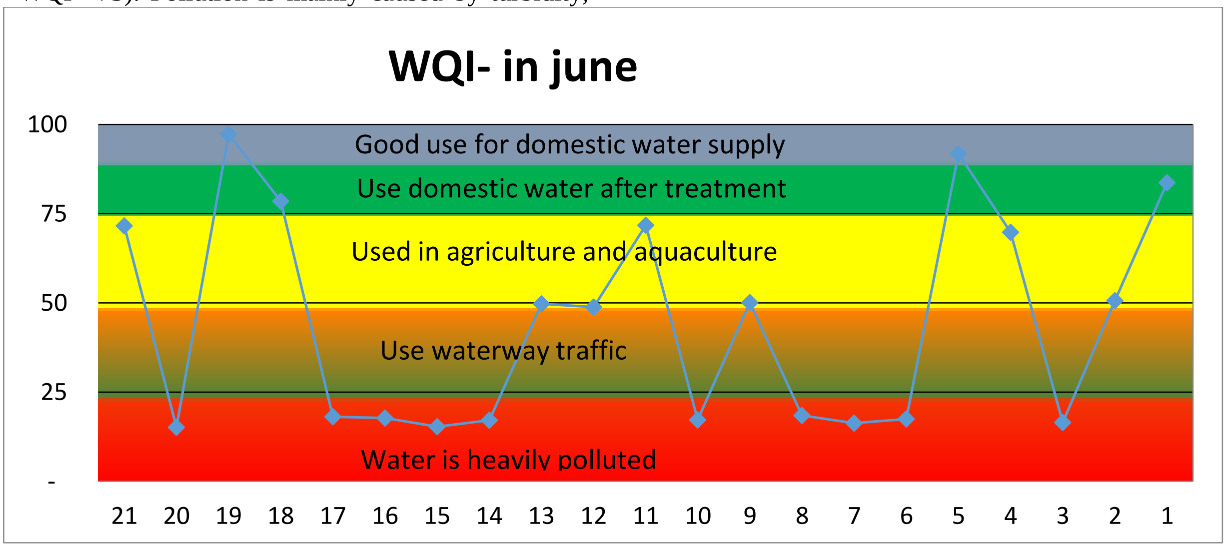


*Figure 4. Water quality at monitoring points in June*

Water pollution in September, about 38.1% of sampling points have very high pollution levels in September (8/21 sampling points have a value of WQI <25). These polluted sites are mainly due to 8 coliform contamination levels with coliform levels> 10000 MPN / 100 ml; 1/8 point has WQI turbidity <25. The level of water pollution is quite high (25 <WQI≤50), only for waterway purposes including 3/21 points, accounting for about 14.28%. Pollution is mainly caused by turbidity and coliform (3/3 points with WQIDoduc <50; 3/3 points of WQIcoliform <50). The remaining indicators are quite good (WQISI> 75). Water quality used for agriculture and fisheries accounts for about 14.3% of the total sampling points (3/21 points). Pollution is mainly caused by turbidity and coliform (3/3 points with WQI Turbidity <75; 3/3 points of WQIcoliform <75; 3/3 of WQITSS <75). Good water quality, used for drinking water accounts for about 33.3% of sampling points (7/21 points). Of which, about 71.4% (5/7 points) is the water used for drinking water, but additional measures are needed. Pollution is mainly detected by 7/7 points with WQI turbidity <90; 1/7 of WQITSS <90.

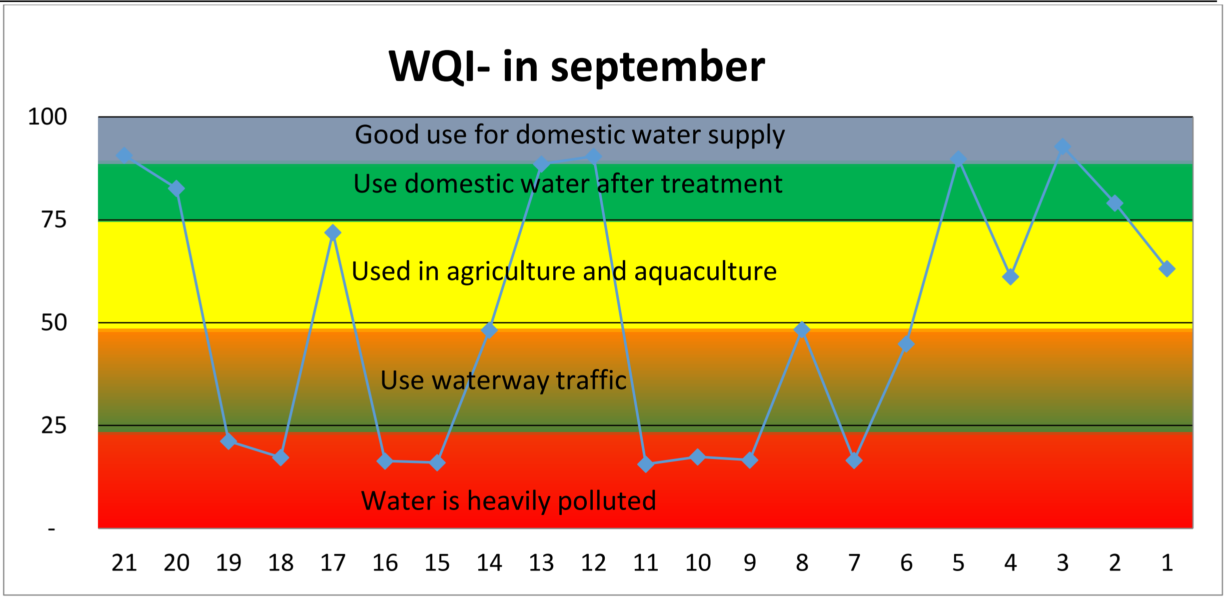


*Figure 5. Water quality at monitoring points in September*

Water pollution in December, about 28.5% of sampling points have very high pollution levels in December (6/21 sampling points have a value of WQI <25). These pollution points are mainly due to the coliform contamination levels of 6/6 points with coliform levels> 10000 MPN / 100 ml. Water quality used for agriculture and fisheries accounts for about 23.8% of the total sampling points (5/21 points). Pollution is mainly caused by turbidity, coliform, DO and TSS (4/5 points have WQI Turbility <50; 3/5 WQIcoliform points <50; 2/5 WQITSS points <50).

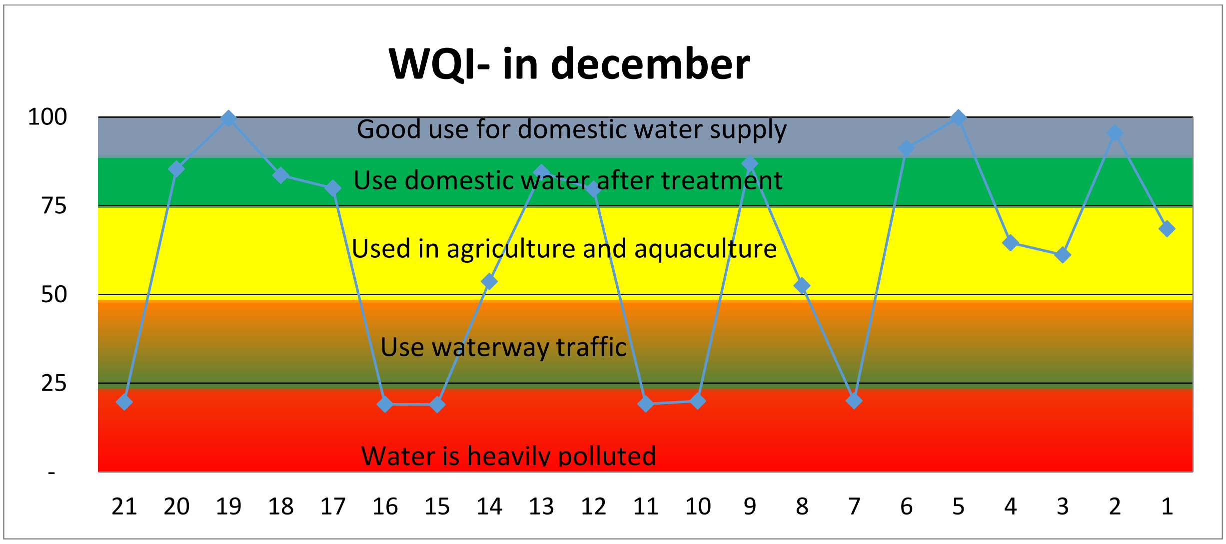


*Figure 6. Water quality at monitoring points in December*

Good water quality, for drinking water accounts for about 47.6% of sampling points (10/21 points). Of which about 60% (6/10 points) is the water used for drinking water, but additional measures are needed. Pollution is mainly detected 6/6 points with WQIDOduc <90; 2/6 WQITSS points <75; 3/6 WQIColiform points <90; 5/6 points WQIDO <90.

Table 5.

**Summary data of the number of monitoring points by WQI value**

| WQI | Febrary (%) | April (%) | June (%) | September (%) | Deceber (%) |
|---|---|---|---|---|---|
| 0-25 | 7 | 5 | 10 | 8 | 6 |
| 26-50 | 0 | 0 | 1 | 3 | 0 |
| 51-75 | 2 | 4 | 6 | 3 | 5 |
| 76-90 | 8 | 4 | 2 | 4 | 6 |
| 91-100 | 4 | 8 | 2 | 3 | 4 |

According to Table 5, the water quality of the months of the year varies. In which, water quality in April and December is considered to be much better than the water quality of the remaining months of the year. June has the most serious water pollution, mainly because this is the beginning of the rainy season, the water is heavily polluted by the turbidity of the water. According to the statistical results, the quality of water is heavily polluted in February at the positions (points 2,7,10,11, 15,16,18); April at points (1,8,11,15,16); June at points (3,6,7,8,10,14,15,16,17,20); September at points 7,9,11,15,16,18,19); December at points (7,10,11,15,16,21). As can be seen from points 11,15,16, the points are of high polluted water at all times of the year. These are the points surrounding the river flowing through the city. This indicates that domestic wastewater from urban areas has polluted water at almost every time of the year. Therefore, it is necessary to take measures to treat water from drains discharging into Dong Nai river.

Table 6.

**Statistics of the number of monitoring points by WQI value**

| WQI | WQI NH4 | WQI DO | WQI BOD5 | WQI COD | WQI PO4 | WQI TSS | WQI Turbidity | WQI Coliform | WQI pH |
|---|---|---|---|---|---|---|---|---|---|
| 0-25 | 0 | 0 | | | | | 9 | 36 | |
| 26-50 | 3 | 17 | | | | 7 | 41 | 16 | |
| 51-75 | 28 | 35 | 1 | 8 | | 30 | 13 | | |
| 76-90 | 26 | 13 | 13 | 29 | 1 | 15 | 27 | 16 | |
| 91-100 | 48 | 40 | 91 | 68 | 104 | 53 | 15 | 37 | 105 |
| tổng | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |

Statistical results of the total number of monitoring points in 2018 by WQI value are shown in Table 6. At high pollution levels (WQI≤25), mainly caused by Coliform (36 points) and Turbidity (7 point). At water pollution level only for waterways, in descending order of pollution: Turbidity> DO> coliform> TSS> N-NH4. At the water level used for agriculture, the pollution order decreases: DO> TSS> N-NH4> Turbidity> COD. At the water level for drinking water, additional cleaning is required, the order of pollution decreases in the order of COD> N-NH4> Coliform Turbidity> DO, DOD5.

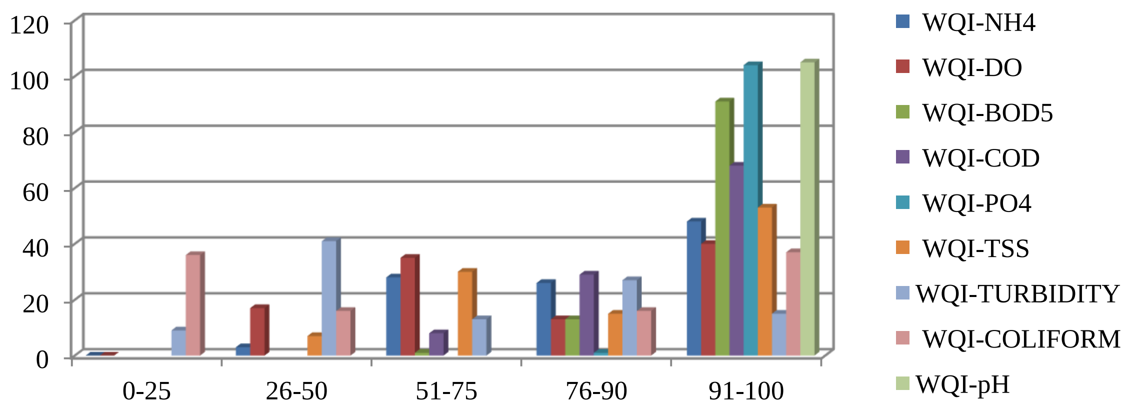


*Figure 7. Diagram showing the number of monitoring points by WQI value*

From the above analysis, it can be concluded that the cause of heavy pollution in the water is mainly due to coliform contamination and turbidity. At lower pollution levels, water is only used for waterway purposes, which is contaminated by many factors including turbidity, coliform, TSS, COD, DO, N-NH4. At the level of water only for agriculture, there are most of the factors causing pollution. It can be seen that most of the occurrence of pollution occurs in the river area running through Bien Hoa city area, with a population of more than 2 million people. A place to receive most of the domestic wastewater discharged by surrounding communities and industrial parks

**Conclusion**

Water quality differs from one month to another throught year. April and December have the best water quality. The area of water pollution is mainly in river areas that flow through residential areas and industrial zones. In general, water is mainly polluted by coliform and turbidity. Coliforms originate from domestic wastewater and industrial wastewater, especially river areas flowing through urban areas and industrial zones, so measures should be taken to treat this wastewater source, aiming to protect water quality of the river.

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## ПРОБЛЕМА ЗАТОНУВШИХ СУДОВ И ИХ ВЛИЯНИЕ НА ЭКОЛОГИЧЕСКУЮ ОБСТАНОВКУ АВАЧИНСКОЙ ГУБЫ

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## PROBLEM OF SHIPS AND THEIR INFLUENCE ON THE ENVIRONMENTAL SITUATION OF AVACHIN LIPS

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**АННОТАЦИЯ**
Цель: анализ «старения судна» и его влияние на экосистему Авачинской губы.
**ANNOTATION**
Purpose: analysis of the "aging of the vessel" and its impact on the ecosystem of the Avacha Bay.
**Ключевые слова**: Затонувшие (заброшенные) суда, фрагменты, собственник, утилизация, коррозия, экосистема, вред.
**Key words**: Sunken (abandoned) ships, fragments, owner, utilization, corrosion, ecosystem, harm.

В данной статье обсуждаются некоторые факторы воздействия на водную экосистему затонувших (заброшенных) судов, оставшихся в водном объекте (в рассматриваемом случае – Авачинской губе) без дальнейшего изъятия и утилизации.

Авачинская губа была открыта в 1703 году русскими казаками во главе с Родионом Преснецовым. С тех пор много лет она являлась укрытием для различных судов во время штормов.

Но, так же, как и многие прибрежные акватории Мирового океана, Авачинскую губу не обошел печальный опыт кораблекрушений, а в дальнейшем - и халатного отношения к природе.

Согласно неофициальным данным, в Авачинской губе в настоящее время находятся порядка 100 заброшенных (затопленных) судов и их фрагментов. Большая часть их находится в «подтопленном» состоянии, а некоторое количество полностью погружено на дно Авачинской губы [2]. Условно уже существуют «площадки» заброшенных судов, основное скопление которых выявлено в районе мыса Санникова, в бухтах Крашенинникова, Сельдевая, Южная.