Research Paper

METHOD OF CALCULATION & APPLICATION OF WQI INDEX TO ASSESS THE STATUS WATER QUALITY AND PROPOSAL OF MANAGEMENT LUY RIVER BINH THUAN PROVINCE

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ABSTRACT

The objective of this study is to apply the WQI index to assess the quality of Luy river surface water flows through Binh Thuan province and propose solutions to improve surface water quality in accordance with the society economic development Binh Thuan. Quality of Luy river water most of the parameters in the upstream areas reach A2 column; QCVN 08-MT: 2015/BTNMT, except BOD_5 and COD exceeding 1.07 - 2.83 times, while downstream only meets the level of B1 column. WQI values have large fluctuations in space and time, WQI in monitoring positions from 53 to 91 (June, 2018).

How to manage and protect water resources both in quantity and quality, to ensure the society economic development with the protection of water resources . To solve this problem it is necessary to assess the needs of water use, identifying the factors likely to impact water resources, pollution assessment based on existing standards or models Vietnam and proposed environmental protection measures to ensure appropriate quality water for society economic development - Binh Thuan province. This paper focuses on assessing water quality Luy river from 2016 to present.

Keywords: *Luy River Binh Thuan, water quality index, assessment, evaluate.*

1. Introduction

In order to assess and determine the level of pollution of surface water resources in the river Luy in Binh Thuan province, the paper presents the selection and application of WQI water quality assessment method according to Decision No. 879/QĐ - TCMT July 1, 2011 of the General Department of Environment on promulgating a manual to calculate water quality index to assess the pollution level of surface water resources, and evaluated according to QCVN 08:2015/BTNMT.

Calculation and application of WQI index to assess the changes in Luy river water quality, propose solutions to sustainable management of water resources for Binh Thuan socio-economic development.

2. Materials and methods

2.1. Concept

The Water Quality Index (WQI) (Decision, 2011), is one of the types of environmental indicators (Environment Index), classified by arithmetic or according to the ability to describe a large number of data and information about Water Environment.

2.2. Advantages of WQI in evaluating water quality developments

The use of WQI overcomes the limitations in the way of evaluating the study of water quality

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according to the traditional method is to apply standards and norms for each individual parameter. From the references on water quality research method using WQI index, it is possible to synthesize and evaluate the advantages and limitations of this method compared with the method of comparison with standards and norms.

2.3. Overview of development history of water quality index method

WQI was first proposed in the US in the years 1956-1970 and is widely applied in many states. Currently many WQI models have been studied and applied in many countries such as India, Chile, England, Wales, Taiwan, Australia, Malaysia and so on. WQI is considered an effective tool for environmental management. in water quality monitoring, water resource management (Huynh, 2018).

From the 70s to the present, in the world, there have been hundreds of works of research and development and application of the WQI model for their country or locality in one of three directions:

- Apply the available WQI model to your country or locality;
- Applying to improve a new WQI model for your country or locality;
- Research and develop a new WQI model for your country or locality.

In which, the first two directions are suitable for application in developing countries because they are less expensive in terms of manpower, time and finance.

2.4. Calculating water quality index

There are many methods for calculating water quality indicators such as the basic model of Bhargava (Bhargava - WQI), the basic model of the US National Sanitation Fund (NSF - WQI), NFS Model - WQI adjusting pressure. for Ho Chi Minh City (NFS-WQI/HCM) (MONRE, 2008) (Huynh, 2018). However, in the article, choosing how to calculate the water quality index according to the manual of calculating the water quality index of the General Department of Environment (Decision, 2011; MONRE, 2008; Huynh, 2018).

2.4.1. Collect and gather monitoring data

+ Monitoring data used to calculate WQI are data of intermittent continental surface water monitoring for periodic monitoring or average value of parameters in a defined period for continuous monitoring (from 2016 to 2018)

+ The parameters used to calculate WQI usually include the numbers: pH, temperature, degree opaque, TSS, DO, BOD_5, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4$, Total Coliform.

+ Monitoring data is included in the calculation and processing, eliminating false values, satisfying the normative process of data quality.

2.4.2. WQI calculation is as follows

+ WQI parameters (WQISI) are calculated for parameters BOD_5, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4^{2}$-, TSS, turbidity, Total Coliform by the following formula:

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

where BP_i is the lower limit concentration of the observed parameter values specified in Table 2 corresponds to the level i; BP_{i+1} is the upper limit concentration of the observed parameter values is specified in Table 2 corresponding to the i + 1 level; q_i: WQI value at level i given in the table corresponding to BPi value; q_{i+1} is WQI value at i + 1 in the table corresponding to BP_{i+1} value; C_p is the value of the monitoring parameter is taken into account.

Calculate WQI value for DO parameter (WQI_{DO}): calculated through saturation % value.

- Step 1: Calculate saturation % DO

Calculate saturation DO

T: water environment temperature at the time of monitoring (unit: ^oC).

Calculate saturation % DO

$DO\%_{\text{bão hòa}} = DO_{\text{hòa tan}} / DO_{\text{bão hòa}} * 100$

Dissolution:Value of observed DO (unit: mg/l)

Table 1. Table of q_i and BP_i values

i	q_i	BPi value convention for each parameter						
		BOD_5 (mg/l)	**COD** (mg/l)	**$N\text{-}NH_4^+$** (mg/l)	**$P\text{-}PO_4^{2-}$** (mg/l)	**Turbidity** (NTU)	**TSS** (mg/l)	**Coliform** (MPN/100ml)
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	7500
4	25	25	50	1	0.5	70	100	10.000
5	1	≥50	≥80	≥5	≥6	≥100	>100	>10.000

Step 2: Calculate the value of WQIDO:

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

where Cp is saturated% DO; BP_i, BP_{i+1}, q_i, q_{i+1} are values corresponding to i, i + 1 in Table 2.

Table 2. Table specifying BP_i and q_i values for saturated DO%

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

Table 3. Table of values for BPi and q_i for pH coefficient

I	**1**	**2**	**3**	**4**	**5**	**6**
BP_i	≤5.5	5.5	6	8.5	9	≥9
q_i	1	50	100	100	50	1

If saturated DO% ≤ 20, WQIDO equals 1.

If 20 < saturation DO value < 88, WQIDO calculated according to formula 2 and use Table 3. If 88 ≤ saturation% DO value 112, then WQIDO equals 100.

If 112 < saturation DO value < 200, WQIDO calculated according to formula 1 and use Table 3. If the value of saturation DO% ≥ 200, then WQIDO equals 1.

- Calculate WQI value for pH coefficient

If the pH value is ≤ 5.5 then WQI_{pH} is equal to 1.

If 5.5 < pH value < then WQI_pH is calculated according to formula 2 and use table 4.

If 6 pH value of pH ≤ 8.5 then WQI_{pH} is equal to 100.

If 8.5 < pH value < 9 then WQI_{pH} is calculated according to formula 1 and use Table 4.

If the pH value is ≥ 9, then WQI_{pH} is equal to 1.

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

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

where WQIa: The value of WQI has been calculated for 05 parameters: DO, BOD_5, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4^{2}$-; WQIb: WQI value calculated for 02 numbers: TSS, turbidity; WQIc: WQI value calculated for Total Coliform count; WQI_{pH}: WQI has calculated for pH coefficient.

Note: The WQI value after calculating will be rounded to an integer.

After calculating WQI, use the WQI value determination table corresponding to the water quality assessment for comparison (Decision, 2011; MONRE, 2008; Huynh, 2018).

Table 4. Level of water quality assessment

WQI	Water quality assessment	Pollution level	Color
91 - 100	Good use for domestic water supply purposes	Unpolluted	Blue
76 - 90	Use for domestic water supply purposes but need appropriate treatment measures	Less pollution	Green
51 - 75	Use for irrigation purposes and other similar purposes	medium	yellow
26 - 50	Used for water way and other similar purposes	heavy pollution	Orange
0 - 25	Heavy polluted water, requiring future treatment measures	High pollution	Red

3. Results and disscution

3.1. Evolutions of water quality of Luy river from 2016 to present

At the monitoring points across the Luy river, the water quality varies from DO, BOD_5, COD, pH, temperature, nitrate, nitrite and phosphate, total iron), turbidity and coliform.

Temperature: At different monitoring sites, the temperature varies and tends to increase. The temperature at the same monitoring location over the years has a difference of about 1 - 2.9^{o}C. All monitoring positions on the whole route over the years have temperatures ranging from 26.1^{o}C to 29^{o}C and average temperature of about 27.1^oC. QCVN08:2008/BTNMT-National technical regulation on surface water quality has no regulation on temperature parameters.

pH: At monitoring locations, pH at the same monitoring point over the years has a difference of about 0.45-0.76. All monitoring positions on the whole route over the years have pH fluctuating between 7.02-8.45 and within the limits of the regulation. In 2016 - 2018, the pH decrease due to the influence of rain promotes the acidification of compounds in the soil.

Variable suspended solids and turbidity

Suspended solids: Suspended solids content at the same monitoring location over the years has a difference of 0.29 - 12.6 mg/l and all monitoring positions across the route over the years exceed the limit of the standard from 1.3 to 1.9 times.

Turbidity: At the same monitoring position over the years there is a difference in turbidity from 7 to 63.9 mg/l and tends to increase from 2016 to 2018. Turbidity on the entire Luy river is over for the purpose of use.

Evolution of metal pollution

Total iron: The total iron content of the rainy season is usually higher than the dry season, the same location monitored over the years has the difference of the total iron content of about 2 - 2.9 mg/l, most of the locations monitoring has an increasing trend from 2016 to 2018 and gradually decreases from 2016 to 2018, most of them exceed the limit of the standard from 1.72 to 4.4 times.

The evolution of organic pollution

DO: At the monitoring sites, the DO content tends to decrease, the survey shows that it is affected by domestic waste of riverine inhabitants and agricultural production activities. At the same location monitoring over the years there is a difference of DO content from 0.8 to 1.6 mg/l, Over the years there is DO content fluctuating between 5.1-6.7 mg/l and within the limits of the norm.

BOD_5: At the monitoring locations tend to increase BOD_5 content, due to the impact of domestic waste of riverine inhabitants and agricultural production activities. At the same monitoring position over the years with the difference of BOD_5 content from 8 to 18 mg/l, all monitoring positions over the years have BOD5 content fluctuating in the range of 0.9 - 7 mg/l and within the limits of the regulation. In 2016 - 2018, BOD_5 content showed signs of increase due to the influence of rain and organic compounds

COD: At monitoring sites there is a tendency to increase due to the impact of domestic waste of people living along canals and agricultural production. At the same monitoring position over the years there is a difference of COD content from 10-22 mg/l and most of the monitoring positions (53-91 mg/l). WQI in monitoring positions from 53 to 91 (Huynh, 2018). On the whole route over the years, COD content is within the limits of the regulation

Changes in nutrient pollution (Ammonium, nitrite, nitrate and phosphate).

Ammonium: At the monitoring locations tend to increase the content of ammonium. At the same monitoring point over the years, there is a difference of ammonium content from 0.019 to 0.89 mg/l and most of the monitoring positions across the route over the years have ammonium content within the limits of the standard. QCVN 08: 2008/BTNMT.

Nitrite: At the monitoring sites, there is a tendency to increase, at the same monitoring point over the years, there is a difference of nitrite content from 0.008 - 0.061 mg/l and all monitoring positions on the whole route have the function Nitrite content is within the limits of the norm.

Nitrate: All the important positions on the whole route over the years have nitrate content ranging from 0.09 to 0.788 mg/l and within the limits of the regulation. In 2016 - 2018, nitrate content showed signs of increasing due to the effects of rain, which led to nutrient compounds into the river.

Phosphate: At the same monitoring point over the years there is a high difference in phosphate content and over phosphate monitoring years within the limits of the norm, and from 2016 - 2018, phosphate tends to decrease.

Microbial contamination

Coliform: At locations of rainy monitoring, coliform content is often higher than dry season. Coliform, most of the monitoring points over the years exceed the norm

3.2. Evaluate surface water quality changes according to WQI index

If comparing and evaluating each parameter at monitoring points in the Luy river with QCVN 08:2008/BTNMT, only the Luy river basin water source can be identified.

The Luy River Binh Thuan is polluted with any parameters, not determined how pollution is. This is a limited issue in comparing each parameter in the current QCVN. Therefore, it is necessary to have a combination with WQI calculation method to compare and evaluate immediately the level of water pollution.

The zoning map of water quality of Luy river basin as shown in Figure 1 shows that the water source in the downstream area of Luy river which flows through Phan Ri Cua - Tuy Phong town has been polluted. This result is consistent with the spatial evolution, the farther away from the concentration area of population and the

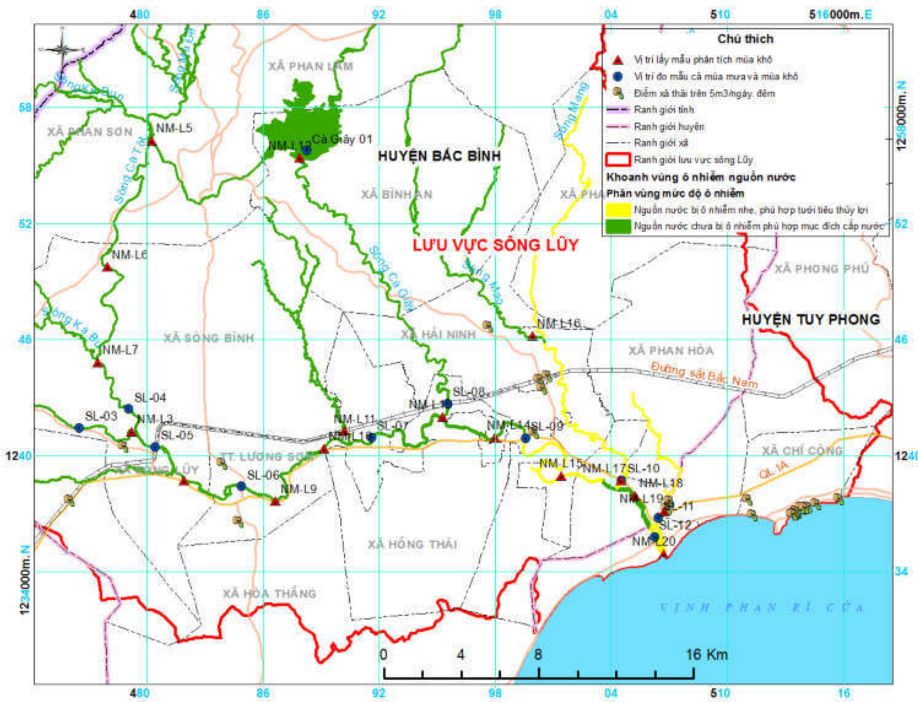

Fig.1. Water quality maps are established by WQI index for Luy river basin

source of waste, the better the quality of water, at the same time, under the influence of flow, the content of pollutants decreases gradually when away from the discharge location. From the results of assessing the current situation in the basin, it is possible to identify the quality of the river Luy has negative developments by pollutants in domestic wastewater; shrimp farming wastewater.

4. Conclution

The speed of economic development in Binh Thuan province has affected the water quality of Luy river basin, the level of water pollution through WQI water quality assessment method.

The use of QCVN 08:2008/BTNMT to assess water quality is only possible to identify the pollution level of each parameter, while using the WQI water quality assessment method (MONRE, 2008) provides an overview of water quality through a scale of pollution assessment. The highest average WQI rainy season is 76 and low is 13, the highest WQI dry season is 91 and the lowest is 16, the dry season is higher than the rainy season. The combination of the WQI index with QCVN 08:2008/BTNMT allows to accurately assess the water quality as data.

Data helps leaders at all levels to promptly adjust and make accurate decisions on solutions to minimize water quality pollution.

The results of assessment of Luy river basin water quality are mainly polluted with suspended solids, turbidity and coliform. Over time, the water quality of Luy river basin is not stable over the years and tends to be worse in the rainy season. According to space, the water quality of Luy river basin is being polluted at medium level for the upstream, heavily polluted in the middle and very heavy pollution in the downstream.

Management of water resources in the Luy river basin needs to focus on water quality to ensure water resources to meet the objectives and orientation of socio-economic development in Binh Thuan province, especially water for domestic use. and agricultural production.

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