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Study on the Use of the Indonesian Water Quality Index Method, CCME, Pollution Index and Storet in Determining Water Quality Status - Case Study of the Cirarab River

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Abstract. Water Quality Index (WQI) is a number without unit to show quality of water body based on the value of several weighted monitoring parameters. Several methods have been developed to calculate the value of Water Quality Index, which are Pollution Index (PI), STORET, Canadian Council of Ministers of Environment Water Quality Index (CCME-WQI) and National Sanitation Foundation Water Quality Index (NSF-WQI). In Indonesia, the method commonly used to determine WQI is pollution index (PI) and STORET. The Indonesian Water Quality Index (WQI-INA) is the latest WQI calculation method developed from NSF-WQI method in 2017 thus providing a weighting value that approaches river conditions in tropical countries.The purpose of this study is to compare WQI values calculated based on WQI-INA method with WQI values that calculate based on Pollution Index, STORET and CCME methods using Cirarab River monitoring data (2015-2018).The Study result indicates that using WQI-INA method gives consistent results in each monitoring location while STORET method gives the same value results even though the monitoring results data is very different. PI method also gives quite different result to WQI-INA value because of range of the PI values is too narrow, so it does not reflect the actual river condition. The CCME WQI method results are the closest to WQI-INA value but require more parameter input rather than WQI–INA. Based on this study, the WQI-INA method is very good to be developed further because it is easy to use and simple but gives good results for WQI assessment.

INTRODUCTION

Clean water is an important thing which is a basic need for the community. For this reason, clean water availability in sufficient numbers is one of the main government programs. The river is one raw water source that is easy to find and inexpensive, but the current condition of the river, especially on Java, is quite alarming. Therefore, maintenance of river water quality is an important thing to do. In order to maintain river water quality, it is necessary to have water quality management [3].

Water quality management is management efforts undertaken to be able to maintain river water quality so that it is suitable for its designation. These management efforts must then be adjusted to the condition of the river water quality so that the programs and activities carried out are on target. The condition of this river quality is stated in the term River Water Quality Index (WQI) [6,9].

WQI is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating information about overall water quality to citizens and policy makers. The use of WQI simplifies the presentation of monitoring results in water bodies, because it summarizes in a single unit value and the combined effects of a number of water quality parameters are analyzed [7]. The WQI value can be used to provide a quick initial indication of the condition of water quality so that it is a useful measure tools for reducing the rate of water pollution. WQI can also provide an indication of the health of water bodies at various points and can track changes over time [1,2].

The Water Quality Index - Indonesia (WQI - INA) is a breakthrough new way to calculate the Water Quality Index (WQI) [1]. Standard methods that are widely used are Pollution Index and STORET methods because both are listed

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in the Minister of Environment Regulation No. 115 of 2003 concerning Guidelines for Determination of Water Quality Status [4]. Another method commonly used as a comparison is the method developed by the Canadian Council Ministry of Environment (CCME) [10]. Basically calculations using the Methods of Pollutant Index, STORET and CCME are based on the level of pollution relative to the water quality standard written in PP No. 82 of 2001. Meanhile, The WQI-INA method was developed by researchers from the Center for environmental impact control facilities, Ministry of Environment from the National Sanitation Foundation Water Quality Index method by selecting parameters that have a greater effect on water quality assessments. The most influential parameter will get the highest weighting value compared to the others [1].

In this study the application of four methods above are compared by using them to calculate the Cirarab River WQI in order to find out which method is easier to use, cheaper and can describe the whole condition of the Cirarab River.

MATERIALS AND METHOD

Materials

Data for this study are water quality monitoring of the Cirarab River in 4 years (2015-2018) conducted by the Office of Environment and Forestry of Banten Province in 3 locations, namely Pasar Kemis Bridge for upstream river position, Kotabumi Bridge for middle river position and Cirarab Bridge for downstream river position.

Method

WQI calculations on the Cirarab River using these four methods are conducted with a spreadsheet tool. After the calculation results are obtained for each method, the data is compared based on the location of monitoring. The analysis is carried out to find out the similarities and the differences betwen 4 WQI methods, the advantages and disadvantages of using each method by looking at the correlation between the real river conditions shown by the results of data monitoring and the WQI calculation method that are used for calculate that.

RESULT AND DISSCUSION

The calculations result using these 4 methods on the monitoring data from year 2015 to year 2018 in 3 locations can be seen in the Table 1 until Table 3.

TABLE 1. Water Quality Index Year 2015

Location	Upstream Pasar Kemis Bridge	Middle Stream Kotabumi Bridge	Downstream Cirarab Bridge
STORET	-90 (heavily polluted)	-84 (heavily polluted)	-100 (heavily polluted)
POLLUTION INDEX	1.79 (slightly polluted)	2.06 (slightly polluted)	3.08 (slightly polluted)
CCME	66 (Fair)	64 (Fair)	66 (Fair)
WQI-INA	69.09 (medium)	69.03 (medium)	68.09 (medium)

Source : Base on Calculation, 2020

From the calculation above, it is clearly seen that the STORET and Pollution Index methods give different values from the CCME and WQI-INA methods. The same results are appearing in the calculations that is performed for data of 2016, 2017 and 2018, respectively.

TABLE 2. Water Quality Index Year 2016

Location	Upstream Pasar Kemis Bridge	Middle Stream Kotabumi Bridge	Downstream Cirarab Bridge
STORET	-84 (heavily polluted)	-112 (heavily polluted)	-96 (heavily polluted)
POLLUTION INDEX	4.07 (slightly polluted)	5.64 (fairly polluted)	3.34 (slightly polluted)
CCME	61 (marginal)	61 (marginal)	62 (marginal)
WQI-INA	69.01 (medium)	67.81 (medium)	73.78 (good enough)

Source: Base on Calculation, 2020

TABLE 3. Water Quality Index Year 2017

Location	Upstream Pasar Kemis Bridge	Middle Stream Kotabumi Bridge	Downstream Cirarab Bridge
STORET	-102 (heavily polluted)	-108 (heavily polluted)	-100 (heavily polluted)
POLLUTION INDEX	5.79 (fairly polluted)	7.17 (fairly polluted)	6.77 (fairly polluted)
CCME	61 (marginal)	54 (marginal)	61 (marginal)
WQI-INA	63.88 (medium)	61.48 (medium)	66.58 (medium)

Source : Base on Calculation, 2020

TABLE 4. Water Quality Index Year 2018

Location	Upstream Pasar Kemis Bridge	Middle Stream Kotabumi Bridge	Downstream Cirarab Bridge
STORET	-120 (heavily polluted)	-112 (heavily polluted)	-124 (heavily polluted)
POLLUTION INDEX	4.42 (slightly polluted)	4.42 (slightly polluted)	4.51 (slightly polluted)
CCME	55 (marginal)	59 (marginal)	53 (marginal)
WQI-INA	64.65 (medium)	61.48 (medium)	60.45 (medium)

Source: Base on Calculation, 2020

The STORET method provides heavy polluted results in all locations with values ranging from -84 to -124 as can be seen in Table 1 to Table 4. The classification of STORET Method values according to US EPA standards is as follows

TABLE 5. Classification of STORET Method Values

Very Good	score = 0	Meet quality Standard
Good	score = -1 s/d -10	Slightly Polluted
Medium	score = -11 s/d -30	Fairly Polluted
Bad	score = < 31	Heavily Polluted

Source: US EPA Standard

The range of this method is narrow and the distance between the values is also not too wide. Applying this classification for rivers with conditions like the Cirarab River, will give the same results for all location. The pollution index method provides result from slightly polluted to fairly polluted in all locations with values ranging from 1.79 to 6.77. The Pollution Index method also classifies the values obtained from calculations into 4 groups, which are:

- $0 \leq IP \leq 1,0$ = *good*
- $1,0 < IP \leq 5,0$ = *slightly polluted*
- $5,0 < IP \leq 10$ = *fairly polluted*
- $IP > 10,0$ = *heavily polluted*

The range of STORET values and Pollution Index are only divided into 4 categories, so just like the STORET method, the result form Index Pollution calculation are less able to reflect the actual conditions in rivers with conditions like the Cirarab River [9,10]. The Pollution Index method itself in calculating WQI uses only 7 parameters which are total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total phosphate (TP), fecal coliform and total coliform [4].

On the other hand, the CCME method and the WQI-INA method provide results that are approaching each other and consistently at each location according to the monitoring data obtained as can be seen in Figure 1.

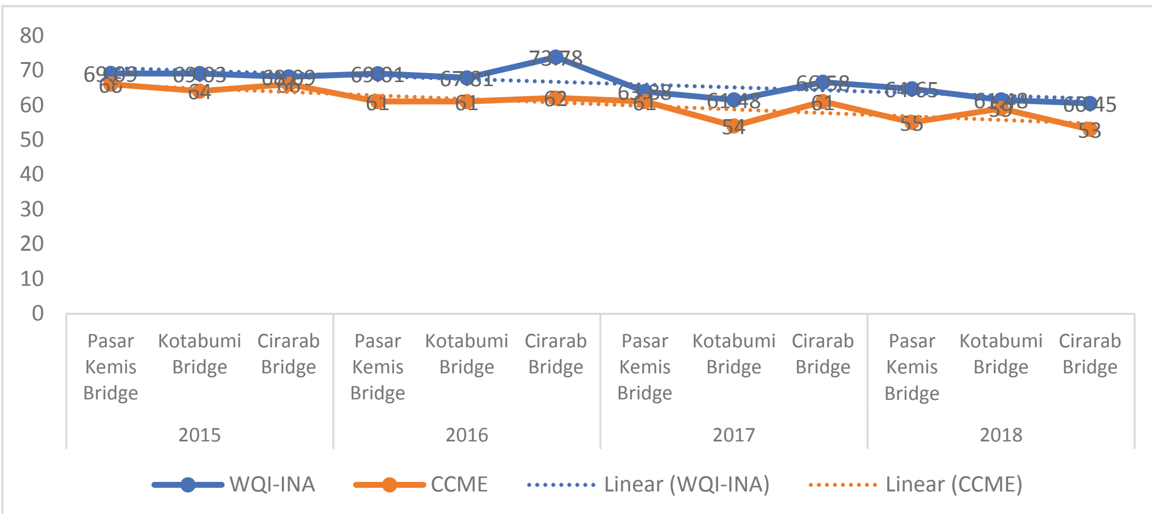

FIGURE 1. Trend Line CCME Method and WQI - INA (source : Base on Calculation)

The CCME method range consists of 5 categories, as can be seen on Table 6 below.

TABLE 6. CCME WQI Classification

Score	Category	Notes
95-100	Excellent	Water quality is maintained with almost imperceptible damage. Water conditions are very close to the original quality standard
80-94	Good	Water quality is maintained but with minimal damage. Water conditions rarely meet quality standards.
65-79	Fair	Water quality is usually maintained but sometimes it is bad and threatened.
45-64	Marginal	Water quality is often poor and does not meet standards.
0-44	Bad	Water quality is almost always poor or threatened. Water conditions usually do not meet standards.

With a wider range of classifications and a scale from 0-100 the results of the WQI values are close to the actual river conditions, so that it appears that the calculation of WQI formulations from CCME is quite good [9,10]. However, to obtain such good results, the WQI-CCME Formulation need to analize all parameters contained in the water quality standard which naturally makes it relatively expensive [4].

The WQI - INA method is being developed by the Center for Quality Research and Environmental Laboratories (P3KLL) in 2017 from National Sanitation Foundation method. In this method, they selected the parameters which has the most influence on the water quality, the sub-index for each parameter and the weighting, using the Delphi method with 100 experts involved in the questionnaire. The results of the questionnaire were then processed to obtain parameters that were considered the most influential on water quality, as well as the weights for each parameter, as can be seen in Table 7.

TABLE 7. WQI – INA's Parameter and Weighted

Parameter	Weighted
DO	0.143
Fecal Coli	0.134
COD	0.120
pH	0.117
BOD	0.113
NH3-N	0.092
Total Phosphate	0.085
TSS	0.074
NO3-N	0.069
TDS	0.053

The results of the questionnaire were processed to get sub-indexes of each parameter and then combined with the results of weighting parameters to formulate the WQI. In WQI - INA there are 6 classifications as can be seen in Table 8.

TABLE 8. WQI – INA Classification

Score	Criteria
$100 \geq I \geq 90$	Very Good
$90 > I \geq 80$	Good
$80 > I \geq 70$	Good Enough
$70\ I \geq 50$	Medium
$50 > I \geq 35$	"Marginal"
$35 > I \geq 0$	"Bad"

The weighting and sub-index value of each parameter can be modified, adjusted to the conditions and characteristics of the environment in which the river is located by entering new parameters that are considered more influential, for example if an area has a lot of gold mining, of course the Hg parameter is more influential than the TSS parameter [1].

Range of WQI - INA values that are quite wide between 0 to 100, more criteria and classification and easy to modify the weighting can give the WQI results that are close to the actual river conditions. The WQI calculation result of Cirarab River using the WQI -INA method show a good consistency for each monitoring location by examining only 10 parameters for each location. Therefore the cost ofriver water quality monitoring can be done at a lower cost than that of using the CCME analysis method but the results are almost thee same. It needs to be taken into consideration due to the fact that the budget allocation for monitoring water quality in the regions is very small.

CONCLUSION

WQI - INA Calculation Results on the Cirarab River give good and consistent results in accordance with the monitoring data. The WQI -INA method as an alternative for calculating the value of WQI is feasible to be further developed because it can give good results and can be modified in accordance with the conditions and characteristics of the environment in which the river is located and the cost of analysis is cheaper.

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