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SECOND ANNUAL
UNIVERSITAS MALAHAYATI
INTERNATIONAL CONFERENCE
ON GREEN TECHNOLOGY AND
ENGINEERING

On April 15-17th, 2009

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UNIVERSITAS MALAHAYATI
BANDAR LAMPUNG
2009
The second (2\textsuperscript{nd}) International Conference on Green Technology and Engineering 2009 (ISGTE2009), Faculty of Engineering Universitas Malahayati, was conducted on 15-17 April 2009. The conference was organized by Faculty of Engineering and collaborated with International Islamic University Malaysia (IIUM) and University Putra Malaysia (UPM).

The participants of the conference are about 300 participants come from 9 countries and more than 60 higher institutions, among others: Unhas, ITS, UI, Tri Sakti, ITB, Unila, Unsri, Unibraw, Unpad, Undip, Unsyah, UPM (University Putra Malaysia), IIUM (International Islamic University Malaysia), UTM (University Technology Malaysia), UTHM, University of Pashawar Pakistan, Univ. Melbourne Australia, Tokyo Institute of Technology Japan, Yangon Technological Univ., and others, which reflect the importance of Green Technology and Engineering. The concept of sustainable development based on the environmental firmament nowadays has become central issues in many developing as well as developed countries. These issues are very important and the topic of this issue can create awareness of the societies to involve in the development of their country toward the sustainable development.

The conference provide platform for researchers, engineers and academicians to meet and share ideas, achievement as well as experiences through the presentation of papers and discussion. These events are important to promote and encourage the application of new techniques to practitioners as well as enhancing the knowledge of engineers with the current requirements of analysis, design and construction of any engineering concept. The conference also functions as platform to recommend any appropriate remedial action for the implementation and enforcement of policies related to environmental engineering fields. Furthermore, this seminar provides opportunities to market faculties’ expertise in the field environmental engineering, civil engineering, structural engineering, mechanical engineering and so on.

On behalf of Steering Committee, we would like to express our deepest gratitude to the Foundation Alih Teknology, Rector Universitas Malahayati, International Advisory Board members, the Keynote speakers, and to all participants. We are also grateful to all organizing committee and all the reviewers, without whose efforts such a high standard for the conference could not have been attained. We would like to express our deepest gratitude to the Faculty of Engineering Universitas Malahayati for conducting such conference.

Bandar Lampung, 15 April 2009

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On April 15-17th, 2009

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Proposing Water Quality Index Calculation Method for Indonesian Water Quality Monitoring Program

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Abstract

A Water Quality Index (WQI) provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. Unfortunately, there is no such Water Quality Index calculation method proposed as a standard tool for water quality monitoring in Indonesia. This paper aims to carry out a comparison study between two Water Quality Index calculation method, NSF and Malaysian WQI, and find whether one of them is suitable if applied for water quality monitoring in Indonesia. Both method are simple but able to provide water index based on some very important parameters and giving the public a general idea the possible problems with the water in the region. As the most wise consideration maybe NSF WQI can be used as WQI calculation method for drinking water quality monitoring. On the other hand, Malaysian WQI can be employed to measure water quality in the river and other river bodies such as lake, pond, and reservoir.

KEYWORDS: WQI, NSF, Malaysian

I. Introduction

Water resources is dynamic and complex system. The problem of water resources relates to many aspects such as physical aspect, organizational aspect, planning aspect, operational aspect, and monitoring aspect (Hussein and Zen, 2004). The goals of water monitoring program, like any environmental monitoring program, is to report the monitoring results to both, government and general public. This kind of purpose poses a particular problem in the case of water quality monitoring because of the complexity associated with analyzing a large number of measured variables. Usually, a traditional practice has been carried out in order to produce reports describing trends and compliance with official guidelines or other objectives on a variable by variable basis. The advantage of this approach is that it provides a wealth of data and information. However, in many cases, government and the general public have neither the inclination nor the training to study these reports in detail. Rather, they require statements concerning the general status of the system of concern (CCME, 2001).

An alternative solution to this problem is to reduce the multivariate nature of water quality data by employing an index that will mathematically combine all water quality measures and provide a general and readily understood description of water. The index is called Water Quality Index (WQI). A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. This type of index is similar to the index developed for air quality that shows if its a red or blue air quality day (BASIN, 2005). In a short word, a Water Quality Index (WQI) is a tool used to summarize large amounts of complex, highly technical water quality data into a simple, easy-to-understand message for the public and decision-makers. Similar to the ultra violet (UV) index or an air quality index, it can indicate whether the overall quality of water bodies poses a potential threat to various uses of that water, such as for drinking water, habitat for aquatic life, irrigation water for agriculture and livestock and recreation and aesthetics (UNEP, 2002).

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The use of an index to "grade" water quality is a controversial issue among water quality scientists. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. The index presented here is not specifically aimed at human health or aquatic life regulations. However, a water index based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea the possible problems with the water in the region.

2. Focus of the Study

There are various Water Quality Index developed in the world. The most developed Water Quality Index calculation methods maybe exist in Canada. Most all provinces in Canada have their own Water Quality Index calculation method. In the United States, a commonly-used water quality index (WQI) was developed by the National Sanitation Foundation (NSF) in 1970 (Brown et al., 1970). The NSF WQI was developed to provide a standardized method for comparing the water quality of various bodies of water. In Malaysia, Malaysian Water Quality Index was developed by The Department of Environment (DOE, 1998) and used to measure water quality for 462 rivers in Malaysia (Rahman, 2002).

Unfortunately, there is no such Water Quality Index calculation method proposed as a standard tool for water quality monitoring in Indonesia. This paper aims to carry out a comparison study between two Water Quality Index calculation method, NSF and Malaysian WQI, and find whether one of them is suitable if applied for water quality monitoring in Indonesia.

3. NSF Water Quality Index

NSF Water Quality Index (NSF WQI) was developed in 1970 by National Sanitation Foundation of United States (Canter, 1996). The National Sanitation Foundation Water Quality Index (NSF WQI) is the most respected and utilized water quality index in the U.S. However, this index has been criticized for not adequately representing water quality in all areas of the U.S. The “one size fits all” structure of the index causes some regional water quality concerns to be overlooked in the overall index value.

The index calculation involved nine water parameter which are (NSF, 2004):
- Dissolved Oxygen (DO) in % of saturation
- Fecal Coliform in average number of organisms per 100 ml water
- pH
- BOD5 in mg/L
- NO3 in mg/L
- PO4 in mg/L
- Temperature Deviation in °C
- Turbidity in Jackson Turbidity Unit (FTU)
- Total Solid (TS) in mg/L

Each of these parameters has its own factor (Wi) describing the importance each parameter in the calculation. The weighing factor for each parameter is described below:

Table 1. Weighing Factor for Each Parameter in NSF WQI Calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>W</th>
<th>Parameter</th>
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<tr>
<td>DO</td>
<td>0.17</td>
<td>PO4</td>
</tr>
<tr>
<td>F. Coliform</td>
<td>0.15</td>
<td>Temp. Dev.</td>
</tr>
<tr>
<td>pH</td>
<td>0.12</td>
<td>Turbidity</td>
</tr>
<tr>
<td>BOD5</td>
<td>0.1</td>
<td>Total Solid</td>
</tr>
<tr>
<td>NO3</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Each parameter also has index value (WQIi) from serial of graphs developed by NSF, an example of the graphs is presented in the appendix of this paper.

There are two methods can be used to calculate NSF WQI. The first method is called weighted sum of the indices (WQIa), which is expressed as:

\[ WQI_a = \sum_{i=1}^{n} W_i I_i \] (1)

Another method is called weighted aggregation function (WQIm), which is expressed as:

\[ WQI_m = \prod_{i=1}^{n} I_i^{W_i} \] (2)

The interpretation of WQI is based on the description suggested in the table below:

Table 2. Descriptor and Colors Suggested for WQI

<table>
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<tr>
<th>Descriptor Words</th>
<th>Numerical Range of WQI</th>
<th>Color</th>
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<tr>
<td>Very Bad</td>
<td>0 - 25</td>
<td>Red</td>
</tr>
<tr>
<td>Bad</td>
<td>26 - 50</td>
<td>Orange</td>
</tr>
<tr>
<td>Medium</td>
<td>51 - 70</td>
<td>Yellow</td>
</tr>
<tr>
<td>Good</td>
<td>71 - 90</td>
<td>Green</td>
</tr>
<tr>
<td>Excellent</td>
<td>91 - 100</td>
<td>Blue</td>
</tr>
</tbody>
</table>

4. Malaysian Water Quality Index

Like other Water Quality Indices, Malaysian Water Quality Index relates a group of water quality parameters to a common scale and combines them into a single number in accordance with a chosen method or model of computation. The objective of the Malaysian WQI system is to use it as an objective means of assessment of a water body for compliance with the standards adopted for designated classes of beneficial uses in Malaysia. The desired used of WQI to an assessment of water quality trends for management purposes even though...
The Malaysian WQI calculation involved six water parameters which are (Omar et al., 1992): Dissolved Oxygen (DO) in % of saturation Biological Oxygen Demand (BOD) in mg/L Chemical Oxygen Demand (COD) in mg/L Ammoniacal Nitrogen (AN) in mg/L Suspended Solid (SS) in mg/L pH

The Malaysian WQI is calculated using formula based on the Department of Environment of Malaysia. The formula is given below:

\[
WQI = 0.22 \cdot SIDO + 0.19 \cdot SIBOD + 0.16 \cdot SICOD + 0.15 \cdot SIAN + 0.16 \cdot SISS + 0.12 \cdot SipH
\]

Where:
- SIDO = Sub-Index DO
- SIBOD = Sub-Index BOD
- SICOD = Sub-Index COD
- SIAN = Sub-Index NH3N
- SISS = Sub-Index SS
- SipH = Sub-Index pH

The SIDO is calculated based on the equation in certain condition which is:

\[
SIDO = \begin{cases} 
0 & \text{for } x \leq 8 \\
100 & \text{for } x > 92 
\end{cases}
\]

The SIBOD is calculated based on the equation in certain condition which is:

\[
SIBOD = \begin{cases} 
0.395 + 0.030x^2 - 0.00020x^3 & \text{for } 8 < x < 92 
\end{cases}
\]

The SICOD is calculated based on the equation in certain condition which is:

\[
SICOD = \begin{cases} 
100.4 - 4.23x & \text{for } x \leq 5 \\
108 \cdot \exp(-0.055x) - 0.1x & \text{for } x > 5 
\end{cases}
\]

The SIAN is calculated based on the equation in certain condition which is:

\[
SIAN = \begin{cases} 
100.5 - 105x & \text{for } x \leq 0.3 \\
94 \cdot \exp(-0.573x) - 5 \cdot 1x - 21 & \text{for } 0.3 < x < 4 \\
0 & \text{for } x \geq 4 
\end{cases}
\]

The SISS is calculated based on the equation in certain condition which is:

\[
SISS = \begin{cases} 
97.5 \cdot \exp(-0.00676x) + 0.05x & \text{for } x \leq 100 \\
71 \cdot \exp(-0.0061x) - 0.015x & \text{for } 100 < x < 1000 \\
0 & \text{for } x \geq 1000 
\end{cases}
\]

The SipH is calculated based on the equation in certain condition which is:

\[
SipH = \begin{cases} 
17.2 - 17.2x + 5.02x^2 & \text{for } x < 5.5 \\
-242 + 95.5x - 6.67x^2 & \text{for } 5.5 \leq x < 7 \\
-181 + 82.4x - 6.05x^2 & \text{for } 7 \leq x \leq 8.75 \\
536 - 77.0x + 2.76x^2 & \text{for } x > 8.75 
\end{cases}
\]

The range of Malaysian WQI value is between 0 to 100. General rating scale for the Water Quality Index (WQI) applied in some water resources development purposes are:

- For general use of water:
  - Range 0 ≤ 40 = very polluted water
  - Range 40 ≤ 60 = slightly polluted water
  - Range > 60 = clean water

- For classification of water:
  - Range 0 ≤ 40 = Class V
  - Range 40 ≤ 50 = Class IV
  - Range 50 ≤ 80 = Class III
  - Range 80 ≤ 90 = Class II
  - Range > 90 = Class I

- For public water supply:
  - Range 0 ≤ 40 = not acceptable for public water supply
  - Range 40 ≤ 50 = doubtful for public water supply
  - Range 50 ≤ 60 = needs expensive treatment for public water supply
  - Range 60 ≤ 80 = needs minor purification for public water supply
  - Range > 90 = no need treatment for public water supply

- For recreation water:
  - Range 0 ≤ 20 = not acceptable for recreation
  - Range 20 ≤ 30 = obvious pollution appearing, still not acceptable for all recreation

- For fisheries:
  - Range 0 ≤ 30 = not acceptable for fisheries
  - Range 30 ≤ 40 = only for coarse fish
  - Range 40 ≤ 50 = only for handy fish
  - Range 50 ≤ 60 = doubtful for sensitive fish
  - Range 60 ≤ 70 = marginal for trout
  - Range > 70 = acceptable for all fish

- For navigation:
  - Range 0 ≤ 30 = not acceptable for navigation
  - Range 30 ≤ 40 = obvious pollution appearing
  - Range > 50 = acceptable for all navigation

- For water transportation:
  - Range 0 ≤ 10 = not acceptable for water transportation
Range > 10  =  acceptable for water transportation

5. Result and Discussion

It is very difficult to say that one method of WQI calculation is better than others. It is also not easy to state that one method of WQI calculation is the best in the world. Every WQI calculation method has its own specification and applied to specific location and specific water body. For example WQI in Canada and United State is designed to measure drinking water quality. On the other hand, Malaysian WQI is calculated in order to measure water quality in the river.

Geographically, we may state that Malaysian WQI has better fitting if applied in Indonesian if compared to the NSF WQI. This assumption is taken with consideration that characteristic of water bodies in Indonesia has similar type to the ones in Malaysia. This statement maybe quiet reasonable as we know that Indonesia and Malaysia both are located in the southeast Asia region. However, this is not automatically saying that NSF WQI is not suitable for water quality monitoring in Indonesia. NSF WQI has been ever used to measure water quality in more than 30 rivers and 40 ponds in Jakarta with consideration that this WQI calculation method has demonstrated good quality results in many water quality monitoring research in the world (Hendrawan, 2005). The calculation result of Water Quality Index value on this study shows that 83 % of rivers and 79 % of ponds in Jakarta City are below 51 or categorized as bad water quality.

On the other hand, Malaysian WQI calculation also shows a good reputation in measuring water quality in Malaysia. Malaysian WQI calculation has been used as standard calculation for water quality in Water Quality Monitoring Program in Malaysia (Rahman, 2002). Until today, Malaysian WQI is employed to measure water samples from 902 manual stations in 120 basins (462 rivers) in Malaysia. The Water Quality Monitoring Program aims to:

- detect changes in river water quality on a continuous basis.
- transmit real-time Water Quality levels violating the ambient
- standard for specific parameters to The Department of Environment
- do immediate inspection will be conducted at suspected sites.
- monitor water quality in sensitive locations including upstream of water abstraction points.

For water quality monitoring in Indonesia, it is not necessary for us to debate the best method must be used. Both method can be used in any water quality monitoring in Indonesia. Both method are simple but able to provide water index based on some very important parameters and giving the public a general idea the possible problems with the water in the region. The process of calculation of both method is also quiet simple and easy. There are several websites provide facility to calculate NSF WQI or Malaysia WQI. As the most wise consideration maybe NSF WQI can be used as WQI calculation method specifically for drinking water quality monitoring. On the other hand, Malaysian WQI can be employed to measure water quality in the river and other river bodies such as lake, pond, and reservoir. Research aiming to develop new method of WQI calculation for Indonesian water should be continuously carried out. However, since the research needs time and cost, for the time being it is quiet reasonable to use NSF WQI or Malaysian WQI in water quality monitoring program in Indonesia.

Finally, although a single number of WQI cannot tell the whole story of water quality, the WQI is still the most valuable method used for water quality monitoring. Monitoring water quality using WQI will spend less money and time. Also, it does not need any sophisticated lab to analyze the water samples. This fact is suitable for Indonesian water monitoring program which is very broad but financed by less funding.

6. Conclusion

Comparison study between two Water Quality Index calculation method, NSF WQI and Malaysian WQI has been carried out. The study states that both method are suitable if applied for water quality monitoring in Indonesia. As the most wise consideration maybe Indonesian Government can use NSF WQI calculation method specifically for drinking water quality monitoring. On the other hand, Malaysian WQI can be employed to measure water quality in the river and other river bodies such as lake, pond, and reservoir.

Although a single number of WQI cannot tell the whole story of water quality, the WQI is still the most valuable method used for water quality monitoring. It gives the public a general idea the possible problems with the water in the region.

7. References


