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RIVER WATER QUALITY ASSESSMENT USING BENTHIC MACROINVERTEBRATES IN CITARUM UPSTREAM INDONESIA

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Assessment of river water quality because changes in land use and pollution were still a problem in several countries, particularly in developing countries, included Indonesia. Based on river water quality assessment, index needs to be developed using bio-indicators. The aim of this study was to determine the benthic macroinvertebrates community in predicted water quality based on influence of organic pollutants, inorganic, nutrients, and toxic. Measurement of the physical and chemical parameter have been done on momentary conditions, and then used benthic macroinvertebrates as biological parameter to indicate the actual environmental conditions based on the characteristics of each benthic macroinvertebrates relating to the preferences of local environmental conditions. This research based on case study and using the purposive sampling method with three times sampling in July, September and November 2014 at 7 locations in upstream Citarum. Further analysis of water quality data using pollution index and benthic index of biological for the assessment of river water quality. The results show that for all site the dominant benthic is Chironomidae. Parameter BOD, COD, TSS, Turbidity, and substrate are the most affected for benthic macroinvertebrates. Pollution index results index value range from 1.64 to 5.37 and Family Biotic Index results index value range from 4.17 to 7.13. For linear regression analysis between Pollution Index and Family Biotic Index obtained the value of the correlation coefficient (R) 0.53 showed the most significant relationship between the two index compared to the other. Based on the results of evaluation station Wayang mountain, Guha mountain, Puncak Cae mountain, and Halimun mountain are not polluted until slightly polluted. While Cikitu Village, Babakan Village, and Wangisagara are moderate polluted until heavy polluted.

Keywords: River Water quality, Benthic Macroinvertebrate, Bioassessment.

1. INTRODUCTION

The deteriorating of river quality because change of land use and pollution still becomes a problem in a several country, especially in development country include Indonesia. Monitoring the changes of water quality in rivers can be performed through studies of the organisms living in water to prevented deteriorating of river quality. Macrobenthic organisms have been the most commonly used as indicators of running water quality. Macroinvertebrates present several advantages compared to other groups of organisms: they are ubiquitous and diverse, exhibit different feeding habits, are sedentary and have life cycles ranging from a few weeks to a few years, and convenient size for field examination, storage, and transport (Ratnawati et al. 2008).
The study about qualitative concepts of interactions river ecosystem has been found that benthic community were affected by environmental condition. Goethals and De Pauw (2001) explained interaction from each physical and chemical variables that involved each other in this concept and the relationship with macrobenthic community life. The aims of this study were to evaluate macrobenthic community in predicted the river quality and ecological status.

Many studies have attempted to detect the river quality in each of the river location, species of composition, and the macrobenthic density as the bioindicator of river quality. Data from BPLHD (2003) about ecology status in Citarum upstream from Wayang mountain station using Shannon-Wiener index with category light polluted, while from Kmp. Babakan with category light polluted. And then Ratnawati research (2008) from Wayang mountain station using Shannon-Wiener index and Family Biotic Index include moderate polluted, while from Kmp. Babakan with category moderate polluted, and Wangisagara with category moderate polluted.

Because of that the study about bioassessment between macrobenthic dynamic population with physical and chemical of the river quality base of qualitative concept river ecosystem were held and for the case study has been chosen Citarum upstream location.

2. MATERIALS AND METHODS

2.1. Study Area

Macrobenthic community structures and physicochemical parameters were assessed in seven sampling sites located in Citarum upstream region. Spring on the Wayang mountain was one of the Citarum upstream that flows into Kmp. Cikitu, Kmp. Babakan, and Wangisagara, while spring on the Guha mountain, Puncak Cae, and Halimun mountain flow directly to the Citarum upstream (Fig. 1). Wayang mountain located at height 1572 meters from sea level near protected forest. Guha mountain located at 1852 meters from sea level, Puncak Cae mountain located at 936 meters from sea level, Halimun mountain located at 1400 meters from sea level and this three mountain near shrubs. Kmp. Cikitu located at 1521 meters from sea level, Kmp. Babakan located at 1057 meters from sea level, and Wangisagara located at 745 meters from sea level. This three sites were identified along this river with the site near agricultural being categorized as moderately impacted. Major threats on this river are household wastes, agricultural activities, and habitat degradation by human activities.

![Figure 1: Research location in Citarum Upstream.](image-url)
2.2. Sampling Design

Sampling sites were categorized according to the level of water and habitat quality as follows: reference or least impacted (4 sites) and moderately impacted (3 sites). Reference sites are Wayang mountain, Guha mountain, Puncak Cae mountain, and Halimun mountain. The streams of all reference sites flow through mixed deciduous forest. Moderately impacted were test sites known to be influenced by varying levels. Agriculture is the dominant activity throughout the watershed. The test sites are Kmp. Cikitu, Kmp. Babakan, and Wangisagara.

1.2.1. Physicochemical Data Collection

Physical and chemical parameters of water were measured in accordance with Government Regulation No. 82 2001 grade II and some of the parameters that affect the growth of macrobenthic. Samples are stored in 4000 ml plastic bottle containers for chemical analysis. Samples of water in bottles made preservation by storing in a cool box at a temperature of 4 °C, and then analyzed in the laboratory by following the method in APHA (1995). In the laboratory 50 parameters were examined (physical, organic chemical, and anorganic chemical). Then a few parameters were chosen to calculate polluted index.

1.2.2. Macroinvertebrates Sampling

Macroinvertebrates sampling was conducted in accordance with surber net method. This surber net has rectangular shape with pores of 0.5 mm (APHA 1995) and size 25 x 40 cm². Surber net also have a surface area 1000 cm². Because sampling were done 3 times on each location at any time, so the total net surface became 1000 cm² x 3 = 3000 cm².

2.3. Analysis Data Method

2.3.1. Pollution Index

Pollution index used to determine the contamination level water quality parameters that allowed by calculations based on the Ministry of the Environmental number 115, 2013 for status water quality. Parameter chosen for polluted index calculation were TSS, TDS, BOD, COD, Total P, DO, NO₃, and pH. Further assessment of water quality is determined using pollution index for water quality using the equation:

\[ PI_j = \sqrt{ \frac{\left(\frac{C_i}{L_{ij}}\right)^2 + \left(\frac{C_i}{L_{ij}}\right)^2}{2}} \]  

Where \( L_{ij} \) is water quality concentration in quality standards (j), \( C_i \) is water quality concentration analysis laboratorium (i), and \( PI_j \) is Polluted index \( C_i/L_{ij} \).

2.3.2. Macrobenthic Analysis

a. Dominant Macrobenthic

From the number and types of macrobenthic composition at seven locations on the three times sampling, the dominant family in each location is based on an abundance of family macrobenthic >3% and were always there at the time of sampling (Sudarso 2015).
b. **Benthic Index of Biological**

For macrobenthic diversity using the Shannon-Wiener diversity index, Family Biotic Index (FBI), and Lincoln Quality Index (LQI). Shannon-Wiener index combined two component from community structure, there are density and taxa. The equation for Shannon-Wiener:

$$H' = -\sum_{i} \frac{n_i}{N} \log_2 \frac{n_i}{N}$$

(2)

Where $H'$ or $d$ = diversity index, $n_i = \text{Total individu in one species}$, $N = \text{Total individu species that found}$. Then, Family Biotic Index to identify and count the number of individuals in each taxon from one plot. Write a tolerance value of each taxa based on criteria Hilsenhoff. Family biotic index equation is:

$$FBI = \frac{\sum (x_i \cdot t_i)}{n}$$

(3)

Where $x_i$ = total individu, $t_i$ = tolerance score from family, $n = \text{total organisms that found in one plot}$. Then for derivate from BMWP and ASPT index is Lincoln Quality Index (LQI) dan Overall Quality Rating (OQR). BMWP index (Biological Monitoring Working Party) is a biological classification system in order to monitor river pollution nationwide. Lincoln Quality Index (LQI) and Overall Quality Rating (OQR) derived from merging the index value BMWP and ASPT that has to be normalized in order to produce a single index value.

### 2.4. Regression Analysis

Linear regression using Microsoft Excel were used to test whether the physicochemical parameters and benthic macroinvertebrates have a significant relationship.

### 3. RESULTS AND DISCUSSION

#### 3.1. Dominant Macrobenthic

The result of dominant macrobenthic from each location are:

a. Location SR 1 G. Wayang: Thiaridae, Pachychilidae, and Chironomidae;

b. Location SR 2 G. Puncak Cae: Chironomidae;

c. Location SR 3 G. Halimun: Chironomidae and Capniidae;

d. Location SR 4 G. Guha: Chironomidae and Hydropsychidae;

e. Location ST 1 Kmp. Cikitu: Glassiphoniidae and Chironomidae;

f. Location ST 2 Kmp. Babakan: Chironomidae, Hydropsychidae, and Baetidae;

g. Location ST 3 Wangisagara: Chironomidae and Hydropsychidae.

#### 3.2. Index Calculation Result

##### 3.2.1. Pollution Index

The result of pollution index from each location are shows on the Table 1.
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4th Asian Academic Society International Conference (AASIC) 2016

Table 1: Classification Polluted Degree based on Pollution Index

<table>
<thead>
<tr>
<th>No</th>
<th>Research site</th>
<th>Average</th>
<th>Water Quality Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G. Wayang</td>
<td>1.85</td>
<td>light polluted</td>
</tr>
<tr>
<td>2</td>
<td>G. Puncak Cae</td>
<td>1.93</td>
<td>light polluted</td>
</tr>
<tr>
<td>3</td>
<td>G. Halimun</td>
<td>1.64</td>
<td>light polluted</td>
</tr>
<tr>
<td>4</td>
<td>G. Guha</td>
<td>2.04</td>
<td>light polluted</td>
</tr>
<tr>
<td>5</td>
<td>Kmp. Cikitu</td>
<td>5.37</td>
<td>Moderate polluted</td>
</tr>
<tr>
<td>6</td>
<td>Kmp. Babakan</td>
<td>2.62</td>
<td>light polluted</td>
</tr>
<tr>
<td>7</td>
<td>Wangisagara</td>
<td>3.54</td>
<td>light polluted</td>
</tr>
</tbody>
</table>

It shows the status of pollution in all of research site include light polluted, except in Kmp. Cikitu moderate polluted with average score 5.37.

3.2.2. Shannon-Wiener Index

The calculation of the Shannon-Wiener index for macrobenthic at each study site are shows on Table 2. The status of pollution in site reference range from good until light polluted (2.01-3.55), while in site test are moderate polluted (1.18-1.51).

Table 2: Classification Polluted Degree based on Shannon-Wiener Index

<table>
<thead>
<tr>
<th>No</th>
<th>Research site</th>
<th>Average</th>
<th>Water Quality Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G. Wayang</td>
<td>3.55</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>G. Puncak Cae</td>
<td>2.01</td>
<td>Light polluted</td>
</tr>
<tr>
<td>3</td>
<td>G. Halimun</td>
<td>2.49</td>
<td>Light polluted</td>
</tr>
<tr>
<td>4</td>
<td>G. Guha</td>
<td>2.14</td>
<td>Light polluted</td>
</tr>
<tr>
<td>5</td>
<td>Kmp. Cikitu</td>
<td>1.30</td>
<td>Moderate polluted</td>
</tr>
<tr>
<td>6</td>
<td>Kmp. Babakan</td>
<td>1.18</td>
<td>Moderate polluted</td>
</tr>
<tr>
<td>7</td>
<td>Wangisagara</td>
<td>1.51</td>
<td>Moderate polluted</td>
</tr>
</tbody>
</table>

3.2.3. Family Biotic Index

From the calculation of Family Biotic Index for macrozoobenthos at each study site by Table 3. Shows the status of pollution in site reference range from very good to moderate polluted (4.17-5.15) while ini site test from moderate polluted to bad polluted (5.67-7.13).

Table 3: Classification Polluted Degree based on Family Biotic Index

<table>
<thead>
<tr>
<th>No</th>
<th>Research site</th>
<th>Average</th>
<th>Water Quality Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G. Wayang</td>
<td>4.17</td>
<td>Very Good</td>
</tr>
<tr>
<td>2</td>
<td>G. Puncak Cae</td>
<td>5.15</td>
<td>Moderate polluted</td>
</tr>
<tr>
<td>3</td>
<td>G. Halimun</td>
<td>4.43</td>
<td>Good</td>
</tr>
<tr>
<td>4</td>
<td>G. Guha</td>
<td>4.93</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>Kmp. Cikitu</td>
<td>7.13</td>
<td>Bad polluted</td>
</tr>
<tr>
<td>6</td>
<td>Kmp. Babakan</td>
<td>5.8</td>
<td>Bad enough polluted</td>
</tr>
<tr>
<td>7</td>
<td>Wangisagara</td>
<td>5.67</td>
<td>Moderate polluted</td>
</tr>
</tbody>
</table>
3.2.4. Lincoln Quality Index

From the calculation using the Lincoln Quality Index for macrobenthic at each study site by Table 4. Shows the pollution status of the reference site have criteria from excellent to good (5-5.17), while site test have criteria from moderate to very bad (1.67-3).

Table 4: Classification Polluted Degree based on Lincoln Quality Index

<table>
<thead>
<tr>
<th>No</th>
<th>Research site</th>
<th>average</th>
<th>water quality criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G. Wayang</td>
<td>5.17</td>
<td>Excellent</td>
</tr>
<tr>
<td>2</td>
<td>G. Puncak Sae</td>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>3</td>
<td>G. Halimun</td>
<td>5</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>G. Guha</td>
<td>4.17</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>Kmp. Cikitu</td>
<td>1.67</td>
<td>Very bad</td>
</tr>
<tr>
<td>6</td>
<td>Kmp. Babakan</td>
<td>2.17</td>
<td>Bad</td>
</tr>
<tr>
<td>7</td>
<td>Wangisagara</td>
<td>3</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

3.3. Correlation between Polluted Index and Benthic Index of Biological

For linear regression analysis between pollution index and Family Biotic Index obtained the highest value of the correlation coefficient (R) 0.528 showed a significant relationship between the two indexes. Linear regression between pollution index and Family Biotic Index show in the Graphic 2.

![Linear regression between Pollution Index and Family Biotic Index](image_url)

Figure 2: Linear regression between Pollution Index and Family Biotic Index.

4. CONCLUSIONS

Dominant macrobenthic in reference site are Thiaridae, Pachychilidae, Chironomidae, and Capniidae. While, in site test are Glassiphoniidae, Chironomidae, Hydropsychidae, and Baetidae.
Relationship between Pollution Index with Family Biotic Index (FBI) has the highest correlation with a correlation coefficient (R) 0.528. Water quality criteria based Family Biotic Index from reference site category range from very good to moderate polluted (4.17-5.15), while site test have category range from moderate to bad polluted (5.67-7.13).

REFERENCES