The influence of riparian characteristics on the diversity and abundance of macroinvertebrates at cascade-pond system universitas Indonesia Depok

Nadia Rizky Junita1, Dwita Sutjiningsih2 and Evi Anggraheni3

1Undergraduate student in Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia,
2Lecturer in Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Indonesia
3Lecturer in Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Indonesia

nadiaerje@gmail.com

Abstract. At the Universitas Indonesia (UI) there are six cascade-pond water quality decreased from year to year. This can be seen in plain view, on the change of water color, odor, and the amount of solid waste that is in cascade-pond that comes from outside the UI. The decrease of water quality is one of the reasons caused by land use change in UI Water Catchment Area. Previous studies tested the condition of waters with biological parameters. Biological parameters were tested using macroinvertebrate as a biological indicator, with the result of Average Score Per Taxon (ASPT) index proved that Kenanga cascade-pond include in heavy polluted. Agathis, Mahoni, Puspa, and Ulin is moderately polluted, and Salam is lightly polluted, resulting a hypothesis that the conditions of the UI riparian affects most to the diversity and abundance of macroinvertebrates (Fadillah, 2017). In this study to prove the effect of riparian characteristics on macroinvertebrates using Tropical Rapid Appraisal Riparian Condition (TRARC) Version 1 for the riparian, and the Average Score Per Taxon (ASPT) index for macroinvertebrates, the result proves that the value of riparian conditions affects the diversity and abundance of macroinvertebrates, evidenced from the results of R (0.1 - 0.7) with the correlation results (0.1 - 0.5) and the value of riparian pressure also affects the diversity and abundance of macroinvertebrata, this is evidenced from the results of R (0.01 - 0.6 ) with correlation result (0.05 - 0.6)

Keywords: macroinvertebrates, cascade-pond system, water quality, riparian

1. Introduction

There are six cascade-pond at the Universitas Indonesia (UI) which are in the condition of quality degradation from year to year, it is caused by the riparian that has been occupied by various kinds of watertight cover. Increased waterproof cover that has an indispensable effect on the water body especially for small-scale air catchment areas of 13-77 km². Increased land cover may affect various
problems including: Improved quality, decreased air quality, and habitat damage to freshwater aquatic animals [1].

The riparian is an ecological entity with a system of water bodies. The existence of riparian cascade-pondations is intended for the prevention of abrasion or other matters which may cause a reduction of the aquatic area, the ecological and aesthetic value of the area protecting the biodiversity of aquatic organisms. In the riparian zones cascade-pondations, there are not allow the construction of buildings except for buildings intended for the management of water bodies, or water use and are not subject to the removal of materials that damage the function of the ecosystem, except for restoration [2]. When viewed ecologically, the riparian is a habitat where the river ecosystem develops. The ecosystem is a unity between biotics and abiotics, all sorts of interactions or reciprocal relationships of living things as well as the environment which includes the area or river area. Aquatic animals that can be used as biological indicators are from aquatic species such as algae, bacteria, protozoa, macroinvertebrates and fish, but in the five types of aquatic animals, the best and most suitable for biological and ecological indicators are from group of macroinvertebrate forms, because of habitat preference factor and also its relatively low mobility cause living creature can be used as a living creature whose existence is directly influenced by all materials entering into the aquatic environment.

The results obtained from the research of the quality of the waters in the campus UI Depok using the Biotic Index with macroinvertebrata with information: Kenanga cascade-pond including polluted heavy, where Agathis contaminated medium, Mahoni contaminated medium, Puspa mild contaminated, Ulin contaminated medium and Salam contaminated lightly [3].

The existence of macroinvertebrates is strongly influenced by the UI cascade ponds, whether under natural conditions or has been plastered or constructed. However, when compared to the physical characteristics of the UI cascade-pond riparian, not all macroinvertebrates exist in natural riparian, but some are in desperate conditions or on constructed land. Not all of the UI cascade-pond that have been plastered or has been constructed is contaminated. When examined with macroinvertebrates, there are also some resistant macroinvertebrates with contaminated water located in UI cascade pond is still in a natural state. Water quality worldwide is characterized by the width of variability. Therefore the quality of natural water sources used for different purposes should be determined based on specific water quality parameters that most likely influence water use. Water quality can be determined by the characteristics of the riverbanks and riparian that can be viewed physically through the temperature, color, floating debris, turbidity and suspended solids and flavors, and also determined by living creatures that adapt in water. It is needed to be reviewed more deeply about the assessment of physical characteristics of the existing riparian in the six cascade-pond in UI Depok.

2. Research Methodology

2.1. Study Location

The locations reviewed for this research are located in six UI Depok cascade pond, there are Kenanga, Agathis, Mahoni, Puspa, Ulin, and Salam. The sample point taken is in the zone that has been created in each cascade-ponds

2.1.1 Kenanga Cascade-pond.

In cascade-pond Kenanga located between Universitas Indonesia Library, Mosque Universitas Indonesia, and Balairung Universitas Indonesia have 10 zone of sampling point, that is as shown below:
2.1.2 Agathis Cascade-pond.
Next, 6 zones of sampling point in cascade-pond Agathis located among the Faculty of Mathematics & Natural Sciences with State Polytechnic of Jakarta. Only zones 1, 2, 5 and 6 are taken. In zones 3 and 4 can not be taken because they are overgrown by water hyacinth so they can not be step on and walk there.

2.1.3 Mahoni Cascade-pond.
Then, 8 zone of sampling point in Mahoni cascade pond which is located between Faculty of Engineering with Faculty of Cultural Science. All zones can be sampled, except in zone 7, because on its riparian land is still under construction.
2.1.4 Puspa Cascade-pond.
Then 6 zones of sampling point at Cascade-pond Puspa located in Forest area of University of Indonesia.

2.1.5 Ulin Cascade-pond.
After that, 7 zone of sampling point in Cascade-pond Ulin located in Forest area of Universitas Indonesia. It is only taken samples of zone 1, 2, 5, 6, and 7, besides can not be taken sample because it is not possible to be traced and step on.
2.1.6 Salam Cascade-pond.
And the last is Salam cascade pond which located in the forest area of University of Indonesia in the upstream, middle, and downstream, with 10 zone of sampling point. Only zones 1, 2, 6, 7, 8, 9, and 10 that can be sampled, others can not because it is not possible to be explored.

![Figure 6. Cascade-pond Salam Zone.](image)

2.2. Framework of The Study
This study was conducted with several stages, namely data collection, Riparian Value Assessment, Scoring Macroinvertebrates, and correlation between riparian and macroinvertebrates.

![Figure 7. Mind map of Study Correlation between Macroinvertebrates and Riparian](image)

At the research stage, the authors first identifies the problem about the condition of the waters in UI cascade ponds, the authors then searches the literature study related to the condition of the waters of UI
specifically about the riparian of UI as well as about the macroinvertebrata which is used as the valuation in the biotic index. Furthermore, the authors provide an assessment of the condition of UI riparian using Tropical Rapid Appraisal of Riparian Condition Version 1, then accompanied by the determination of the sampling location to take macroinvertebrates in several zones in the six UI cascade pond. Then the authors took a macroinvertebrate sample corresponding to the location zone of each UI cascade pond. After obtaining a sample of macroinvertebrates, the authors analyzed the results obtained in the family type available in the Biological Monitoring Working Party (BMWP) table. Then, the result data from the macroinvertebrata is given an assessment using the Average Score Per Taxon (ASPT) biotik index which is often used by many countries and is relatively easy, then linked to the waters condition of the UI cascade pond. Finally, the authors compare the results of the UI riparian along with the results of macroinvertebrates, whether the good UI riparian conditions lead to good macroinvertebrate results as well and have good UI aquatic outcomes, or there is no connection between the riparianconditions of UI and the resulting macroinvertebrata each UI cascade pond.

2.3. Macroinvertebrates Sampling Methods

Biomonitoring is a biological water quality monitoring conducted by looking at the presence of an indicator organism cluster that live in the water. The Biological Monitoring Working Party (BMWP) is required for biotic assessments based on organism indicators, the system relies on identification to a family level that is not specific to a single watershed or geographic area. BMWP has been standardized by the International Organization for Indonesia (ISO). Can be used to reflect the impact of organic pollution, such as yields and waste disposal. The following is a scores assessment of the biotic index of a group of organisms:

![Figure 8. Biological Monitoring Working Party Score](image_url)
2.3.1 Macroinvertebrates.
Macroinvertebrates are organisms that live on the bottom of the waters, either those whom attached to the substrate, moving over the substrate, or digging a hole. Macroinvertebrates can live on substrates in the form of mud, sand, gravel, stone, and organic waste at the bottom of the water. Macroinvertebrates are larger than 1 mm (> 1mm) [5]
Macroinvertebrate community structures can be determined based on macroinvertebrate composition and relative abundance. The index of diversity and index of dominance is also needed in the study of macroinvertebrate community structure. Macroinvertebrate community structure is needed to determine the cascade-pond quality based on biotic index. This is because the assessment of biotic index is done by scoring the macroinvertebrate taxa group present in the sample unit.

2.3.2 Average Score Per Taxon (ASPT).
The average sensitivity of a organisms family, now known as the Average Score Per Taxon (ASPT) can be determined by dividing the BMWP score by the amount of taxa obtained. The highest value of the taxa in a region can be taken into consideration to determine the magnitude of the ASPT value [6]
Assessment of macroinvertebrate samples are using the ASPT index, because it is relatively easy to use in the assessment of water quality biomonitoring. The ASPT index calculation as follows:

\[
\text{ASPT Index} = \frac{\sum \text{BMWP score} \times \text{taxa}}{\sum \text{taxa}}
\]

BMWP score : Taxa’s found scoring (Figure 8)
Description :
Taxa : Macroinvertebrates found at the time of the sample
The results of the ASPT index are as follows:
- Score ASPT > 6 : No Polluted
- Score ASPT 5-6 : Lighly Polluted
- Score ASPT 4-5 : Moderately Polluted
- Score ASPT < 4 : Heavy Polluted

2.4. Riparian Assessment Methods
Tropical Rapid Appraisal of Riparian Condition Version 1 is a visual assessment of riparian zones using simple condition indicators, facilitating the appraiser without having to be specific in the field of botanists. This rating indicator is suitable for flow with well-defined channels, not designed for estuaries or floodplains adjacent to the riparian zone [7]
The index of riparian conditions is derived from 24 indicators grouped into 4 sub-indices: Plant cover, regeneration, weeds, and erosion that can be combined to obtain the index of riparian conditions. And also the pressure index comes from six indicators that help identify possible causes of changing conditions.
The Tropical Rapid Appraisal of Riparian Condition Version 1 uses cross-sectional section as the division of assessment area with length (5 - 20 m) along with 50 m width, but in fact the zone division for this study is divided according to the conditions of the riparian, and unspoiled land with an area of 50 m length. In the Pressure assessment there are 2 sub indicators that can not be filled but included in the assessment, including Animal, Fire, and Flow regime: large dams, because in each riparian there is no sub-indicator. Assessment points from the Tropical Rapid Appraisal of Riparian Condition Version 1 indicators are as follows:

| Sub-indicator & Indicator | Scoring (Score 1-5) |
|---------------------------|---------------------|
| **PLANT COVER** | Percentage cover of trees >5m tall |


Table 1. Tropical Rapid Appraisal Riparian Condition Version 1 Scoring.
| Sub-indicator & Indicator | Scoring (Score 1-5) |
|---------------------------|---------------------|
| 2. Canopy continuity      | Percentage of longitudinal bank covered with trees > 5 m tall |
| 3. Midstorey cover        | Percentage cover of vegetation 1.5 – 5 m tall |
| 4. Understorey cover      | Percentage cover of grass |
| 5. Grass cover            | Percentage cover of leaves and fallen branches < 10 cm diameter |
| 6. Organic litter         | Abundance of logs > 10 cm diameter |
| 7. Logs                   |                     |

**REGENERATION**

| 8. Canopy health          | Appearance of canopy health |
| 9. Large trees            | Abundance of trees with trunk diameter > 30 cm |
| 10. Tree size classes     | Variation in tree trunk width |
| 11. Dominant tree regeneration | Abundance of juveniles 0.3 – 3 m |
| 12. Other tree regeneration | Abundance of juveniles 0.3 – 3 m |

**WEEDS**

| 13. Canopy weeds          | Proportion of weed versus native canopy cover |
| 14. Midstorey weeds       | Proportion of weed versus native midstorey cover |
| 15. Understorey weeds     | Proportion of weed versus native understorey cover |
| 16. Grass weeds           | Proportion of weed versus native grass cover |
| 17. Organic litter weeds  | Proportion of weed versus native organic litter cover |
| 18. High impact weeds     | Distribution pattern of listed weed species within the riparian transect |
| 19. High impact weed distribution | |

**EROSION**

| 20. Exposed soil          | Percentage cover of exposed soil/sand/ash |
| 21. Exposed tree roots    | Extent of exposed roots due to erosion |
| 22. Slumping              | Combined width of slumps |
| 23. Gullying              | Combined width of gullies |
| 24. Undercutting          | Combined with of undercuts |

**PRESSURE**

| 25. Bank stability        | 31. Bank slope |
| 32. Instream structures: abundance of human-built instream structures |
| 33. Dominant and maximum bank sediment size |
| 26. Animals: managed and unmanaged | Extent of impact due to managed animals (e.g. stock) and unmanaged animals (e.g. feral pigs) |
| 27. Fire                  | Time since fire and spatial impact of fire |
| Sub-indicator & Indicator | Scoring (Score 1-5) |
|---------------------------|---------------------|
| 28. Tree clearing         | Proximity of clearing to river bank and width of clearing |
| 29. Flow regime           | Reduction of plant regeneration due to large dams |
| 30. Other                 | Extent of damage from human built structures and activities |

How to calculate TRARC's assessment of riparian conditions and pressure:

![Diagram of riparian conditions and pressure calculation]

**Figure 9.** Value calculating riparian conditions and pressure using Tropical Rapid Assessment Riparian Conditions Version 1

The assessment of riparian conditions is influenced by plant cover, regeneration, erosion, and weeds, so if at each value per indicator is large, then the results obtained at riparian conditions are also greater, showing good results. Assessment of riparian pressure is influenced by animals, fire, tree clearing, large regime flow dams, bank stability and other, but in animal, fire and regime large dams are not present throughout the university, it is estimated that the result of riparian pressure having small results shows good results.

2.5 Spearman Coefficient Correlation Methods

Used for non-parametric statistical measurement of ordinal data. Started with a conduction of research data rank, and followed by correlation testing [8]

3. Results & Discussion
At each zone there is already a zone division, then each zone is sampled for an assessment of the biological parameters of the macroinvertebrata using the ASPT index as well as the riparian assessment using TRARC. Here are the results of each cascade-pondation:

### 3.1. Kenanga Cascade-pond

**Table 2. Cascade-pond Kenanga’s result.**

| Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|--------|--------|--------|--------|--------|
| Pressure | 14 low | 4 low | 8 low | 1 low | 8 low |
| Condition | 68 B | 58 C | 63 C | 71 B | 59 C |
| ASPT Index | 2.75 | 4.71 | 4.00 | 3.47 | 4.67 |

**Macroinvertebrates**

| The Value of ASPT Index | Heavily Polluted | Moderately Polluted | Moderately Polluted | Heavily Polluted | Moderately Polluted |
|-------------------------|------------------|---------------------|---------------------|------------------|---------------------|

**Table 3. Cascade-pond Kenanga’s result.**

| Zone 6 | Zone 7 | Zone 8 | Zone 9 | Zone 10 |
|--------|--------|--------|--------|---------|
| Pressure | 2 low | 13 low | 25 Moderate | 8 low | 9 low |
| Condition | 70 B | 58 C | 68 B | 67 B | 70 B |
| ASPT Index | 5.89 | 6.00 | 3.60 | 6.00 | 6.00 |

**Macroinvertebrates**

| The Value of ASPT Index | Lightly Polluted | Lightly Polluted | Heavily Polluted | Heavily Polluted | Lightly Polluted |
|-------------------------|------------------|------------------|-----------------|-----------------|------------------|

### 3.2. Agathis Cascade-pond

**Table 4. Cascade-pond Agathis’s result.**

| Zone 1 | Zone 2 | Zone 5 | Zone 6 |
|--------|--------|--------|--------|
| Pressure | 22 Low | 27 Moderate | 2 Low | 2 Low |
| Condition | 60 C | 69 B | 59 C | 88 A |
| ASPT Index | 3.92 | 2.625 | 3.24 | 5.33 |

**Macroinvertebrates**

| The Value of ASPT Index | Heavily Polluted | Heavily Polluted | Heavily Polluted | Lightly Polluted |
|-------------------------|------------------|-----------------|-----------------|------------------|

### 3.3. Mahoni Cascade-pond

**Table 5. Cascade-pond Mahoni’s result.**

| Zone 1 | Zone 2 | Zone 3 | Zone 4 |
|--------|--------|--------|--------|
| Pressure | 5 low | 8 low | 10 low | minus 7 low |
| Condition | 71 B | 57 C | 63 C | 61 C |
Macroinvertebrates

| ASPT Index | 2.85 | 3.56 | 3.76 | 6.00 |
|------------|------|------|------|------|
| The Value of | Heavily | Heavily | Heavily | Lightly |
| ASPT Index | Polluted | Polluted | Polluted | Polluted |

**Table 6.** Cascade-pond Mahoni’s result.

| Zone 5 | Zone 6 | Zone 8 |
|--------|--------|--------|
| Riparian | | |
| Pressure | 23 low | 14 low | 10 low |
| Condition | 74 B | 55 C | 64 C |
| Macroinvertebrates | | | |
| ASPT Index | 5.21 | 4.83 | 3.67 |
| The Value of | Lightly | Moderately | Heavily |
| ASPT Index | Polluted | Polluted | Polluted |

### 3.4. Puspa Cascade-pond

**Table 7.** Cascade-pond Puspa’s result.

| Zone 1 | Zone 2 | Zone 3 |
|--------|--------|--------|
| Riparian | | |
| Pressure | minus 4 low | minus 4 Low | minus 4 low |
| Condition | 78 B | 83 A | 76 B |
| Macroinvertebrates | | | |
| ASPT Index | 6.27 | 4.87 | 3 |
| The Value of | No Polluted | Moderately | Heavily |
| ASPT Index | Polluted | Polluted | Polluted |

**Table 8.** Cascade-pond Puspa’s result.

| Zone 4 | Zone 5 | Zone 6 |
|--------|--------|--------|
| Riparian | | |
| Pressure | minus 3 Low | minus 4 low | minus 4 low |
| Condition | 76 B | 79 B | 83 A |
| Macroinvertebrates | | | |
| ASPT Index | 4.94 | 4.82 | 5.2 |
| The Value of | Moderately | Moderately | Lightly |
| ASPT Index | Polluted | Polluted | Polluted |

### 3.5. Ulin Cascade-pond

**Table 9.** Cascade-pond Ulin’s result.

| Zone 1 | Zone 2 | Zone 5 | Zone 6 | Zone 7 |
|--------|--------|--------|--------|--------|
| Riparian | | | | |
| Pressure | 9 low | minus 6 low | minus 6 low | minus 4 low | minus 8 low |
| Condition | 63 C | 77 B | 81 A | 76 B | 80 A |
|-----------|------|------|------|------|------|
| Macroinvertebrates | | | | | |
| ASPT Index | 4,72 | 4,73 | 3,75 | 4,60 | 5,29 |
| The Value of ASPT Index | Moderately Polluted | Moderately Polluted | Heavily Polluted | Moderately Polluted | Lightly Polluted |

3.6. Salam Cascade-pond

**Table 10.** Cascade-pond Salam’s result.

| Zone | Zone 1 | Zone 2 | Zone 6 | Zone 7 |
|------|--------|--------|--------|--------|
| Riparian | | | | |
| Pressure | 22 Low | 13 Low | minus 8 Low | 8 Low |
| Condition | 62 C | 70 B | 69 B | 84 A |
| Macroinvertebrates | | | | |
| ASPT Index | 3,82 | 3,00 | 3,35 | 4,74 |
| The Value of ASPT Index | Heavily Polluted | Heavily Polluted | Heavily Polluted | Moderately Polluted |

**Table 11.** Cascade-pond Salam’s result.

| Zone | Zone 8 | Zone 9 | Zone 10 |
|------|--------|--------|---------|
| Riparian | | | |
| Pressure | 11 Low | 25 Moderate | 23 Low |
| Condition | 67 B | 74 B | 65 B |
| Macroinvertebrates | | | |
| ASPT Index | 4,12 | 4,22 | 4,35 |
| The Value of ASPT Index | Moderately Polluted | Moderately Polluted | Moderately Polluted |

3.7. The correlation between riparian pressure, riparian condition with macroinvertebrates

Correlation between riparian pressure, riparian condition with macroinvertebrata as binding variable using Spearman method SPSS 2017, that is:

**Table 12.** Correlation between pressure & condition riparian with macroinvertebrates.

| Macroinvertebrates | Riparian Condition | Riparian Pressure |
|-------------------|--------------------|------------------|
| Kenanga Cascade-pond | -0,272 | -0,056 |
| Agathis Cascade-pond | 0,4 | -0,632 |
| Mahoni Cascade-pond | -0,107 | 0,234 |
| Puspa Cascade-pond | 0,235 | 0,131 |
| Ulin Cascade-pond | -0,3 | -0,103 |
| Salam Cascade-pond | 0,250 | 0,214 |

The correlation between riparian conditions with macroinvertebrates has a very weak correlation between the two, it is proved (0 - 0.25) on all four sites and a sufficient correlation to the Agathis and
ulin sites, this is evidenced (0.26 - 0.5); proportional to straight or not reversed because the results obtained positive, the greater the value of riparian conditions then the greater the value of macroinvertebrates that show good results. The correlation between the riparian pressure and the macroinvertebra has a very weak correlation between the two, it is proved (0 - 0.25) in the five cascade pond and the strong correlation of the Agathis site, it is proved (0.5 - 0.75); inversely due to negative results [9], the smaller the riparian pressure value the greater the value of macroinvertebrates that show good results. In the resulting regression equation, with Macroinvertebrate as the dependent variable, as well as the riparian Condition and Pressure as the independent variable, yields:

| Cascade-pond Kenanga | y = 0.038x + 2.457 | 0.519 | y = −0.049x + 5.156 | 0.277 |
| Cascade-pond Agathis | y = 0.062x − 0.499 | 0.716 | y = −0.05x + 4.444 | 0.568 |
| Cascade-pond Mahoni | y = −0.19x + 5.460 | 0.118 | y = −0.013x + 4.387 | 0.109 |
| Cascade-pond Puspa | y = 0.105x − 3.482 | 0.318 | y = 0.105x + 5.252 | 0.041 |
| Cascade-pond Ulin | y = −0.014x + 5.651 | 0.179 | y = 0.001x + 4.62 | 0.010 |
| Cascade-pond Salam | y = 0.036x + 1.398 | 0.435 | y = 0.018x + 3.699 | 0.347 |

In the above regression results, with y as macroinvertebrata (ordinal data), and x as riparian conditions (ordinal data) and riparian pressure (ordinal data), riparian conditions with R > 0.3 whole Cascade-pond, except where Mahoni and ulin show the influence of macroinvertebrate variables with the variables of demarcation conditions, riparian pressure with R > 0.3 only Salam and Agathis cascade pond shows the influence between macroinvertebrate variables with the variable of riparian pressure. Cascade ponds that have a result R < 0.3 can be attributed to another influence between variables y and variable x affecting the existence of variable y (macroinvertebrates).

4. Conclusion
The existence of macroinvertebrates is influenced by riparian conditions and pressure, this is evidenced by the fact that the riparian conditions indicate very well that under unnatural conditions such as zones present in each site and riparian pressure indicates a low value because it is covered by a natural condition, hence the resulting macroinvertebrates also vary with high scoring scores, the result proves that the value of riparian conditions affects the diversity and abundance of macroinvertebrates, as evidenced by the results of R (0.1 - 0.7) with the result of correlation (0.1 - 0.5) and the value of riparian pressure also affects the diversity and abundance of macroinvertebrates, this is evidenced from the results of R (0.01 - 0.6) with the correlation result (0.05 - 0.6).

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