Evaluation of water quality using plankton diversity in Sumber Maron River District Gondanglegi Kulon East Java-Malang, Indonesia

F Tawati1,2, Y Risjani3 M S Djati 4, A S Leksono5 B Yanuwiadi6

1Doctorate Program of Environmental Science, Brawijaya University, Malang, Indonesia
2Higher Institute for Comprehensive Professions – Gharabuli, Libya
3Department of Biology, Faculty of Science, Brawijaya University, Malang, Indonesia
4Department of Aquatic Resources Management, faculty of fisheries and marine sciences, Brawijaya University

Corresponding author: Fzaya2004@gmail.com

Abstract. The diversity of species in the ecosystem is directly related to abundance or adaptation, and the presence of plankton in the ecosystem is useful for assessing the state of pollution. An assessment of phytoplankton and zooplankton has been carried out at nine sites of the Sumber Maron River, which will help to understand the biodiversity indicators of the river water. Sediment Samples were taken from the lower river and placed in plastic bags with a volume of about one kg during the rainy and dry season of 2016. Phytoplankton diversity was observed in 13 Genus while the diversity of zooplankton included 10 Genus. Thus the present study gives an indication of the diversity of phytoplankton and zooplankton which can be useful as data to determine the status of water quality of the Sumber Maron River.

1. Introduction

Biological density serves as the best indicator of healthy aquatic ecosystem. Rivers are ecosystems of great environmental value with rich animals that consist of societies with complex structures and high biological value. However, their own classification makes them fragile and vulnerable to environmental changes, especially those related to human origin disorders, which often involve irreversible degradation of living organisms [1]. A major impact on rivers is the pollution of their water with household and industrial waste. Agriculture, with intensive use of fertilizers and pesticides, has also contributed significantly to the protection and contamination of aquatic organisms [2,3], as well as human activities that have damaged the environment and its systems and caused disturbances and changes in the chemical composition of water and in the structure of organisms living in this environment [3,4].

The macro-invertebrates play major roles in determining the quality of the aquatic environment; they include insects, crustaceans, crustaceans and mollusks. Water pollutants as fertilizer and detergents were beneficial for the excessive growth of algae [1]. Plankton on which whole aquatic life depends directly or indirectly on many biological conditions and tolerance of living organisms with changes in one or more of these conditions [5]. Phytoplankton in aquatic society serves as food for the development and growth of zooplankton. The large diversity of zooplankton and phytoplankton varies...
with their combinations with seasonal differentiation and production of myrolobantactone such as eggs, larvae, bottom events, nectar, etc. [6]. Most zooplanktons are nutrient filters that use their secretions to breed bacteria, algae and other fine particles of water [7]. It has been found that species diversity in the ecosystem is directly related to abundance or adaptation [8]. Plankton in the ecosystem is useful as bioindicators to assess the state of contamination. In this study we determine the water quality of Sumber Maron river by analyze the diversity diversity of phytoplankton and zooplankton.

2. Materials and Method

Directly survey was done to determined research station of macro-invertebrates sampling. Description of the study area the Sumber Maron River is one of the main rivers of the Kepanjen region. (Fig. 1), flowing westward direction of about 30 miles through the evergreen forest area there are wet, dry climatic seasons prevail in the study area. These classes are defined using the cortex index (AI). The wet season (October / November / December) is characterized by a high monthly precipitation while the dry season (January - February, March - April) is characterized by low precipitation and for the purpose of this study, nine sampling stations were delineated in the river. (https://en.m.wikipedia/wiki,clima)

2.1. Data Collection

Data of macroinvertebrate collected by observing in the research location and the upstream area of Sumbe maron River in Gondanglegi [9]. Sample was then analyze using modified index analysis of Biological Monitoring Working Party (BMWP). Furthermore, the observation of macroinvertebrate and measurement of water parameters were performed in the laboratory. Sampling stations was determined based on the land use at the surrounding area of uppem Sumbermaron River in Gondanglegi Village.

2.2. Isolation and Sequence of TII

DNA isolation was done by using protocol from Doyle & Doyle modified by Maftuchah & Zainudin [31] with CTAB extraction buffer. Isolated DNA was used as a template for DNA amplification. A pair of primer, CpTI-F (5′-ATG AAG AGC ACC ATC TTC TTT GCT C-3′) and CpTI-R (5′-CTT ACT CAT CAT CTT CAT CCC TGG-3′) [32] were used to amplify of TII gene. The total volume of PCR reaction was conducted as following condition: 25 μl total volume, consist of a mixture solution including taq DNA polymerase and 10X buffer TaqPolimerase (100 mMTris-CI, pH 8.3; 500 mM KCl; 15 mM MgCl2; 0.01% gelatin); dNTPS mix (dGTP, dATP, dTTP and dCTP) (Recho); dH2O. The conditions for the PCR reaction was conducted following condition: pre-denaturation 94 °C (5 min), denaturation 94 °C (1 min), annealing 40 °C (1 min), an elongation of 72 °C (2 min) and post-PCR 4 °C (2 min), for 35 cycles. Electrophoresis on a 1.5% agarose and visualization under a UV-transilluminator were used to check the PCR result. The process of sequencing was performed according to the ABI PRISM DNA Analyzer procedure.
2.3 Field sampling and analysis
Samples were evaluated in the rainy season from nine sites along River sampling. Plankton was collected by filtering one Kg from sediment and water. Water samples were collected in a colored bottle to prevent discoloration of algae. Samples were preserved in the iodine iodine solution (1V / 100V) and 70% alcohol which maintains the crisp structure of the animals and is also useful for sample settlement. SODGE WICK - A cell-count rafter was used in 100x magnification for quantitative analysis of phytoplankton and zooplankton [10]. Routine analyzes of physical parameters were performed.
3. Results and Discussion

3.1. Phytoplankton analysis
Phytoplankton communities was observed in rainy and dry season. The results of macro-invertebrate composition are shown in Table (1) and Figure (1). There were 1597 individuals of macro-invertebrates collected in all stations. The abundance of the macro-invertebrates collected in rainy season (163.13±76.19) was higher than that in dry season (32.44±8.61) (Table 1). All dominant genera abundance showed the same trend, except for Groenbaldia. This genus was more abundant in dry season (2.44±1.65) than in rainy season (0.89±0.89). Several genera appeared only in rainy season, these including Hyalotheca, Chlorella, Ulothrix and Plectonema.

Table 1 Mean of abundance of phytoplankton collected from all stations in rainy and dry seasons

| Groups      | Rainy        | Dry          |
|-------------|--------------|--------------|
| Hyalotheca  | 84.44±69.76  | 0.00         |
| Navicula    | 10.67±4.18   | 10.33±2.68   |
| Pinnularia  | 11.22±4.87   | 9.44±3.40    |
| Nitzchia    | 5.11±1.61    | 2.78±1.44    |
| Synedra     | 3.78±1.52    | 2.67±1.37    |
| Chlorella   | 5.11±4.75    | 0.00         |
| Ulothrix    | 4.00±4.00    | 0.00         |
| Plectonema  | 3.89±3.89    | 0.00         |
| Groenbaldia | 0.89±0.89    | 2.44±1.65    |
| Surirella   | 1.56±0.58    | 1.44±0.73    |
| Miscellenies| 14.33±3.37   | 3.33±0.94    |
| Total abundance | 163.13±76.19 | 32.44±8.61   |

Based on the results of phytoplankton sample identification in Sumber Maron River, as many as 11 species which include Hyalotheca, Navicula, Pinnularia, Synedra, Chlorella, Ulothrix, Plectonema, Groenbalida, Surirella, and Miscellenies. The result show that in upstream site, both in rainy and dry season have lowest individual abundance both in rainy season (40.66±21.09 individual) and in dry season (17±11.02 individual). It could be because the substrate in upstream site dominate by sand and mud. In another site, individual microorganism was found highly in downstream in rainy season (284.33±213.86 individual) (Figure 2). The lowest number of genera was found in upstream, both in rainy season (4.33±2.67 genera) and in dry season (1.45±0.67) (Figure 5.30). That station had the lowest number of taxa due to substrate that is dominated by sand and mud. Some species live among vegetations and the others live in the mud. The highest number of genera was found in rainy season both middle stream (10±1.53) and in downstream (10±2.31) (Figure 3).
The lowest diversity was found in upstream, both in rainy season (1.03±0.28) and in dry season (0.69 ± 0.23) (Figure 4). There is no difference in the diversity during the dry and rainy season because the macro-invertebrate diversity is determined by the altitude. Altitude adversely affects diversity in tropical highland rivers due to the reduced oxygen concentration, atmospheric pressure and temperature [11,12], whereas the intensity of solar radiation and the rainfall are increased [13].

In addition, the highest diversity was found in middle stream with the mean of H’ index was 1.63 ±0.19 in dry season and 1.59 ± 0.05 (Figure 4). Based on the scores, the values of the diversity were considered low to moderate levels. The high diversity in the middle stream and downstream is due to the relatively high level of species richness in the area. Meanwhile, the low phytoplankton in the upstream area may be related to low nutrient availability, so that species richness is also low. Despite being a recognizable gradient, the interpretation of the controlling factors of diversity patterns across latitudes can be complex [14], and it is difficult to establish cause and effect. Some studies that analyzed latitudinal gradients and mentioned energy availability, temperature variability, climatology and the study area size as the relevant aspects responsible for changes in diversity [14].
Figure 4. The diversity of macro-invertebrates in all locations both in rainy and dry seasons

The result showed that the taxa richness ($F = 8.77; P<0.001$) and diversity ($4.97; P<0.05$) of macro-invertebrates were significantly highest in middle stream, and higher in rainy season ($5.14; P<0.05$). Meanwhile there was no significant differences of the abundance between seasons and among locations. Several groups also showed different variation in the abundance between seasons and among locations. The effect of season and location was not significant for all dominant genera, but there was significant on the minor genera (Table 2). Most of the minor genera tend to be more abundant in rainy season.

Table 2. Summary of F values followed by degree of significance using General Linear Model Analysis of variance (ANOVA) of the abundance, taxa richness and diversity of several phytoplankton genera

| Group      | Season (S) | Location (L) | S*L     |
|------------|------------|--------------|---------|
| Hyalotheca | N.a.       | 1.20         | N.a.    |
| Pinnularia | 0          | 1.01         | 0.37    |
| Navicula   | 0.14       | 0.85         | 0.07    |
| Nitzchia   | 0.10       | 0.48         | 0.08    |
| Synedra    | 0.74       | 0.22         | 0.38    |
| Chlorella  | N.a.       | N.a.         | N.a.    |
| Pleptonema | N.a.       | N.a.         | N.a.    |
| Surirella  | 0.26       | 1.078        | 0.26    |
| Groenbaldia| N.a.       | N.a.         | N.a.    |
| miscellanies| 40.84***   | 20.29***     | 6.79**  |

Abundance    | 2.54       | 1.01         | 0.93    |
Taxa richness| 5.14*      | 8.77***      | 0.18    |
Diversity    | 0.12       | 4.97*        | 0.56    |

The highest abundance and taxa richness in middle stream may associate with condition of the waters where the location the station is directly opposite the agricultural area so that the nutrients are available relatively high and supportive growth and type development phytoplankton, and this is caused by sampling done on time during the day, when the sun shines brightly, where this is a good
time to phytoplankton perform the process of photosynthesis, so that phytoplankton migrate vertical to the water surface to perform photosynthesis.

Among the genera, Hyalotheca, Navicula, Pinnularia and Nitzchia were dominant in all stations both in rainy and dry seasons (Figure 5). Navicula, Pinnularia and Nitzchia belong to Bacillariophyta. The Bacillariophyta group can develop well in the study sites because of fit water conditions. The water temperature was considered moderate, this level was conducive for Bacillariophyta grow and develop. This group grows well in relatively low of water temperature conditions, so it is often used as an indicator of unpolluted waters [15]. Phytoplankton generally develops well in waters with a temperature of 20-30oC [16].

**Figure 5.** The composition of phytoplankton genera for each station in Sumber Maron river in rainy and dry seasons

Result of the UPGMA cluster analysis showed that phytoplankton was assemblage according to location except in downstream. Invertebrate compositions in middle stream between rainy seasons and dry season were at 81.9%. Invertebrate compositions in upstream between rainy seasons and dry seasons was branched at 88.7%. Branching of the invertebrate compositions in upstream and
downstream between rainy and dry seasons occurred at 81%. All compositions from two season and three locations had more than 80% similarity (Figure 6). This means the composition of phytoplankton in every station was similar. The high percentage of phytoplankton in the three locations can be caused by the geographical condition of the area. The area lies in an altitude between 500 and 667 above sea level. This is considered a highland. The tropical region obtain sufficient sunlight yearly. This also the reason of the high percentage of phytoplankton in the area. The sunlight also determines the precipitation. The driest month is August with precipitation total 26 mm, while the wettest month is January with precipitation total 334 mm. The biomass of phytoplankton is often limited by the availability of nutrients when light availability is sufficient, particularly at elevated temperature and loss rates are not excessive [17].

![Figure 6](image.png)

**Figure 6.** Community compositions between macroinvertebrate between rainy season and dry season and among the locations

Canonical Correspondence Analysis (CCA) revealed that environmental variables were significant for explanation of the variance in family abundance pattern. The sum of the first two canonical eigenvalues was 0.88. The first axis, explained 50.5% of the family-environment relations, while the second explained 38 % of the family-environment relations. Total solid substance (TSS) had significance effect on the family-environment (P< 0.05). A lot of phytoplankton groups responded negatively to TSS such as Groenbaldia, Navicula, Synedra and Nitzchia. While other genera responded to TSS such as Ulotrix, Hyalotheca and Plectonema.
This happens allegedly because the sampling was conducted in the morning when the area was still shady so that the phytoplankton could not photosynthesis and phytoplankton prefer to migrate vertically downwards. Growth phytoplankton is influenced by light in terms of quality and quantity of light, and sunlight is a key condition for the ongoing process of photosynthesis [18].

The abundance of phytoplankton is an indication of fertility in aquatic environments. Plankton type diversity is a mathematical representation that can describe the structure of life and can make it easier to analyze information about the type and number of organisms. Analysis of plankton uniformity was done to see the new pattern distribution of the type of plankton on a the plankton community ecosystem [19]. Analysis of dominance index plankton used to see there whether or not a plankton type is dominates in a type of plankton population. When in a community said to have diversity high species if present many species with individual numbers each relative species evenly, in other words that if a community consists only of few species with number of individuals which is uneven, then the community it has diversity the low one [20].

4. Conclusion
Based on the result, the abundance of the macro-invertebrates collected in rainy season was higher than that in the dry season. The phytoplankton in Sumber Maron River was as many as 11 species which include Hyalotheca, Navicula, Pinnularia, Synebra, Chlorella, Ulothrix, Plectonema, Groenbaldia, Surirella, and Miscellenies. Moreover, the composition of phytoplankton in every station was similar at the average of more than 80%.

Acknowledgment
This study was developed in the framework of the postgraduate study in Universitas Brawijaya. The study was funded by the Ministry of Education, Libya. We thank to the Libyan Embassy and government for the support. We would like also to Jasa Tirta company for the laboratory analysis. We thank the anonymous reviewers and the editor for their constructive and helpful comments.
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