The Structure of Plankton as An Environmental Indicator for Water Management in Upper Part of Rawapening Lake, Semarang Regency, Indonesia

J W Hidayat1), R B Hastuti1), M Hadi1) dan G Yulianto2)
Department Biology, Faculty Science dan Mathematics, University of Diponegoro Semarang
Department Physic, Faculty of Science dan Mathematics University of Diponegoro Semarang
E-mail: wasiqjep@gmail.com

Abstract. The quality of Rawapening waters is constantly changing over time. The bloom growth of water hyacinth, fishery aquaculture activities and environmental pressures are getting heavier as expressed as eutrophication. This will affect in plankton composition. Plankton can provide an indication of changes and environmental quality, especially of its biotic structure and biodiversity. The upper part of Rawapening lake, similar to other part of the lake, is enriched with semi and aquatic plant. The purpose of this research is to analyze the condition of plankton currently, so that it can understand the change of water quality to support lake and fishery managements. The study was conducted in June 2018 on the upper parts of Rawapening Lake, particularly the southern side where many spring waters appear. Plankton collection was done by sampling using plankton net no 25. Data analysis was conducted descriptively and semi-quantitative using community structure including diversity, evenness and domination indices. The results showed that common plankton species found were Melosira sp, Synedra sp and Chlorella sp. Aulacoseira sp is quite abundant in all five stations reaching a range of 34-153 individuals / lt. In term of ecosystem stability, the waters are qualified as small to moderate stability conditions (H index :1.04 - 2.18) The species abundance tend to be small, especially in the spring station, which is associated with low water nutrients from springs. Aulacosiera sp is still dominate the plankton component for some station. The species which previously experienced a high domination, especially the Aulacoseira spp, change into a minority. This condition is mainly related to the changing physical condition of environmental. This, at a glance shows that the former water source area is still in good quality at this time experiencing enrichment. This is related to the increasing fishery practices of floating cage net of cultivation area approaching the spring water areas. The limitation and regulation in this area are urgently implemented and enforced, because clean water supply is important for the supply and circulation, which is not only for culture practice but also the lake in general.

1. Introduction
The availability of water is the subject of concern for all stakeholders, not only in terms of drinking water resource, but also fishery, farming, tourism, energy and of course fish culture. Nowadays, its availability is decreasing both quantitative and qualitatively. Many large lakes that become natural reservoir of freshwater
have been designated as prioritized conservation associated with the worsening degree of contamination [1, 2]. Decreasing water quality is also reported in Rawapening Lake, one of 15 big lake as priority concerned by government. Various efforts are carried out both inside the lake, such as efforts to control water hyacinth and sludge removal; or external with an effort to implement environmentally friendly systems (organic farming, compost processing, etc.) [3].

Environmental quality in Rawapening has been continue to experience pressure, both directly and indirectly [4,5,1]. Cultivation activities (farming, fishery, animal husbandry) have significantly been trigger water fertility and even eutrophication. Water quality on the upstream part is very important to be protected, mainly as a supplier and stocks water to refresh (circulation) the whole body of the lake. The quality of the river on the upstream side, especially the large ones, have brought various components, both physical including sediment and chemicals such as of waste from agriculture and livestock. This condition greatly suppresses the condition of clean water supply that is arise from the surrounding springs. Rawapening has a legendary spring water on the southwest side of the Bukit Cinta [3]. Beside, it is also from many smaller springs emerge around it. The fertility of the surrounding spring water is weakly identified. Most of the study concern on the wider lake body, especially it’s fertility. However as the time goes, it is believed there is different changes. Therefore, it is important to identify and to determine the management of the upstream side, especially through biotic indicators i.e. plankton. Plankton are microorganisms that can describe changes in the environment [1, 4]. The aim of this research is to identify plankton structure that occupy upstream of Rawapening water column. It also to analyze quality of the water based on pollution status

2. Method
2.1. Procedure
The study area chosen is lake body waters of Rawapening, Semarang District, Central Java Indonesia, during April 2018. Five different stations were chosen to collect the data, both for biotic and physico-chemical parameters. Station of the sampling included 3 different water regimes within the lake

![Figure 1. Map of the Rawapening Lake (Rynari,2015)](image-url)

body (Figure.1). Three sample were taken in lake body waters and one sample on paddy irrigation water system as well as in river of Prarat were taken. Thirty (30 L) liter of water sample was filtered using plankton net number 25. Temperature, turbidity, water clarity, salinity, nitrate content and acidity were also measured as physi-chemical parameters. Plankton enumeration and identification were done to find their species composition and individual number. The plankton identification was done under binocular microscope by applying Sedgewick Rafter Cell (SRC) Counter, as done by Suprobowati et al. [5] and Madusari et al [6].
Analysis of plankton was done in the Laboratory of Ecology and Biosystematics, FSM Diponegoro University. Whereas physic-chemical analysis run in organic and inorganic Laboratories of Chemistry Department. Descriptive and semi-quantitative analysis were used, including Biodiversity Shannon-Wiener Index (H'), evenness index (e) and Dominance index [7]. Saprobic index was enumerated to analysis the fertility of the waters, as done by Basmi [8]. The analysis of the index was calculated as follows:

**Shannon-Wiener Diversity Index (H'):**

Diversity index H’ is reckoned to identify the stability of the ecosystem. The formula Shannon-Wiener index [7] is as follow:

\[
H' = -\sum \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right)
\]

Where:
- \(H'\) = diversity index of Shannon-Wiener
- \(n_i\) = number of individuals of species \(i\)
- \(N\) = total number of individuals of all species

**Evenness Index (e)**

Evenness index used was:

\[
e = \frac{H'}{\ln S}
\]

Where: \(e\) = evenness Index \(H'\) = diversity index of Shannon-Wiener, and \(S\) = number of species

**Dominance Index**

Dominance Index used was:

\[
D_i = \frac{n_i}{N} \times 100\%
\]

Note: \(D_i\) = relative density index of species \(i\); \(n_i\) = number of individuals of species \(i\); \(N\) = total number of individuals of all species

Krebs [9] described the dominant category i.e. Dominant species, \(D_i \geq 5\%\); Subdominant species, \(D_i = 2-5\%\) and Non-dominant species, \(D_i = 0-2\%\)

Qualification of the pollution status used a saprobic index based on plankton composition. Saprobic index used as performed by Basmi [8], calculated by the formula:

\[
X = \frac{C + 3D - B - 3A}{A + B + C + D}
\]

Where:
- \(X\) = Saprobic Coefficient, between of -3 to +3
- \(A\) = Number of species groups Cyanophyta (Polisaprobik)
- \(B\) = Number of species groups Euglenophyta (α-Mesosaprobik)
- \(C\) = Number of species groups Chlorophyta (β-Mesosaprobik)
- \(D\) = Number of species groups Chrysophyta (Oligosaprobik)

Data analysis of enrichment potential was done using basic saprobic analysis.

3. Result and Discussion

There are at least 12 species plankton found in upper part of Rawapening lake and riverine water body. Mostly dominated by Bacillariophyta (5 species) followed by Cyanophyta (4 species) and Chorophyta (2 species). In term of proportion, this composition in still consistent to previous findings, i.e. Soeprobowati [5], Hidayat et al. [4]. The commonest found species are *Aulacoseira* sp, *Chlorella* sp and *Synedra* sp. The abundant of these planktons, respectively are varies between 17 – 102; 17- 34, 17-34 individual / lt. The dominant of the *Aulacoseira* sp is consistent to Soeprobowati et al [5]. This species is cosmopolite and withstand to environment change. Cosmopolite usually tend do adapt quickly in disturbed habitat. This species also tend to high in reproductive manner, and therefore high in population.
Table 1. Structure of Plankton in Rawapening lake, April 2018

| No | Nama Spesies    | Stasiun A | Stasiun B | Stasiun C | Stasiun D | Stasiun E |
|----|----------------|-----------|-----------|-----------|-----------|-----------|
| A  | BACILLARIOPHYTA |           |           |           |           |           |
| 1  | Melosira spp   | 0         | 17        | 0         | 17        | 17        |
| 2  | Aulacoseira sp | 17        | 153       | 34        | 102       | 51        |
| 3  | Navicula sp    | 17        | 0         | 0         | 0         | 0         |
| 4  | Nitzchia sp    | 17        | 34        | 0         | 17        | 0         |
| 5  | Synedra sp     | 0         | 17        | 17        | 34        | 17        |
| B  | CHLOROPHYTA    |           |           |           |           |           |
| 6  | Chlorella sp   | 0         | 17        | 17        | 34        | 17        |
| 7  | Scenedesmus sp | 0         | 0         | 0         | 17        | 0         |
| C  | CYANOPHYTA     |           |           |           |           |           |
| 8  | Anabaena sp    | 17        | 0         | 0         | 17        | 17        |
| 9  | Oscillatoria sp| 0         | 0         | 0         | 17        | 0         |
| 10 | Peridinium sp  | 0         | 0         | 0         | 17        | 0         |
| 11 | Spirulina sp   | 0         | 0         | 0         | 34        | 0         |
| D  | ZOOPLANKTON    |           |           |           |           |           |
| 12 | Cyclops sp     | 0         | 0         | 0         | 34        | 17        |

|                | Total individual (N) | 68 | 238 | 68 | 340 | 136 |
|----------------|----------------------|----|-----|----|-----|-----|
| Total species  |                      | 4  | 5   | 3  | 11  | 6   |
| Diversity Index (H') |                | 1.38 | 1.12 | 1.04 | 2.18 | 1.61 |
| Eveness Index (e) |                      | 1  | 0.61 | 0.94 | 0.80 | 0.88 |

**Notes**: Station A: Prarat river; Station B: Irrigation water of Prarat River; Station C: Spring water column; Station D: Fishing zone and Station E: Floating cage zone

The least, non commond population are *Navicula, Spirulina* and *Peridinium*. *Navicula* sp has different pattern to the Bacillariophyta in general. *Navicula* is not found in the fishing, floating cage and spring water zones where most Bacillariophyta was dominan. *Spirulina* sp is generally common species, but this is important for fishery as natural food. Therefore, these low populations are likely related to grazing by fish larvae. *Peridinium*, one species with toxic potential is relative low as small as 17 ind./lt. This is only found in fishing zone in upper part of Lake Rawapening. Unfortunately, as the water nutrition become higher the *Peridinium* will potentially increase. If this population become higher as high as 5000 indv/lt this will affect to the fish culture, contamination. Aunurohim et al. [12] stated that the properties of the algae toxin are produced if the density reaches over 5,000 individuals per liter.

In term of ecosystem stability based on their structure, the diversity index values (H') varies between 1.04 – 2.18. These values indicate the stability are small to moderately criterias. This small values indicates there are many disturbances to this community, which related to fishing, tourist and domestic activities from the surrounding areas. The highest values is found in fishing zones with the index values as much as 2.18. All 12 species can be found here except *Navicula* sp. This station is still suitable to support aquatic lives since there are a lot of peoples fishing by angler and lift net. If there are a lot of fishing activity, indicates there are a lot of fish, and therefore, a lot of food, including their based food phytoplankton. The pH factor is neutral (7.2) and the DO is still maximal (6.7 ppm). This can support metabolic process and will promote the reproduction and population. This stability is also strengthen by a high evennes index (e) as much as 0.80. This mean there are dominan species interact within community. Tourist activity is lakely antropogenic disturbance which dominate the station. The second largest values of diversity index is observed from the floating cage station. There are 6 species found in this station, in which number of the dominant species *Aulacoseira* sp is
decrease significantly about twofold. This is related to the decrease of DO about 3.9 ppm. The spring water is come up from the base of the lake and does not interact with surface air yet and so least in DO value. This number according to Basmi [8] will affect to the lives therein, including plankton and fishes.

The diversity and quality of plankton in irrigation waters tend to low in index and therefore the stability. It is believe related to the dynamic of the debit and farming cycle system. During paddy culture, there is periodic water management i.e flooding and drying; which affect to plankton. The availability of dominant plankton is such as Aulacosiera sp and Nitzschia can be used to feed fish larvae. Shortly, paddy field can support juvenile fish and therefore appropriate to develop a fish-paddy culture (mina padi system) around the lake. Nila (Tilapia) is most potential cultivant to be introduce into paddy field because it can consume not only plankton but also macrobenthos, weed as they grow.

The smallest diversity index is found in spring water station. This is related to the least content of nutrient, especially nitrate (2.05 ppm). Nutrient such as nitrate is mayor nutrient to support the growth of phytoplankton. Physically, the water is clear and least in water hyacith as wel as least in turbidity. The commont component of turbidity in lake is organic matter including plankton. The static water tend to allow desolve organik matter to settle, but it is not the lives plankton.

| No. | Prarat River (A) | Prarat river irrigation (B) | Spring Zone (C) | Fishing Zone (D) | Floating cage Zone (E) |
|-----|------------------|-----------------------------|----------------|-----------------|------------------------|
| 1.  | Temperature (°C) | 25                          | 30.8           | 26.3            | 30.3                   |
| 2.  | DO (mg/l)        | 6.53                        | 5.8            | 6.6             | 6.7                    |
| 3.  | pH               | 6.8                         | 6.17           | 7.9             | 7.2                    |
| 4.  | Nitrate (ppm)    | 4.83                        | 4.35           | 2.05            | 6.52                   |
| 5.  | Amoniak (ppm)    | 0.025                       | 0.002          | 0.014           | 0.013                  |

Table 2. Physico-chemical factors in Rawapening Lake, April 2018

Keterangan:
Station A : Prarat river
Station B : Irrigation water of Prarat River
Station C : Spring water column
Station D : Fishing zone
Station E : Floating cage zone

Water Feasibility to support cultivation

The quality of the water can also be identified their pollution criteria. Result from the calculation showed the value of saprobic index varies between 0.2 – 2.3. The category of saprobic analysis of upper lake Rawapening Semarang were between β-Mesosaprobic up to Oligosaprobic. These indicate qualifcation of moderately up to small polluted. The condition is similar to other finding as reported by Hariyati [10] in the similar work in Rawapening. The small the number the heavier the pollution and visa versa. The least polluted sites is spring water zone with the value of saprobic as big as 2.3. This reason behind non polluted water is consistent to the previous biodiversity explanation, in which small index indicating the low diversity. There are no many activities except small scale tourist mainly boating. The smallest saprobic value (0.2), and therefore the better water for cultivation, were found in station fishery zone. This is consistent to the diversity index and functionality of the zone; as discussed before.

| Station  | Station a | Station b | Station c | Station d | Station e |
|----------|-----------|-----------|-----------|-----------|-----------|

Table 3. Saprobity of the upper lake Rawapening. April 2018
| Saprobic Index (X) | 1.5  | 2.6  | 2.3  | 0.2  | 1.4  |
|---------------------|------|------|------|------|------|
| Category            | Oligosaprob | β-Meso / Oligosaprob | β-Meso / Oligosaprob | Oligosaprob | oligosaprob |

Keterangan:
Station A: Prarat river
Station B: Irrigation water of Prarat River
Station C: Spring water column
Station D: Fishing zone
Station E: Floating cage zone

4. Conclusion
*Aulacosiera* sp, *Synedra* sp and *Chlorella* sp were found commonly plankters in the upper part of the lake; whereas a fish feed plankton *Spirogyra* sp and *Navicula* and *Chorella* sp are observed very small as affect from grazing. The fishing zone is the best in stability. Pollution status of saprobic based for spring water is still least in pollution and therefore should be managed not to be converted into floating cage zone use

**Recommendation**
Conservation and replantation actions should be performed all the way through on the catchment area to keep the spring water sustain in term of external issue, whereas in internal aspect the broadening floating cage culture (semi and intensive fisheries) is should be restricted.

**Acknowledgement**
This research have been funded by Directorate of Research and Public Service Minister of Research and Technology contract no 101-88/UN7.P4.3/PP/2018 (skim PTUPT year 2018). Thank are addressed to the above allocation.

**References**
[1] Soeprobowati, TR, SWA. 2010, Status Trofik Danau Rawapening Dan Solusi Pengelolaannya, *Jurnal Sain Dan Matematika* 18 (4)
[2] Haryani, G.S. 2013. Kondisi Danau di Indonesia dan Strategi Pengelolaannya. Prosiding Pertemuan Ilmiah Tahunan MLI I. 3 Desember 2013. Cibinong.
[3] Soeprobowati, T.R. 2012. Mitigasi Danau Eutrofik: Studi Kasus Danau Rawa Pening. Prosiding Seminar Nasional Limnologi VI Tahun 2012.
[4] Hidayat, JW, TR Soeprobowati, K. Baskoro, 2005, Pemanfaatan Diatoma sebagai Bioindikator di perairan Rawapening, Laporan Hibah Penelitian Tahun 2005 Fakultas MIPA Universitas Diponegoro.
[5] Soeprobowati TR, J.W. Hidayat, WH Rahmanto and K Baskoro, 2008, Pengembangan metode Identifikasi Diatome sebagai Bioindikator di Rawapening, Laporan penelitan Hibah Fakultas Matematika dan Ilmu Pengetahuan Universitas Diponegoro
[6] Madusari B.D., J.W. Hidayat, D.E. Wibowo dan C Muhammad. 2017. *Adv. Sci. Lett.* 23 6435–6437
[7] Odum, EP. 1998. Fundamentals of Ecology. Tjahjono Samingan Translation, 1993.Edisi Ketiga.Yogyakarta : Universitas Gadjahmada
[8] Basmi, J. 2000. *Planktonologi sebagai Bioindikator Pencemaran Perairan*. Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor. Bogor.
[9] Krebs. 1989. *Ecological Methodology*. Harper and Row Pulisher. New York.
[10] Hariyati R, 2018, Bioindicator Of Rawapening Lake Environmenttmental Quality Semarnag Regency Based On Saprobic Value Of Water, the 8th Isnpinsa Proceeding.
[11] Soeprobowati TR dan, SWA Suedy. 2011. *Jurnal Sains dan Matematika* 19 (1)
[12] Aunurohim, D Saptarini dan D Yanthi, 2006, Fitoplankton Penyebab Harmfull Algae Blooms (HABs) di Perairan Sidoarjo, FMIPA Institut Teknologi Sepuluh Nopember Surabaya.