Studies of Carrying Capacity and Zonation at Menjer Lake, Central Java Using A Multidisciplinary Approach for Sustainable Utilization

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Abstract. Tropical lake is one of the unique ecosystems which are functioning in both ecological and economic services. Telaga Menjer as a volcanic lake, has strategic values as a hydropower plant, tourism, agriculture, capture fisheries and floating net cages farming. It influenced a degradation of water quality and quantity, nutrient enrichment and exceed the carrying capacity. Telaga Menjer has a catchment area of around 2.27 km\textsuperscript{2} with a lake surface area of 0.61 km\textsuperscript{2}. The purpose of this research is to investigate the characteristic of lake to know the carrying capacity and utilization zone with a multidisciplinary approach. For measuring its depth, the Hondex PS-7 portable depth sensor is used with a maximum depth of 80 m. The water quality parameters stratification were measured by logger version CTD profiler with a depth interval of 1 m on July 2019. The results showed that DO values were observed until the bottom of lake (45 m). Moreover, Total Nitrogen (TN) was very high concentration, indicating more fertilizer from agriculture. Meanwhile, lower concentration of pesticides were obtained. Next, the land use management, economic values and social carrying capacity of Talaga Menjer should be elucidated in order to maintain the sustainability of the lake.

1. Introduction

Stratification of lake is a natural phenomenon and change at any time, depending on the dynamics of local weather conditions. Changing stratification or stirring of water column is an ecosystem response to maintain flexibility and environmental capacity. In subtropical area, the process of stirring lake water is more different clearly than that in the tropics. This stratification affects chemical and biological processes, such as nutrient dynamics, gas transfer and phytoplankton distribution in the water column \cite{1}\cite{2}\cite{3}.

The problem of managing water resources is very complex and involves many parties as users, users and managers. Given these problems, a concerted effort is needed to use the “One River, One Plan, and One Integrated Management” approach. Water management based on the carrying capacity and carrying capacity of the Ecosystem Environment is related to the water capacity of the burden of anthropogenic activities and the utilization of its resources by humans.
Other thing, tourism activities, *Gethek* boat tourism at Menjer Lake is a livelihood activity that has been developed for a long time by some local residents. This tourism activity faced a problem when it was developed again by the same youth development organization “Karang Taruna” in Maron village, which was assisted by PT. Indonesia Power. The new “*Gethek*” boat tourism activity gave rise to unhealthy competition between the two groups of *Gethek* boat tour operators. The perpetrators of the *Gethek* boat tour long felt disadvantaged and were entitled to tourism activities because the first pioneered at the Menjer Lake. Meanwhile, “*Gethek*” boat tour operators who gather under the youth organization feel meritorious because as a community group that cares about the Menjer Lake environment.

This meritorious claim to save the environment is a reason that has always been used by the Taruna reef group as the basis that the group has the right to develop the *Gethek* boat transportation business, and seeks to organize the organization of the *Gethek* boat in Menjer Lake waters. This invitation was rejected from a group of tourism businesses that have long been developing. This situation is an example of the fact that there is social disharmony that can affect the conservation efforts of Menjer Lake.

![Figure 1. Problem Trees from social perspective](image)

2. Methods

The logger version CTD profiler with optical fast DO sensor RINKO-Profiler was used for our survey. Depth (semiconductor pressure sensor with ranged 0 to 600 m and resolution 0.01m), temperature
thermistor with ranged -3 to 45°C and resolution 0.001°C) and dissolved oxygen/DO (phosphorescence with ranged 0 to 20 mg/L and resolution 0.001 mg/L) were obtained. Measurements were carried out on July 12 – 14, 2019 with an interval depth of 1 m. Batymetri measurement was also conducted.

From social science perspective, unfair competition between the Gethek boat transportation tourism business group is still ongoing, causing a reduction in the income of one of the Gethek tourism business groups. As a result, the number of floating net cages operating in the Menjer Lake has increased. Efforts to overcome competition in the operation of the Gethek Tourism Boat are still ongoing and there are no signs of completion. Local governments have tried to regulate and provide solutions to resolve conflicts between tourism actors and have not yet succeeded. The meeting was held many times but has not yet given a solution.

Social disharmony that can affect the ecological function of Menjer Lake ecosystems can be found in the following problem trees (Fig 1.).

3. Results and Discussion

![Batymetri map at Menjer Lake](image)

Figure 2. Batymetri map at Menjer Lake

In Figure 2, batymetri map at Menjer Lake is shown. Menjer Lake has a catchment area of around 2.27 km² with a lake surface area of 0.61 km². The maximum depth of Menjer Lake was 45 m.

| Trophic Status | Average of Total-N Content (μg/l) | Average of Total-P Content (μg/l) | Average of Chlorophyll-a Levels | Average of Brightness (m) |
|----------------|----------------------------------|----------------------------------|--------------------------------|--------------------------|
| Oligotroph     | ≤ 650                            | 10                               | 2.0                            | 10                       |
| Mesotroph      | 750                              | 30                               | 5.0                            | 4                        |
| Eutroph        | 1900                             | 100                              | 15                             | 2.5                      |
| Hipereutroph   | 1900                             | 100                              | 200                            | 2.5                      |

Based on table 1 for water quality analysis, it found Total Nitrogen levels (2-11 mg / L), Menjer Lake was classified as Hipereutrof, from the surface to a depth of 30 m. Based on Chlorophyll-a
levels (0.5-17.7 mg/L), Menjer Lake was classified as Hyper-eutrophic to Eutrophic, from the surface to a depth of 10 m. Nitrogen is a fertilizer used on agricultural/plantation land in water catchments, household and industrial waste. Based on Total Phosphorus levels (<0.06 mg/L), Menjer Lake was classified as Oligotrophic to Mesotrophic on the surface, but Eutrophic at a depth of more than 15 m. Sources of Phosphorus are erosion from water catchment areas, as well as household waste. For tourism, the appropriate trophic status is oligotrophic to mesotrophic.

Meanwhile, the results showed that DO values were observed until the bottom of the lake (45 m). Moreover, Total Nitrogen (TN) was very high concentration, indicating more fertilizer from agriculture. On the other hand, lower concentration of pesticides were obtained.

Sechhi Depth (SD), Temperature, DO, Turbidity and Chl-a

![Graph showing Sechhi Depth (SD), Temperature, DO, Turbidity and Chl-a](image)

Blue = Middle of reservoir
Red = Near fish cage and water fall
Light Green = Near the port/pier
SD – 1 – 1.5 m

**Figure 3.** Sechhi Depth (SD), Temperature, DO, Turbidity and Chl-a

3.1 The social carrying capacity of the Menjer Lake

The social carrying capacity of the Menjer Lake needs to be taken into account in the sustainable management of the Menjer Lake. Understanding of social carrying capacity is very necessary because development activities that do not pay attention to the social support capacity because development activities that do not pay attention to it will have a greater negative impact than the expected positive impact. Therefore, understanding of social carrying capacity is closely related to the social system of the local community that interacts directly with the Menjer Lake ecosystem. The concept of social carrying capacity is relatively new and there have not been many studies. The definition of social carrying capacity was first recognized in Law Number 10 of 1992 concerning Development of Population and Prosperous Welfare. In this law, social carrying capacity is defined as the ability of humans and different population groups to live together as a society that lives in harmony. Some of the field findings of social disharmony that affect the sustainable management of Menjer Lake, include the Gethek boat tourism conflict [4].
4. Conclusion

The results showed that DO values were observed until the bottom of lake (45 m). Moreover, Total Nitrogen (TN) was very high concentration, indicating more fertilizer from agriculture. Meanwhile, lower concentration of pesticides were obtained. Next, the land use management, economic values and social carrying capacity of Talaga Menjer should be elucidated in order to maintain the sustainability of the lake.

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