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Dissolved oxygen profiles and its problems at Lake Maninjau, West Sumatera - Indonesia

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ABSTRACT

In general, tropical lake in Indonesia is one of the unique ecosystems which are functioning in both ecological and economic services. The objective of this study is to analyze the dissolved oxygen profile of caldera tropical lake represented by Lake Maninjau at West Sumatera, Indonesia and its impact. Lake Maninjau, not only for fisheries culture, but also serves as important hydroelectricity power. Surveys at Lake Maninjau was conducted in August 2006, March 2014, September 2017 and April 2018. The results on the survey in Lake Maninjau showed that the average depth is 105 m. It covers 13,260 ha of area with a height of 461.5 m above sea level and maximum depth of 165 m. The lake water comes from rainfall, small rivers and the surrounding ground water and one outflow in Batang Antokan River. Based on the measurement results, it obtained that dissolved oxygen from the surface layer to a depth of 40 m (2006) has decreased to a depth of 12 m (2018), indicating the worse condition of water quality in 2018 compared with previous years. Currently, bad water quality and mass mortality fishes often occurred. Next, the percentage value of fish cages at Lake Maninjau in 2017 was 0.43%. Besides human activities, it suggested also that the potential impact from fish cages constributed pollutant concentration into this lakes. In order to maintain the sustainability of the lake, basic ecological information is necessary for the next study.

1. INTRODUCTION

Lake Maninjau is a large lake which including in the type of caldera lake. This lake is located in Agam District - West Sumatra and has an important role for daily life and the beauty of the lake (Fig.1). Further, it has become the pride of the surrounding community. Currently, Lake Maninjau has economic functions as a power plant that produces the annual rate of 205 GWH of energy, sources of irrigation water, fishing fish farming in floating cages and catching, and tourism destination [1 & 2]. In addition, from the view of ecological functions, Lake Maninjau could control the water balances of soil, microclimate and habitat for organisms.

Besides hydropower, utilization Maninjau also for fish farming activities in the floating net. Cultivation of fish in floating net began in 1990. Fish farming activities in floating net have increased the high economic growth for local communities. But since 1997, this activity began to decrease because of frequent death of fish caused the loss of business. Since when was there a public complaint that a decrease in water quality of the lake is causing economic loss to the community or local government from both fish farming activities in the cages and tourism. Besides for fish farming in floating cages, Lake Maninjau is also used for tourist activities, especially by foreign tourists [3]. The development of tourism activities also led to the growth of the hotel or inn and restaurant around the lake. But the water quality of the lake such as murky water and odor caused a decline in tourist numbers and the impact on the economy of the community and local government.

In early January 2009, more than 13 thousand tons of disaster death of fishes occurred at Lake Maninjau. From measuring the water quality of lake from observation by Limnology station - Research Centre for Limnology LIPI, on January 2009, reported a drop of dissolve oxygen (DO) 1.05 mg/l in water surface (normal conditions approximately 7 mg/l) with temperatures 28^{o}C and pH 7.17. At three meters of water depth, dissolved oxygen (DO) content had reached 0.46 mg/l and temperature 27.2^{o}C. The water column is normally used for floating cage. The low oxygen content was causing mass death of fishes. This disaster is related to what is called by local people as "tubo sulfur." Generally sulfur turbo phenomenon has been frequently occurs at the beginning of the year. In addition, there is a possibility of circulation influence on the vertical profiles of dissolved oxygen in some of the lakes, where related to the seasonal

meteorological patterns [4].

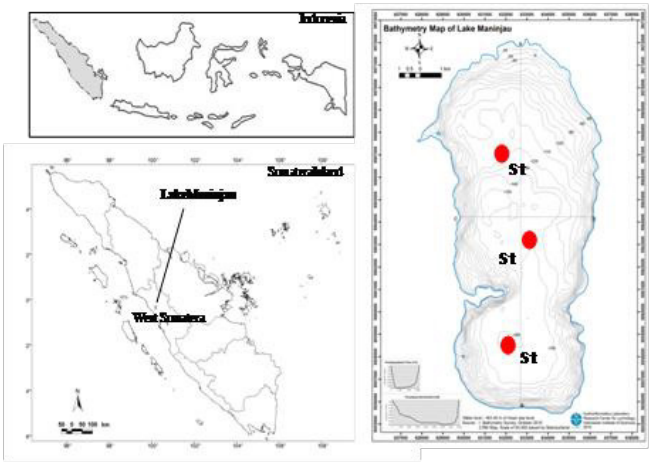

Fig. 1 Locations of study area

2. METHOD

Survey at Lake Maninjau was conducted in August 2006, March 2014, September 2017 and April 2018. Not only survey at field, but also to collect the secondary data for supporting the analyze.

We conducted dissolved oxygen (DO) profile measurememt in August 2006 by multi-probe sensor YSI 6600. Measurements were carried out until to the depth of 50 m with an interval of 0.4 m. Dissolved oxygen (DO) profiles was obtained with ranged 0 to 50 mg/L and resolution 0.01 mg/L. Meanwhile, DO profile measurement in March 2014, September 2017 and April 2018 were taken from three locations at Lake Maninjau by ringko profiler, supported by University of Tsukuba, Japan. The logger version CTD profiler with optical fast DO sensor RINKO-Profiler was used for survey. Depth (semiconductor pressure sensor with ranged 0 to 600 m and resolution 0.01m) and dissolved oxygen/DO (phosphorescence with ranged 0 to 20 mg/L and resolution 0.001mg/L) were obtained at each station. Measurements were carried out until to the depth of 160 m with an interval of 0.1 m.

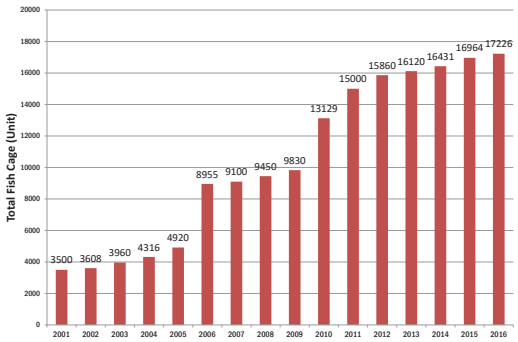

Fig. 2 The amount of fish cage at Lake Maninjau since 2001

Source : Agam Regency – West Sumatera (2016)[6]

Finally, fish aquaculture cages established at lake Maninjau was also observed and accounted (Fig. 2). At Lake Maninjau, there are approximately 16,000 unit fish culture cages in 2017, in general with sized 5 x 5 m [5].

Through campaigning "Save Maninjau" by local government [6], they succeed to hold the growth rate of fish cage and the total fish cage were 16,776 unit and 17,226 unit for 2017 and 2016, respectively.

3. RESULTS AND DISCUSSION

Lake Maninjau is located at an altitude of 461.5 m above sea level with a surface area of 9,737.5 ha and a maximum depth of 165 m. Lake Maninjau is a caldera lake formed by volcanic activity in 60,000 years ago [7]. The source of water comes from rain water lakes and streams as well as the surrounding ground water. This lake has a water line out called Batang Antokan flowing into the Indian Ocean, on the West coast of West Sumatra.

In Lake Maninjau, since 1983 is used for power generation that the average annual production of 205 GWH, by building a dam at the outlet (Antokan River, which is the basis of the river at an altitude of 462 m). The dam raised the water level of the lake from a height of 462 m from sea level to 464 m. In addition, outflow from the lake is used for power generation through the intake structure at a height of between 457.15 m to 453.75 m from sea level.

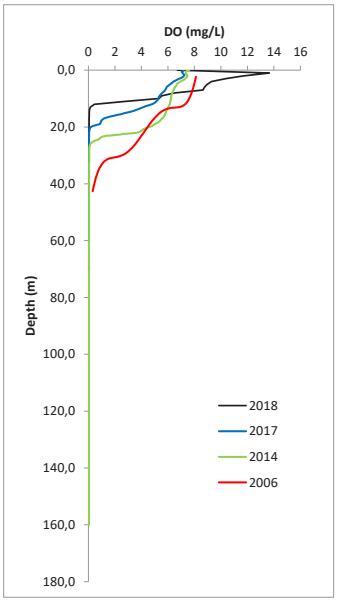

Fig. 3 DO profiles at Lake Maninjau (August 2006, March 2014, September 2017 and April 2018)

Based on Fig. 3, high dissolved oxygen content in the surface layer and the base of diminishing. Dissolved oxygen from the surface layer to a depth of 40 m (2006) has decreased to a depth of 12 m (2018), indicating the worse condition of water quality in 2018 compared with previous years.

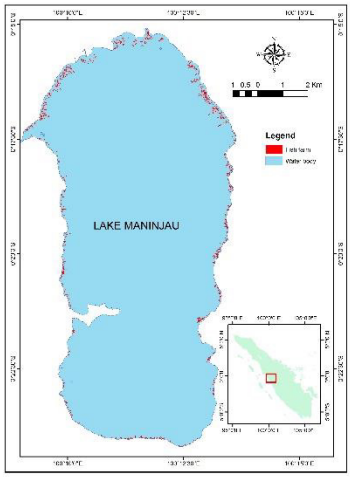

Fig. 4 Distribution of fish cage (red colour) in 2016

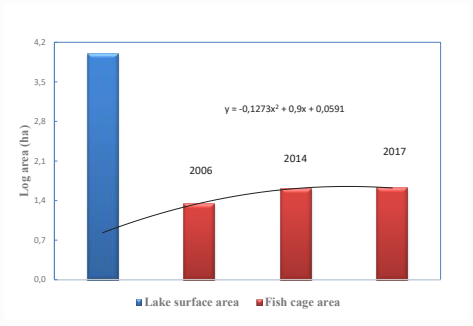

Fig. 5 Comparison between lake surface and fish cage areas for 2006, 2014 and 2017

Based on survey and secondary data, we obtained the distribution of fish cage (Fig 4). Next, in Fig. 5 showed comparison among fish cage areas (log area (ha)) in three years observed. The fish cage area were 22.4 ha, 41.1 ha and 41.9 ha for 2006, 2014 and 2017, respectively. It suggested the growth of fish cages as pollutant also influenced water quality at Lake Maninjau.

4. CONCLUSION

Lake Maninjau function in ecological and economic services as a caldera tropical lakes has faced in various problems. The decreasing of dissolved oxygen layer from the surface layer compared with previous years, indicating the larger impact from human activities constribute to the water quality on the lake.

It found the percentage value of fish cages at Lake Maninjau was higher in 2017 (0.43%) than that in 2006 (0.23%). Based on this ratio, the density of aquaculture which indicated the potential impact i.e. pollutants from fish cages at Lake Maninjau. Consequently, in order to maintain the sustainability of these lakes, basic ecological information is necessary for the next study.

REFERENCES

[1] Puslit Limnologi. Permasalahan Danau Maninjau dan Pendekatan Penyelesaiannya. Kerjasama Antara Proyek Pengembangan dan Peningkatan Kemampuan Teknologi dengan Puslit Limnologi LIPI, Cibinong-Bogor. 2001.

[2] Fakhrudin M, Wibowo H, Subehi L and Ridwansyah I. Karakterisasi Hidrologi Danau Maninjau Sumatera Barat. Prosiding Seminar Nasional Limnologi 2002. Pusat Penelitian Limnologi – LIPI, 65 – 75. 2002.

[3] Subehi L, Siti Norasikin Ismail, Ridwansyah I, Muzzalifah Abd Hamid, Mashhor Mansor. Analysis of the influence of reservoirs utilization to water quality profiles in Indonesia (Saguling – Jatiluhur) and Malaysia (Temengor – Chenderoh) with special references to cascade reservoirs. IOP Conf. Series: Earth and Environmental Science 118, 012025 doi :10.1088/1755-1315/118/1/012025. 2018.

[4] Fukushima T, Matsushita B, Subehi L, Setiawan F, Wibowo H. Will hypolimnetic waters become anoxic in all deep tropical lakes? Scientific Reports. DOI: 10.1038/srep45320, Nature Research Journal. 2017.

[5] Direktur Jenderal Perikanan Budidaya,Kementerian Kelautan dan Perikanan. Kebijakan pengelolaan perikanan buidaya di perairan umum daratan. Seminar Nasional Limnologi VII, LIPI. Cibinong, Bogor. 2014

[6] Agam Regency. Save Maninjau. Presentation of Agam Regency on JSPS Workshop, Tsukuba – March. 2018.

[7] Santoso, Batu UML. Morfogenesis daerah danau kaldera Maninjau, Sumatera Barat. Jurnal Sumber Daya Geologi. Vol.XVII No. 2. 2007.