

Assessment of Water Quality Index of Beratan Lake Using NSF WQI Indicator

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Abstract

Beratan Lake is one of the lake in Bali which serves as place for agriculture, aquaculture, as well as tourism and recreational attractions. The growing number of facilities around the lake potentially increases the number of waste discharge to the lake as most of the industry do not equipped with necessary waste management plant. The aim of this study is to assess the water quality in Beratan Lake and later be used to improve the water management. Five stations for water sampling were purposively chosen as representation of each side of the lake. The coordinate locations were recorded by Epicollect. Nine water quality parameters were measured for each water samples from each station: temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphate, nitrate, turbidity, and fecal coliform. The water quality were calculated based on National Sanitation Foundation Water Quality Index (NSFWQI). NSFWQI for water of Beratan Lake was 78 which indicates good quality. Although the most result has been satisfying, fecal coliform and pH showed score lower than 55. Assessment of the Beratan Lake by WQI revealed that the lake water is in good quality. However, two of nine parameters need to be improved to ensure the safety for further use. Fecal coliform and pH were still needs to be modified to improve the water quality in this lake. With the increasing of human activities in the area around the lake, it is necessary to regularly monitor the quality of water.

Keywords: Beratan, lake, NSFWQI, water quality

Abstrak

Danau Beratan merupakan salah satu danau di Bali yang berfungsi tidak hanya sebagai sumber air pertanian, melainkan pula sebagai obyek wisata dan rekreasi. Meningkatnya jumlah fasilitas di sekitar danau berpotensi untuk meningkatkan jumlah limbah buangan ke danau dikarenakan sebagian usaha di sekitar danau tidak memiliki instalasi pengolahan limbah. Tujuan penelitian ini adalah untuk mengukur kualitas air Danau Batur yang hasilnya dapat digunakan untuk meningkatkan manajemen kualitas air di danau ini. Lima titik sampel dipilih secara purposif mewakili setiap sisi danau. Lokasi koordinat sampling dicatat dengan aplikasi Epicollect. Sembilan parameter kualitas air diukur, yakni: temperatur, pH, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), fosfat, nitrat, kekeruhan, dan fecal coliform. Kualitas air dihitung menggunakan metode *National Sanitation Foundation Water Quality Index* (NSFWQI). Indeks kualitas air Danau Beratan berdasarkan NSFWQI sebesar 78 yang diinterpretasikan sebagai kualitas air yang baik. Namun meskipun demikian, fecal coliform dan pH air di Danau Beratan menunjukkan skor kurang dari 55. Penilaian kualitas air Danau Beratan berdasarkan WQI menunjukkan bahwa kondisi air Danau Beratan tergolong baik. Namun 2 dari 9 parameter kualitas air masih perlu ditingkatkan untuk memastikan keamanan penggunaannya. Fecal coliform dan pH masih perlu diperbaiki untuk meningkatkan kualitas air Danau Beratan. Dengan meningkatnya aktivitas masyarakat di sekitar danau, maka sangatlah penting untuk memonitor kualitas air danau secara rutin.

Kata Kunci: Beratan, danau, NSFWQI, kualitas air

INTRODUCTION

Water plays pivotal roles in every aspect of human life. Good quality of water is essential for improving quality of life and health. Waste discharges from domestic sources, agricultural runoff, aquaculture effluents, and tourism industry waste have

deteriorated water sources like rivers and lakes¹. The release of domestic and agriculture waste around the water body has resulted in eutrophication and leads to uncontrolled growth of plants and algae². This phenomena impairs the freshwater ecosystem, including the aquatic life. The rapid growth

of population and community development have worsened the water natures³.

Surface water reservoir like lake is an important source of freshwater. In Bali, a lake is not only a water body that provide water for domestic purposes but also has important contribution to social and economic aspects. Beratan Lake is one of the lake in Bali which serves as place for agriculture, aquaculture, as well as tourism and recreational attractions. The upsurge of tourism activity could deteriorate the water quality of this lake. The growing number of facilities around the lake potentially increases the number of waste discharge to the lake as most of the industry do not equipped with necessary waste management plant. Additionally, the old habits of the community such as bathing and washing in the lake as well as littering garbage into the lake result in the water pollution.

Toxic chemical and organic contaminants in water may cause negative effect on the human health^(4,5). Some studies suggested that the contaminants could induce neurologic and chronic illnesses⁽⁶⁻⁸⁾. A study conducted by World Health Organization (WHO) estimated that 1.1 billion people around the world have limited access to healthy drinking water⁹. Because of the crucial roles of water in health, ecology, and economy, it is essential to monitor and control the quality of water in the water resources such as lake. Evaluation of water quality is important to provide accurate information on the current condition of the water and serves as basis for development of pollution control. Variation of water quality needs to be recorded regularly using reliable tools and methods. There are several parameters for qualifying the water condition, comprises physical, chemical, and biological parameters.

Water quality index (WQI) is a defined numeric digit which expresses the level of water quality. It is an effective tool to summarize the quality of water given the extent of water quality parameters³. This technique of calculating water quality becomes an important method for assessment of surface water as it offers simplified evaluation. National Sanitation Foundation's Water Quality Index (NSFWQI) is one of the most frequently used for communicating the quality of water to the concerned citizens and policy makers.

NSFWQI was proposed by Brown, McClelland (10) with the support of United State National Sanitation Foundation (UNNSF). This method uses nine parameters for the calculation of water quality index based on the weighting from the expert panel's opinion. The nine parameters for this calculation are dissolved oxygen (DO), Fecal Coliform, BOD, pH, water temperature (°C), Phosphate, Nitrate, Total Suspended Solid (TSS) and turbidity.

Khadafi¹¹ in Media Indonesia reported that three lakes in Bali have been polluted, including Beratan Lake. Even though there are regular measurement of water parameters by Badan Lingkungan Hidup (BLH) of Tabanan Regency, the assessment of overall water quality index of Beratan Lake in

term of WQI has not ever been published scientifically. Considering the importance of monitoring the quality of water body, especially in the region with growing number of population and economy, the present study involved in the assessment of water quality index of Beratan Lake. The aim of this study is to provide the essential information on the level of pollution load into the ecosystem in Beratan Lake and later be used to improve the water management.

METHOD

This study was conducted in June 2018 in Beratan Lake. Beratan Lake is a fresh water basin located in Tabanan Regency, Bali. The area of the lake is about 375.6 hectares, with depth range of 22 -48 m. It is surrounded by agriculture, aquaculture and tourism areas. Five stations for water sampling were purposively chosen as representation of each side of the lake. The coordinate locations were recorded by Epicollect. Nine water quality parameters were measured for each water samples from each station. The measurement of temperature (°C), pH, and total dissolved solids (TDS) were done *in situ* during sampling process. While the other six parameters, including dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphate, nitrate, turbidity, and fecal coliform were determined in Laboratorium Kesehatan Provinsi Bali. The water samples were kept in a cool box supplied with ice pack. The lag time between the sampling and the analysis did not exceed 24 hours. The water quality were assessed based on National Sanitation Foundation Water Quality Index (NSF WQI).

$$WQI = \sum W_i x Q_i$$

Qi: Quality rating; Wi: Weighting factor

Values of Qi for each parameter were obtained from table provided by¹², while Wi is the weighting factor for each parameter based on the value issued by the National Sanitation Foundation Water Quality Index (NSF WQI).

Table 1. Interpretation of Water Quality Index

Index Range	Water Quality
90 - 100	Excellent
70 - 90	Good
50 - 70	Medium
25 - 50	Bad
0 - 25	Very bad

RESULTS AND DISCUSSION

The water quality of Beratan Lake was assessed by measuring nine parameters of water quality as tabulated in Table 2. The samples were obtained from five stations as presented by figure 1. The locations of stations were chosen purposively to represent area of agriculture, aquaculture, tourism, and green open space.

Picture 1. Locations of sampling stations of Water Quality Index, Beratan Lake

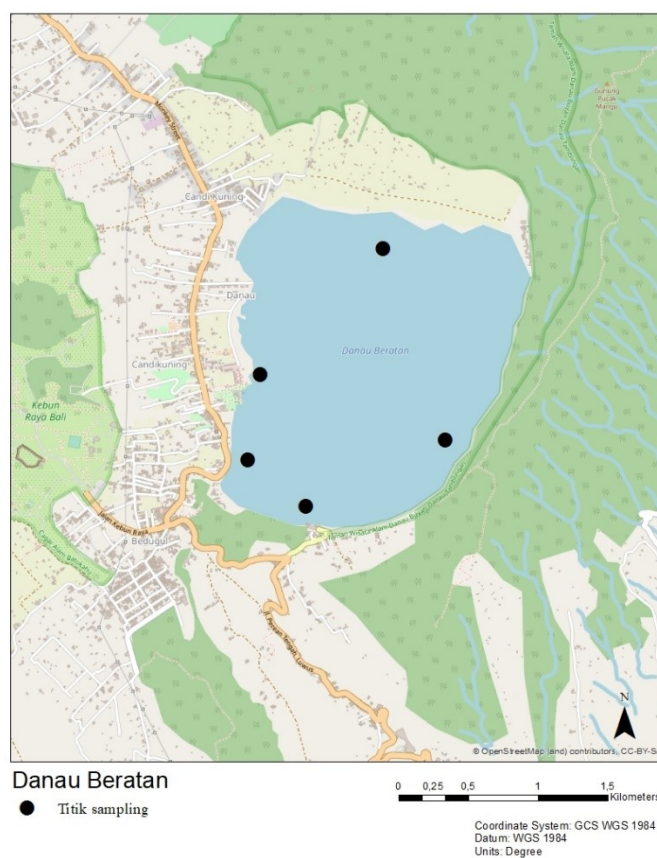


Table 2. Result of water assessment from 5 stations in Beratan Lake

Factor	Unit	SD	Min	Max	Mean
Dissolved Oxygen	mg/l	0.03	7.76	7.85	7.80
Fecal Coliform	MPN/100 ml	1093	0	2200	448
pH		0.05	8.77	8.93	8.86
Biochemical oxygen demand	mg/l	0.19	1.03	1.42	1.23
Temperature Change	°C	0.24	22.80	23.30	22.92
Total Phosphate	mg/l	0.14	0.02	0.35	0.16
Nitrates	mg/l	0.18	0.00	0.37	0.16
Turbidity	NTU	0.52	1.73	2.75	2.26
Total Dissolved Solids	mg/l	0.82	16.00	18.00	17.20

Note: Nephelometric Turbidity Units

The pH measurement of Beratan Lake showed alkaline condition with average value of 8.86 ± 0.05 . Comparing to other studies, assesment of Tondano Lake showed more variability in the pH values, which ranged from 5.70 to 9.30¹³ and 6.8 to 8.2¹⁴. Whereas, a study of water sources around Bedugul by Arthana¹⁵ has shown lower average pH value of 6.07. However, the pH of water in this study is still within the accepted range for water standard 1. The standard pH for water is 6 to 9 both for drinking water and aquatic life^(16,17). The high level of pH could be related to high salinity and increased by carbonate-rich soil^(15,17). On the other

hand, low pH level is associated with higher sulfate content.

Water temperature of Beratan Lake during the day ranged from 22.80 to 23.30 °C, while the temperature change during day and night was approximately 3 °C. Optimum water temperature for aquatic life is between 28 -32 °C¹⁴. The temperature change of this lake also meets the criteria for standard water 1 as regulated by Peraturan Gubernur Bali¹⁶.

Turbidity was rated as one of the most important parameter for water quality assessment¹⁰. It describes the amount of cloudiness in the water

which caused by both dissolved and suspended particles. Turbidity of water in Beratan Lake was found to be 1.73 to 2.75 NTU. This value is within the range of accepted level for drinking water (<10 NTU). The total dissolved solids (TDS) in the study area was 16 mg/l to 18 mg/l. This result is lower compare to the measurements of TDS in lake in India and China^(18,1,19). TDS in water indicates the concentration of inorganic salts and organic matter such as carbonates, nitrate, sodium, calcium, magnesium, and chloride. It may also suggest sewage contamination and rapid plankton growth.

The DO and BOD in Beratan Lake suggested that both chemical parameters meet the standard water quality. The DO in Beratan Lake was 7.86 ± 7.76 mg/l, while the standard 1 for water quality based on Bali Governor Regulation is not less than 6.0 mg/l. BOD of Beratan Lake ranged from 1.03 to 1.42 mg/l, which relatively lower compare to the BOD found in Tondano Lake (3.28 mg/l)¹⁴. BOD will affect the dissolved oxygen as it is representing the amount of oxygen needed by microorganism to

decompose organic material in the water.

The present study showed that the fecal coliform in Beratan Lake was 0 to 2200/100 ml. The fecal coliform was recorded highest at the station near to the dock area of Beratan Lake. The presence of fecal coliform in a water body is an indication of contamination from fecal material. It also can be used as indicator organism which may give information on the presence of pathogenic bacteria.

Nitrate and phosphate levels in Beratan Lake were relatively low (0.16 mg/l). Both parameters showed values below the maximum contaminant levels and they meet the criteria for safe drinking water¹⁹. The criteria for standard water quality 1 for nitrate and phosphate are 10 mg/l and 2.0 mg/l, respectively¹⁶. Low level of nitrate and phosphate were also found by Purnamawati, Arthana²¹ in Buyan Lake. The sources of these chemical contaminations were predicted to come from aquaculture pollution and the use of fertilizers.

Table 3. Water Quality Index calculation

Parameters	Unit	Factor Value	Wi	Qi	Wi x Qi
DO	% Saturation	94.40	0.17	98.00	16.66
Fecal Coliform	MPN/100 ml	448.00	0.16	30.00	4.8
pH		8.86	0.11	53.00	5.83
BOD	mg/l	1.23	0.11	93.00	10.23
Temperature Change	°C	3.00	0.10	81.00	8.1
Total Phosphate	mg/l	0.16	0.10	94.00	9.4
Nitrates	mg/l	0.16	0.10	97.00	9.7
Turbidity	NTU	2.26	0.08	92.00	7.36
TS	mg/l	17.20	0.07	83.00	5.81
WQI					78 (good)

The calculation of water quality index (WQI) of Beratan Lake is given in Table 3. The observed values of the nine parameters were transformed into quality rating (Qi) based on Qi histogram. The WQI based on NSFQI method showed the overall water quality index was 78 which indicates good quality. Although this result has been satisfying, two parameters showed less than 55 score. Fecal coliform and pH need to be modified to improve water quality for further use. This NSFQI has been a beneficial tools for water management and provide the overall water quality information.

CONCLUSION

Assessment of the Beratan Lake by WQI revealed that the lake water is in good quality. However, two of nine parameters need to be improved to ensure the safety for further use. Fecal coliform and pH were still needs to be modified to improve the water quality in this lake. With the increasing of human activities in the area around the lake, it is

necessary to regularly monitor the quality of water. In addition, a responsible ecosystem measures needs to be implemented along with community based monitoring program. This NSF WQI can be an effective tool to provide overall information to the community and policy makers regarding to the latest status of the water quality and plan for water management accordingly.

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