

Lake Batur water quality analysis through Storet method as an effort to control lake water pollution

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ABSTRACT

This study aims to analyze the quality of Lake Batur which aims to maintain the preservation of Lake Batur as a form of sustainable tourism in Bangli Regency. In this study, there are three sample points, namely in Songan Village, Toya Bungkah and Kedisan Village. In this study, it will be analyzed through 11 parameters analyzed, namely temperature, odor, taste, color, pH, nitrate, BOD, DO, total phosphate, total coliform and fecal coliform. In this test, the method used is the STORET method, and in the analysis of the strategy used for pollution control using the SWOT method. Based on the results of the STORET calculation, the sample in Songan Village is included in the category of light pollution with a value of -4, the sample of Kedisan Village all indicators meet the Class 3 Water Quality Standard, and at the sample point in Toya Bungkah is included in the category of light pollution with a value of -8. The indicator that has a value exceeding the Class III Water Quality Standard, namely at the sample location of Songan and Toya Bungkah Villages, is the BOD level. So that the recommended strategy for its management based on SWOT analysis is to optimize the Strengths and Opportunities owned by Lake Batur, namely developing tourism around the lake which is based on sustainable development and in line with regular lake rejuvenation efforts carried out to maintain the balance of lake water quality by the community and the surrounding government.

Keywords:

Water Quality of Lake Batur

Method Storet

Lake Water Control

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INTRODUCTION

Water is the source of life for all living things. Water is a chemical compound that has an abundant amount in nature, but the more technology develops and the population grows, the need for one of them water will certainly increase (Cosgrove & Loucks, 2015; Gavrilescu, 2021; B. K. Mishra et al., 2021; R. K. Mishra, 2023; Saravanan et al., 2021). Industrial activities, agricultural practices, and urban expansion have led to increased pollution, depletion, and competition for clean water (Akhtar et al., 2021; Fito & Van Hulle, 2021; Sarker et al., 2021; Wato et al., 2020; Yasin et al., 2020). As a result, ensuring sustainable management and conservation of water resources has become a critical challenge. Addressing these issues requires innovative solutions, such as improved water treatment technologies, efficient usage practices, and stronger environmental regulations to safeguard this essential resource for future generations.

Lakes are one of the natural resources that are included in freshwater ecosystems. The lake is also one of the ecosystems that is directly adjacent to human activities. The space and land around the lake are overhauled into land that is used by humans, including as settlements, road infrastructure, agricultural land, recreation, so that it causes excessive use of the lake (over exploited) (Catto et al., 2020; Cooke et al., 2023; Jakovljević et al., 2022; Liu, 2023; Zhang, 2020). One of the lakes in Bali that is close to community activities is Lake Batur.

Lake Batur is one of the lakes located in Kintamani District, Bangli Regency. Lake Batur is a type of active caldera lake located in the caldera resulting from the eruption of Mount Batur. Lake Batur is a lake that directly intersects with the community, which is characterized by agricultural activities around the lake and fish cultivation through ponds in Lake Batur. The increase in community activities around the lake has an impact on the quality of the lake. The accumulation of pollutants into lake water that comes from various types

of pollutants, the quality of lake water will definitely change or there will be significant changes in the biological, chemical and physical components of the lake (Wijana, 2010). Based on the results of research conducted by Handayani et al. (2011) it was stated that the water condition of Lake Batur based on BOD and ammonia parameters has exceeded the quality standards of Bali Governor Regulation Number 8 of 2017, namely BOD of 8.72 mg/L and ammonia of 0.86 mg/L. high levels of BOD and ammonia are pollution caused by domestic activities. Therefore, it is necessary to test lake water regularly to maintain water quality and sustainability of Lake Batur.

This study aims to analyze the quality of Lake Batur which aims to maintain the preservation of Lake Batur as a form of sustainable tourism in Bangli Regency. The research contribution based on this sentence involves evaluating the quality of Lake Batur to support its preservation as a key component of sustainable tourism in Bangli Regency. This study contributes by providing insights into the current environmental status of Lake Batur and identifying factors that impact its quality. By focusing on maintaining the lake's health and sustainability, the research aims to inform strategies for responsible tourism development that balance ecological preservation with tourism activities. This work supports the broader goal of promoting sustainable tourism practices that protect natural resources while benefiting local communities and visitors.

METHOD

This research was carried out in Lake Batur, Kintamani District, Bangli Regency. Lake Batur is the largest lake on the island of Bali which has an area of 16.5 km² with a maximum depth of about 60m – 70m and is located at an altitude of 1050 meters above sea level. In this study, 3 sample points were taken, namely in the Songan, Toya Bungkah and Kedisan Village areas.

In this study, the quality is measured through the STORET method which compares water quality data with water classes adjusted to their designation to determine the status of water quality, by classifying water into four classes. After obtaining the water quality of Lake Batur, appropriate countermeasures are needed which in this study are analyzed through the SWOT method.

In sampling, referring to the procedure, this study refers to SNI 6989.57:2008 part 57 regarding Surface Water Sampling Methods. Samples were taken from 3 sample points, namely in Songan Village, Toya Bungkah and Kedisan Village. The samples that have been taken will go through the sample analysis process is carried out *ex situ*, namely in the regional laboratory by analyzing the parameters of Color, Temperature, PH, Taste, and Odor, DO, BOD, Phosphate, Nitrate, Focal Coliform.

The analysis of Lake Batur water quality was carried out through the STORET method, which is the data from the research results that have been analyzed by comparing using class III water quality standards for freshwater in the Bali Governor Regulation No.16 of 2016. (Decree of the Minister of Environment No. 115 of 2003). The STORET method uses a method of awarding points that exceed the quality standard. The number of values will determine the level of pollution that occurs. The ways to determine the quality status of water quality with the STORET method are:

- 1) Collect water quality and water discharge data periodically so that it forms data from time to time
- 2) Compare the data from the measurement results of each water parameter with the quality standard value in accordance with the water class
- 3) If the measurement results meet the standard value of water quality, a score of 0 is given
- 4) If the measurement results do not meet the standard value of water quality, then it is given a score:

Table 1. A value system to determine the status of water quality

Number of examples	Value	Parameter		
		Physics	Chemistry	Biology
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

Source: Decree of the Minister of State for the Environment. Number: 115 of 2003

The way to determine the status of water quality is to use the value system from the "US-EPA" (Environmental Protection Agency) by classifying water quality into 4 classes. The number of negatives from all parameters is calculated and then the water quality status is determined through the number of scores obtained based on the criteria in the table.

Table 2. Classification of water quality in the storet method

Class	Class Category	Score	Category
A	Very good	0	Meet quality standards
B	Good	-1 to -10	Light contamination
C	Medium	-11 to -30	Moderate pollution
D	Bad	-31	Heavy pollution

Source: Decree of the Minister of State for the Environment. Number: 115 of 2003

RESULTS AND DISCUSSION

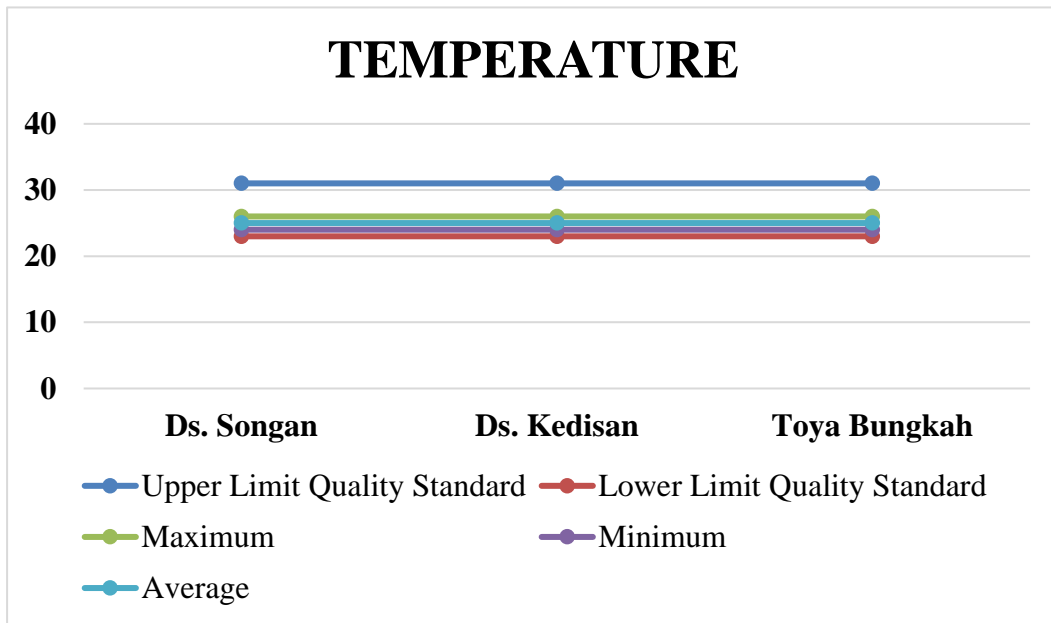


Figure 1. Results of Water Temperature Measurement of Lake Batur

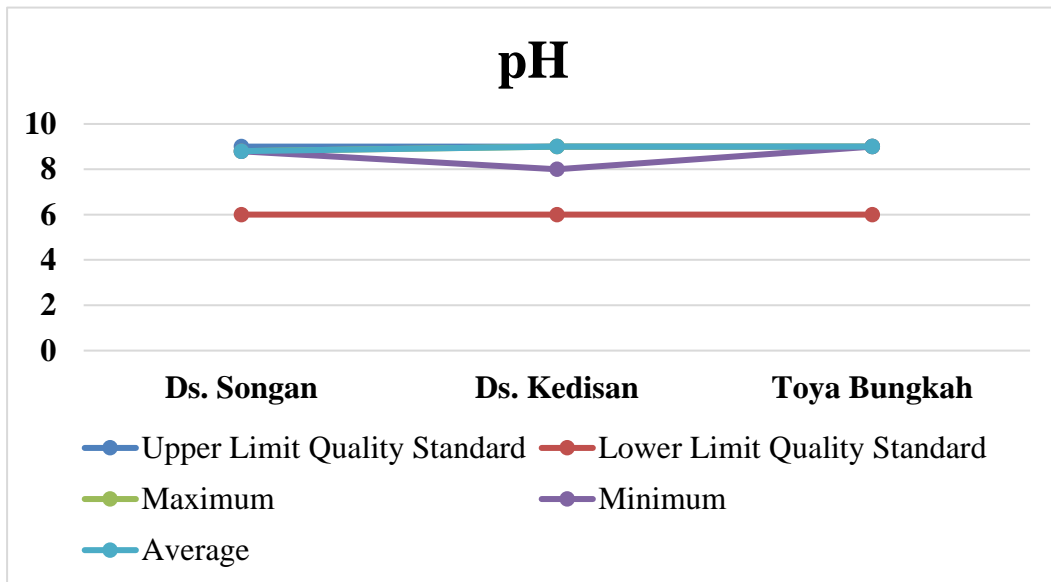


Figure 2. Results of Lake Batur Ph measurement

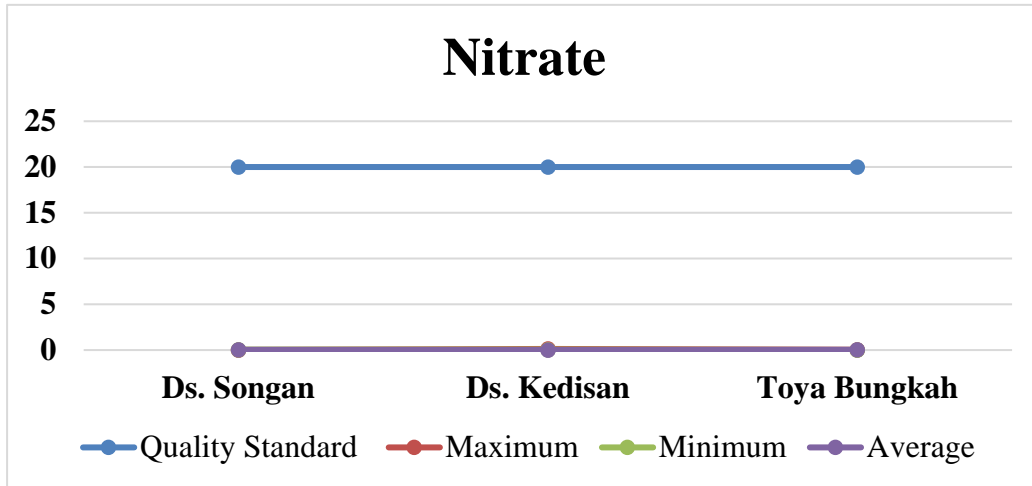


Figure 3. Results of Lake Batur Nitrate Measurement

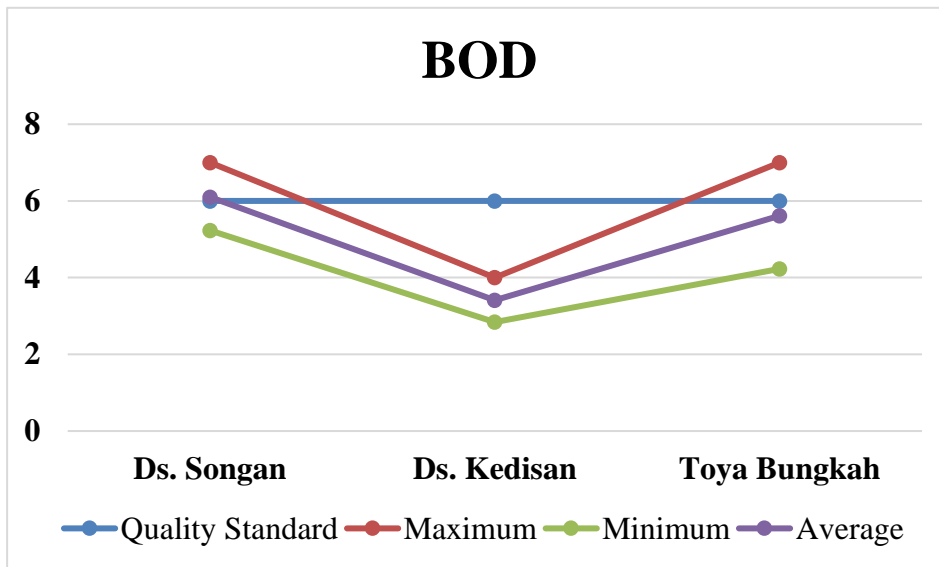


Figure 4. Results of BOD Measurement of Lake Batur

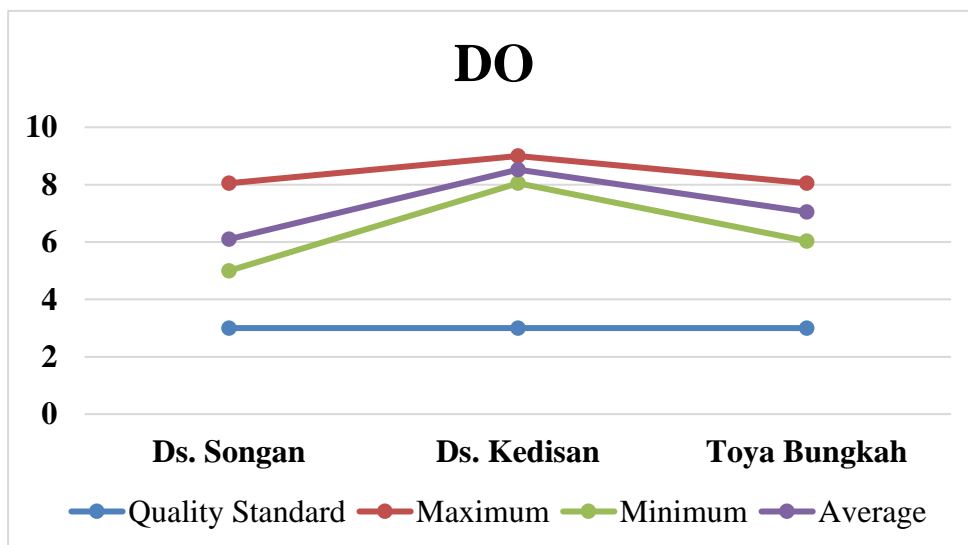


Figure 5. Results of DO Measurements on Lake Batur

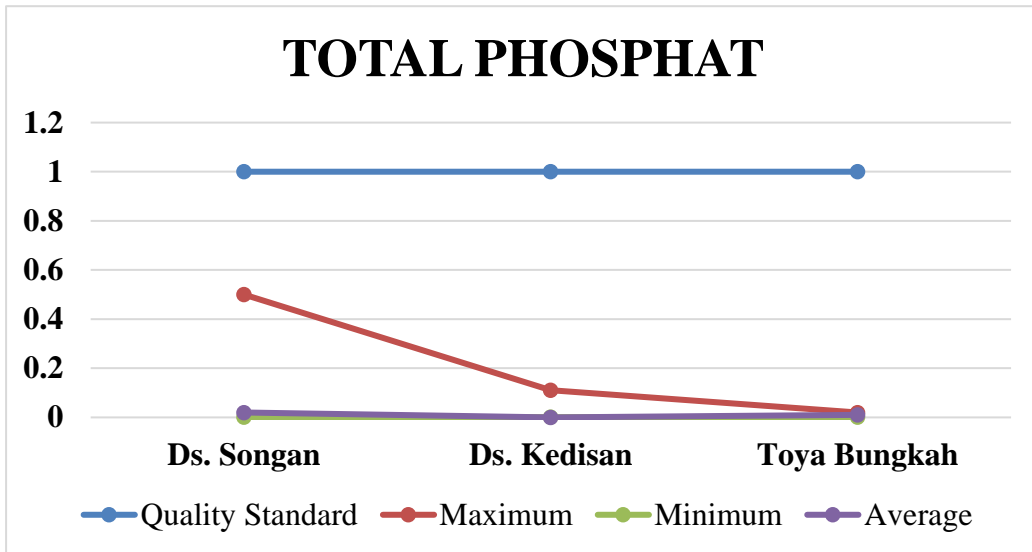


Figure 6. Results of Total Phosphate Measurement in Lake Batur

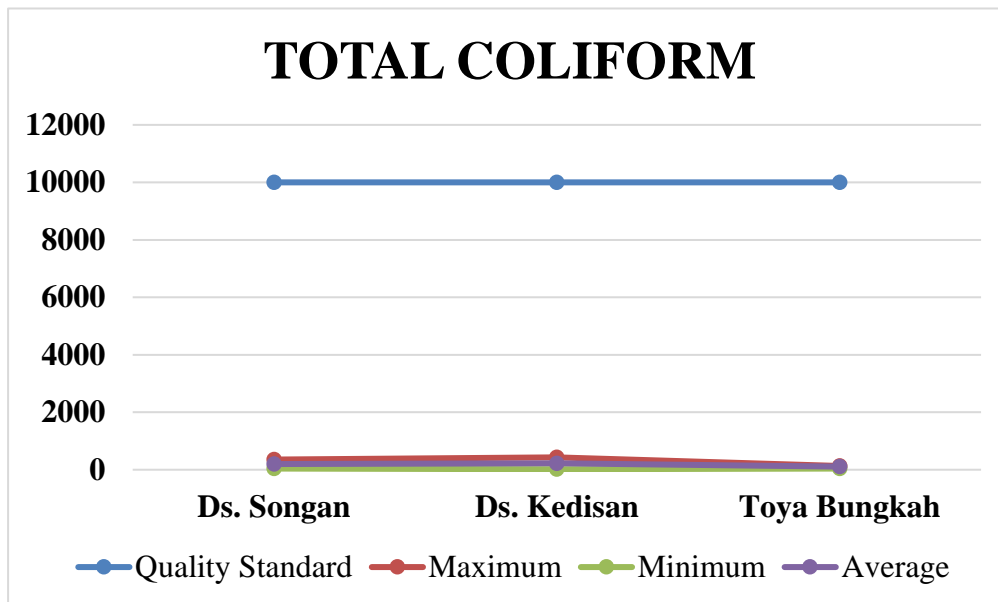


Figure 7. Results of total coliform measurements on Lake Batur

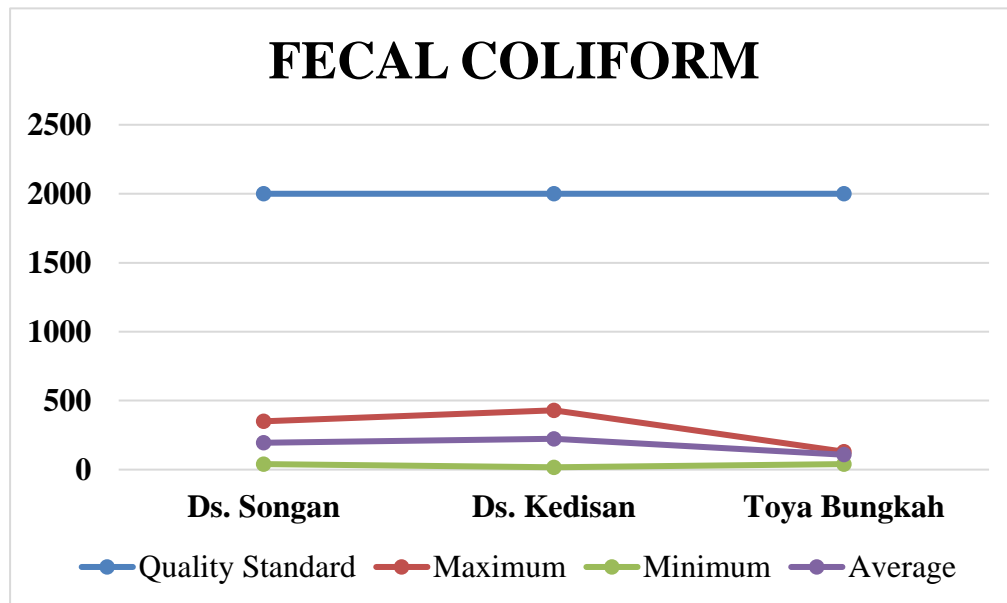


Figure 8. Results of Fecal Coliform Measurement in Lake Batur

Lake Batur is one of the lakes located in Bali, which is included in the 15 national priority lakes for the need for countermeasures to reduce pollution that has an impact on lake water pollution. Lake Batur has a depth of 60-70 meters and an area of 16.05 km². Lake Batur is a type of closed lake, namely a lake that receives water flow from the river, but is not flowed back into other rivers, because it does not have a water channel or outlet. Lake Batur is also an area or area that has high mobility, there are various community activities that are in direct contact with Lake Batur, for example, fish farming through a cage system, agricultural activities carried out on the shores of Lake Batur and there are various tourist attractions such as restaurants and lodgings. These activities will produce waste that if the disposal and processing process is not carried out properly, it will also have an impact on Lake Batur.

Physical Parameters

Temperature

In the results of water temperature measurements carried out during the study, it was obtained that the average water temperature at each sample point had a low variation, the average temperature was 24-26°C. In the sample in Songan village, the lowest temperature was 24 degrees Celsius, while the highest temperature was 26 degrees Celsius. so the average temperature of lake water in Songan Village is 25 degrees Celsius. In Kedisan Village and Toya Bungkah have the same temperature. Temperature is one of the physical parameters that has a direct influence on the life of aquatic biota in it, as well as affecting the presence of dissolved oxygen. The temperature at the three sample points did not exceed the limits of the Class III Water Quality Standard.

Smell, Taste and Color

In the results of organoleptic tests on odor, taste and color parameters, the results obtained from 3 sampling locations, that the water from Lake Batur does not have a significant odor, does not have a strong or clear color, and does not have a taste that is an indication of pollution.

Chemical Parameter

pH

The degree of acidity (pH) in this study had unvaried results. The pH range is from 8.9 to 9.015. in accordance with the class III water quality standard according to the Governor of Bali Regulation Number 16 of 2016, namely the water pH limit for class 3 water quality, which is 9. At the 3 sample points, no pH levels were found that exceeded the class III water quality standard. The pH concentration in a body of water affects the fertility of a body because of the small body. Acidic waters will have an impact on the death of high aquatic biota, this also happens when the waters have an alkaline pH value. The pH in a water is also affected by the concentration of CO₂ during the day, because there is a high photosynthesis process, it will have an impact on decreasing CO₂ levels so that the pH of the water will increase.

Nitrate

Nitrates are the main form of nitrogen located in natural waters and are a major source of nutrients for the growth of aquatic plants and algae. Nitrate is one of the substances that is easily soluble in water because it has stable properties. Nitrate levels that exceed 20 mg/L for class III environmental quality standards have described the occurrence of pollution caused by human activities themselves. In the three samples carried out by the study, it was found that in Songan, Kedisan and Toya Bungkah Villages did not have nitrate levels that exceeded environmental quality standards. This means that the level of nitrate pollution does not exist in Lake Batur.

BOD

Biological Oxygen Demand or what is called biological oxygen demand is the amount of oxygen needed by a microorganism in water which aims to decompose and oxidize organic waste in the water. In this study, the results were obtained that Songan and Toya Bungkah Villages have a maximum BOD level of 7, which means that the 2 areas are polluted with BOD, because the BOD level exceeds the class III water quality standard set by the Governor of Bali No. 16 of 2016.

DO (Dissolved Oxygen)

Dissolved Oxygen (DO) is an oxygen content in the aquatic ecosystem that is needed by all aquatic biota and aquatic biogeochemical processes. In the three samples in Songan, Toya Bungkah, and Kedisan Villages, from the results of the analysis carried out, the DO levels at the three sample points have exceeded the minimum limit of the Class 3 Water Quality Standard, this indicates that Lake Batur has an optimal concentration of DO to meet its biological life

Total Phosphate

An area of water that has phosphate levels is the result of household, industrial and agricultural waste. The high phosphate content is able to increase the growth of algae, which has an impact on the difficulty of sunlight to illuminate the waters (Ahmed et al., 2022). In the three samples, namely in Songan Village, Kedisan Village and Toya Bungkah, based on the results of the analysis carried out, the total phosphate content in the three waters did not exceed the standard threshold of class III environmental quality,

Biological Parameter

Total Coliform dan Fecal Coliform

The bacteria most commonly found in water is *Escherichia coli* which is a type of bacteria that lives and thrives on human or animal feces. The bacteria are an indication of water pollution, this is because *Escherichia coli* bacteria produce ethionine which can be produced by pathogenic bacteria that have a health impact on humans. In the 3 samples, namely Songan Village, Kedisan Village and Toya Bungkah, based on the results of the analysis carried out, the levels of Total Coliform and Fecal coliform in Lake Batur did not exceed the standard threshold of environmental quality class III, this indicates that Lake Batur did not experience Total Coliform and Fecal coliform pollution.

From the results of the analysis carried out to determine the water quality of Lake Batur which was carried out through the STORET method using 11 parameters. From the results of the STORET calculation from the three sample points, it can be determined that the water quality status of Lake Batur is:

Table 6. Determination of the Water Quality Status of Lake Batur

No.	Sample location	Total Score	Status
1.	Songan Village	-4	Lightly polluted
2.	Kedisan Village	0	Meet Quality Standards
3.	Toya Bungkah	-4	Lightly polluted

Based on the results of the STORET calculation in table 6. It was obtained that the sample location in Songan Village was included in the category of light pollution, at the sample location of Kedisan Village all indicators met the Class III Water Quality Standard, and at the sample point in Toya Bungkah was included in the category of light pollution.

The indicator that has a value that exceeds the Water Quality Standard at the sample locations of Songan and Toya Bungkah Villages is the BOD level. BOD levels in a body of water are influenced by light, temperature, sunlight, oxygen levels, water movement and biological growth. A high BOD indicates that the need for oxygen by microorganisms to oxidize organic matter is very high. High BOD levels indicate that there

has been an oxygen deficit (Musdalifah et al., 2022). Biological Oxygen Demand is the amount of oxygen needed by a microorganism in water which aims to decompose and oxidize organic waste in waters. BOD levels in a water area are an indicator of the quality of a water area. The higher the BOD level that is used to decompose organic matter in the water by microorganisms, the lower the quality of the water. The BOD value or the amount of oxygen dissolved in water is used in the oxidation process of organic matter, namely carbohydrates, organic matter and protein. A high number of BODs indicates that the high activity of microorganisms to decompose organic matter makes the water quality worse, while if the number of BODs is lower, the water quality is better.

The increase in BOD levels in Lake Batur is influenced by several factors, one of which is domestic agricultural waste. The geographical location of the land in the area of Lake Batur tends to be sloping, and centered on the lake, so that when it rains, the soil that has been polluted by chemicals derived from agricultural chemical fertilizers will accumulate in the lake, which has an impact on increasing BOD levels in Lake Batur (Wijana, 2010).

CONCLUSION

The Lake Batur sample in Kedisan Village meets the Class 3 Water Quality Standard, while Toya Bungkah and Songan Villages have light pollution levels. The BOD level exceeds the Class III Water Quality Standard at these locations. A SWOT analysis suggests maximizing Lake Batur's strengths and opportunities by promoting sustainable tourism and implementing lake rejuvenation initiatives. Future research could explore the impact of sustainable tourism practices on water quality and overall health, focusing on how these practices affect BOD levels and other water quality indicators. It could also assess the effectiveness of management strategies in mitigating light pollution and maintaining water quality within Class III standards. Comparative studies of similar lakes undergoing sustainable tourism development could provide valuable insights and best practices for managing Lake Batur's resources effectively.

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