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Determination of potential fisheries areas based on trophic status (case study in Situ Gede, Tasikmalaya)

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ABSTRACT

Situ Gede is one of the artificial lakes/reservoirs in Tasikmalaya, West Java. The lake has functioned as a source of household water needs, fisheries, and tourism. According to determine the development of water management requires information on the trophic status and water quality. This study aimed to obtain information on the trophic status and water quality of Situ Gede. The research was conducted in Situ Gede, Tasikmalaya, West Java, in 2018. Measurement and analysis of water quality parameters used the SNI and APHA methods, while the measurement of trophic status used the Carlson Trophic State Index (TSI). The relationship between water quality parameters and TSI scores was analyzed using Statistica version 8. Based on the analysis, the trophic status of Situ Gede ranged from 69.06-79.04, with an average of 74.61. This value indicated that Situ Gede's trophic status was on a eutrophic level. The physical and chemical parameters that affect the trophic status of Situ Gede are TP, pH, conductivity, TDS, and temperature. The TP values, conductivity, pH, and temperature at Situ Gede were still categorized as normal. The trophic of Situ Gede can be a source of fish growth. Moreover, in general, Situ Gede waters still have sufficient water quality for fish life. Therefore, Situ Gede has the potential to capture fisheries, recreational fisheries, and aquaculture.

Introduction

Indonesia has 0.05 million ha of artificial lakes/reservoirs, consisting of around 840 lakes and 735 situ/small lakes (Kartamihardja *et al.*, 2009). Lake/situ is one of the freshwater sources to support the organisms' activities (Pamudjianto and Sutiono, 2018). The function of situ is as the water catchment area and prevent flooding by flowing the water into the main river. The situ is also the area of protection for aquatic flora and fauna, water sources for household water needs, fisheries, and tourism (Susanto *et al.*, 2016). The multipurpose use of situ makes competence between the user. Since the users modified the environmental structure, it causes the alteration of water quality and quantity (aquatic ecosystems disturbed). Human activities around the situ are one of the problems in the inland fisheries sector. The waters' carrying capacity will be degraded by human activities, including inland fishery resources (Kartamihardja *et al.*, 2009; Amri *et al.*, 2009; Priadie, 2011; Muthmainnah *et al.*, 2017; Setiawan *et al.*, 2019).

Situ Gede is one of seven artificial lakes/reservoirs in Tasikmalaya, West Java. Some previous study results showed the function of Situ Gede were close with human need, such as a water source of household, earn money from fishery activities, and tourism (Heri and Priadie, 2008; Fahmi, 2017; Ridwana *et al.*, 2018; Priantana and Santoso, 2019; Setiawan *et al.*, 2019). The source of Situ Gede water comes from the Cikunir and Cibanjaran rivers. Currently, Situ Gede faced problems, i.e., (1) reduced water supply into situ, (2) high sedimentation rates, and (3) narrowing of inundation areas where fish living (Heri and Priadie, 2008).

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In Situ and all inland waters, the fisheries sector is only a secondary function. However, fishery activities play an important role in contributing to the protein source and the local community's livelihood. Besides, the local government also expected that the community would utilize Situ Gede's fish in the content of the "*Gemar Makan Ikan"* program or consumption needs (Adji, 2020). Therefore, fishery resources in Situ Gede need to be preserved by applying appropriate management patterns.

In fisheries sector, it needs attention to water fertility level. The trophic status is an indicator of the fertility level of water. The eutrophication status of a lake/reservoir is classified based on increased nutrient levels in the water. Eutrophication is a water condition rich in nutrients, especially nitrogen and phosphorus (Soeprobowati and Suedy, 2010). In general, there are three categories of trophic status, i.e., eutrophic, mesotrophic, and oligotrophic. The water is said to be eutrophic if it has high nutrients and supports the aquatic animals that live in it (Wiryanto *et al*., 2012). Mesotrophic waters have moderate nutrient conditions, while oligotrophic waters describe low nutrient conditions, so the waters could not support relatively large fish populations.

To obtain the trophic status, it can be done by calculating the total concentration of phosphorus, chlorophyll-a, and water transparency (Prasad and Siddaraju, 2012; Zulfia and Aisyah, 2013). The higher water nutrient condition will be increased the primary productivity (chlorophyll plankton content). The higher the water's primary productivity will make the greater the carrying capacity of its inhabitants. On the other hand, the low primary productivity indicates a low carrying capacity (Soeprobowati and Suedy, 2010).

Eutrophication conditions are one of the problems for aquatic ecosystems. Human activities around the waters and natural waters of waters can cause changes in the watershed's trophic status. Decreasing water quality due to eutrophication will reduce the water function and disrupt the ecosystem itself (Samudra *et al*., 2013; Sulastri *et al*., 2016). The invasion of floating water plants and phytoplankton populations' dominant eutrophication (Soeprobowati and Suedy, 2010; Zulfia and Aisyah, 2013; Sulastri *et al*., 2016). Trophic status can monitor water quality (Soeprobowati and Suedy, 2010; Zulfia and Aisyah, 2013; Shaleh *et al*., 2014; Sulastri *et al*., 2016; Indriani *et al*., 2016). Trophic status information is useful in utilize of Situ Gede resources. It requires information on the trophic status and water quality to determine the development of water management. The capture fisheries or aquaculture activities should notice the feasibility of trophic status and the number of potential waters as benchmarks for aquatic land utilization (Samuel and Ardiansyah, 2016).

Research on Situ Gede water quality is still limited, while the trophic status of Situ Gede does not exist yet. Therefore, the purpose of this study was to obtain the trophic status and water quality of Situ Gede that expected to provide the fundamental materials or suggestions for developing fisheries' potential in Situ Gede.

Material and Methods

The research was conducted in Situ Gede, Tasikmalaya, West Java in 2018 (Figure 1). The data were collected by conducting direct survey. The water samples were taken from three stations. Station 1 was the rumpon (07°20.043'S; 108°11.289'N); Station 2 was the inlet of Situ Gede (07°20.178'S; 108°11.219'N); and Station 3 was the outlet of Situ Gede (07°20.239'S; 108°11.377'N). There many water plants and gill net of fishing gear in Station 1. This location is one of fishing ground in Situ Gede. Furthermore, the availability of water in Situ Gede comes from Cikunir River and Cibanjaran River. The station 2 was the inlet of Situ Gede that got supplies water from those rivers. Meanwhile, at station 3 is Situ Gede outlet that leads to Mangkubumi Village for irrigation.

Water quality data were collected in each station. The parameters observed in this study included temperature, brightness, pH, dissolved oxygen (DO), Total Dissolved Suspense (TDS), conductivity, nitrite (NO_2), nitrate (NO_3), ammonia (NH_3), total phosphorus (TP), and chlorophyll-a. Water samples were taken using water sampler as two liters. The sample of water was put into bottle, and transferred to the Research Institute for Inland Fisheries and Extension Laboratory, Palembang to be analyzed.

Data analysis

The measurement and analysis of water quality parameters refers to the SNI and APHA methods (2005), while the analysis of trophic status uses the Carlson Trophic State Index (TSI) method. TSI analysis was performed using parameters of brightness, total phosphorus content, and chlorophyll-a content. The TSI of Carlson (1977) was calculated using the following formulae:

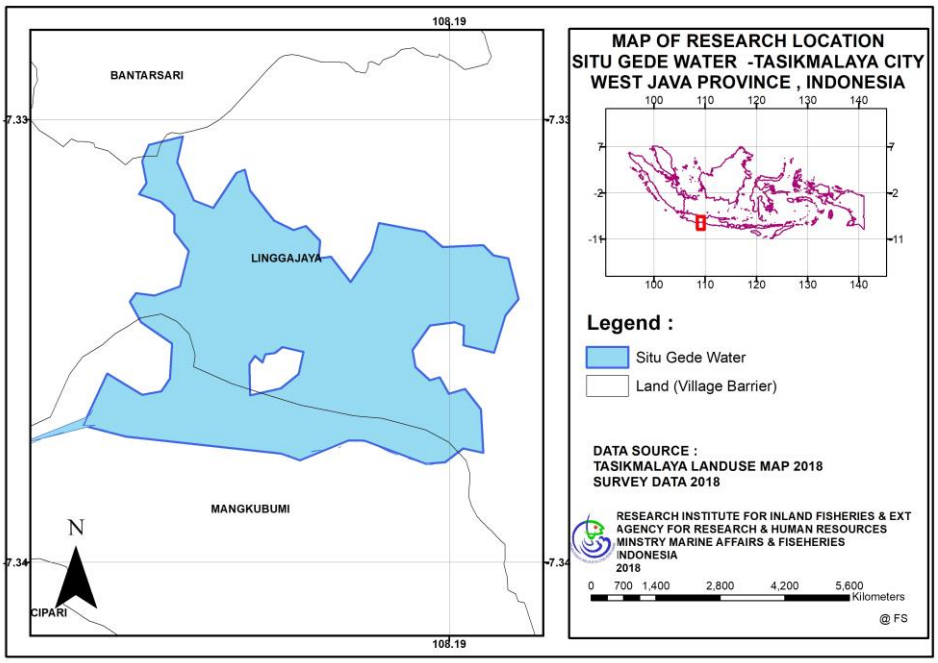

Figure 1. Map of research location.

Table 1. Carlson's trophic state index values and classification of lakes/situ (Prasad and Siddaraju, 2012; Samuel and Adiansyah, 2016).

TSI values	Trophic Status	Attributes
<30	Oligotrophic	Clean water, oxygen throughout the year in the hypolimnion
30-40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40-50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50-60	Eutrophic (low)	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60-70	Eutrophic (moderate)	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70-80	Eutrophic (high)	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Hypereutrophic	Algal scum, summer fish kills, few macrophytes

TSI (SD) =60-14,41 ln (SD).....(1)
TSI (CA) =30,6+9,81 ln (CA).....(2)
TSI (TP) =4,15+14,42 ln (TP).....(3)
average TSI =[TSI (SD)+TSI (CA)+TSI (TP)]/3.....(4)

Where:
SD = transparency using the Secchi disk (m)
CA = Chlorophyll-a (µg/l)
TP = Total phospor (µg/l).

Based on the values of TSI the lakes/situ are classified oligotrophic (low productive), mesotrophic (moderately productive), and eutrophic (highly productive). The range of the Carlson's trophic state index values and classification of situ are presented in Table 1. Lastly, to determine the relationship between water quality parameters and TSI scores were analyzed using Statistica version 8.

Results

The results of trophic status and water quality of Situ Gede are presented in Table 2. The physical and chemical values of Situ Gede waters were not different between stations. The average temperature of Situ Gede at three stations was 24.3 °C. Brightness values ranged from 0.20 to 0.30 m with an average of 0.25 m. The area with the lowest brightness value was located in the inlet area, while the highest was at rumpon. The brightness value was related to the TDS conditions at the observation station. Situ Gede's TDS content ranged from 167.5-172 mg/l. The highest area of TDS content was in inlet, while the lowest was in

rumpon. The greater number of dissolved solids in the solution, the greater number of ions in the solution will be. Conductivity values of Situ Gede ranged from 0.24 to 0.62 mS/cm.

During the study, the pH value of Situ Gede was 6, which meant the waters tend neutral to acidic. Situ Gede dissolved oxygen content was high enough for aquatic life. DO values ranged from 9.2-11.4 mg/l. Meanwhile, Situ Gede's nitrite and nitrate content were low. Nitrite values ranged from 0.014-0.015 mg/l, while nitrates ranged from 0.048-0.748 mg/l. Situ Gede ammonia content ranged from 0.027-0.23 mg/l. The value was still within the limits tolerated by fish life. The total phosphorus value in Situ Gede ranged from 0.085-0.489 mg/l with an average of 0.275 mg/l. The inlet station had the highest total phosphorus content compared to other stations.

The Situ Gede trophic status analysis based on the TSI calculations is presented in Table 3. Situ Gede chlorophyll-a content ranged from 21.03-28.14 mg/l. Based on calculations, the trophic status values of Situ Gede waters ranged from 69.06-79.04, with an average of 74.61. This value illustrates that Situ Gede's trophic status belongs to the eutrophic group.

Table 2. The physical-chemical quality parameters of Situ Gede water.

Parameter	Station		
	Rumpon	Inlet	Outlet
Physical parameter			
Temperature (°C)	24.3	24.3	24.3
Brightness (m)	0.30	0.20	0.25
TDS (mg/l)	167.5	172	170.9
Conductivity (mS/cm)	0.24	0.262	0.259
Chemical parameter			
DO (mg/l)	9.2	11.9	9.4
pH	6	6	6
NO_2 (mg/l)	0.015	0.015	0.014
NO_3 (mg/l)	0.748	0.059	0.048
NH_3 (mg/l)	0.23	0.027	0.112
Total Phosphorus (mg/l)	0.085	0.489	0.251
Chlorophyll-a (mg/l)	23.65	21.03	28.14

Table 3. The trophic status of Situ Gede.

Station	TP (mg/l)	Brightness (m)	Chlorophyll-a (mg/l)	TSI Score	Trophic status
Rumpon	85	0.30	23.65	69.06	Eutrophic
Inlet	489	0.20	21.03	79.04	Eutrophic
Outlet	251	0.25	28.14	75.71	Eutrophic
Average±SD	275±203.07	0.25±0.05	24.27±3.59	74.61±5.08	Eutrophic

Based on Statistica version 8 analyses, the chemical parameters that affected the trophic status of Situ Gede waters are TP, pH, conductivity, TDS, and temperature. It showed in Table 4.

Table 4. Matrix correlation of water quality parameters ($p < 0.05$).

Variabel	NO_2	NH_3	TP	Chl-a	pH	DO	Cond	TDS	Temp	Brightness	TSI	NO_3
NO_2	1.00	0.09	0.10	-0.93	0.19	0.44	-0.14	-0.28	-0.28	0.00	-0.19	0.51
NH_3	0.09	1.00	-0.98	0.27	-0.96	-0.85	-0.99	-0.98	-0.98	1.00	-1.00	0.90
TP	0.10	-0.98	1.00	-0.46	1.00	0.94	0.97	0.93	0.93	-0.99	0.96	-0.80
Chl-a	-0.93	0.27	-0.46	1.00	-0.53	-0.74	-0.23	-0.08	-0.09	0.36	-0.18	-0.16
pH	0.19	-0.96	1.00	-0.53	1.00	0.96	0.94	0.89	0.89	-0.98	0.93	-0.75
DO	0.44	-85.00	0.94	-0.74	0.96	1.00	0.83	0.74	0.74	-0.90	0.80	-0.55
Cond	-0.14	-0.99	0.97	-0.23	0.94	0.83	1.00	0.99	0.99	-0.99	0.99	-0.92
TDS	-0.28	-0.98	0.93	-0.08	0.89	0.74	0.99	1.00	0.99	-0.96	0.99	-0.97
Temp	0.00	-0.98	0.93	-0.09	0.89	0.74	0.99	0.99	1.00	-0.96	0.99	-0.97
Brightness	0.00	1.00	-0.99	0.36	-0.98	-0.90	-0.99	-0.96	-0.96	1.00	-0.98	0.86
TSI	-0.19	-1.00	0.96	-0.18	0.93	0.80	0.99	1.00	1.00	-0.98	1.00	-0.94
NO_3	0.51	0.90	-0.80	-0.16	-0.08	-0.55	-0.92	-0.97	-0.97	0.86	-0.94	1.00

Discussion

The study results showed that the trophic status of Situ Gede was a eutrophic group. The eutrophic condition is characterized by high water nutrient content, decreased brightness, and blue-green algae dominance (Prasad and Siddaraju, 2012; Zulfia and Aisyah, 2013; Shaleh *et al.*, 2014; Samuel and Ditya, 2019). Meanwhile, Situ Gede's inlet area has a higher eutrophic level than others, while the outlet station has the lowest eutrophic level. The inlet's high trophic level was due to its entry point for nutrients from residential activity, agriculture, and livestock from Situ Gede residents.

The trophic status of Situ Gede was influenced by parameters TP, pH, conductivity, TDS, and temperature. Phosphorus is the main parameter in determining the trophic status of waters. Prasad and Siddaraju (2012) noted that phosphorus changes in aquatic ecosystems could turn their trophic status. The TP level of Situ Gede based on this study was higher than the previous ten years' research, which was 0.023 mg/l (Heri and Priadie, 2008). However, the range of TP values (0.2 mg/l) was still within limits required by Government Regulation No. 82 of 2001 water class I and II. The high level of TP Situ Gede was caused by organic matter in the water bodies. The source of phosphate in water comes from livestock waste, floating net cage activity, household activities such as detergents, agricultural waste such as fertilizer use, industrial waste, and natural processes (Fried *et al.*, 2003; Brahmana and Achmad, 2012; Syandri *et al.*, 2014; Samuel *et al.*, 2015).

Meanwhile, the lowest TP level was at the rumpon station. The utilization of phosphate by aquatic plants in the sampling station caused the TP content to be lower than other stations. Phosphate is a form of phosphorus that plants can use (Samudra *et al.*, 2013; Zulfia and Aisyah, 2013).

The TDS, conductivity, pH, and temperature parameters in this study also influenced the trophic status of Situ Gede. Total Dissolved Solids (TDS) is the number of solids derived from dissolved materials (inorganic and organic compounds) that can pass through filters smaller than two µm (Salim and Dharmawan, 2017; Irwan and Afdal, 2016). In general, the dissolved material in natural waters is not toxic, but it will reduce the quality of the water if it is too much. This material can increase the turbidity value of the waters, which will inhibit the penetration of sunlight and affect other water processes (Salim and Dharmawan, 2017). The primary source of TDS content in Situ Gede is wastewater containing soap and detergents, such as household wastewater. Overall, the TDS value of Situ Gede is still far below the limits required by Government Regulation No. 82 of 2001 water class I, II, III, and IV, which is 1000 mg/l. The more significant amount of dissolved solids in the solution will make the number of ions in the solution higher. The increase in TDS will be followed by conductivity values (Arlindia and Afdal, 2015; Irwan and Afdal, 2016).

The electrical conductivity of water is a measure of a solution's ability to conduct an electric current. The electrical conductivity value shows the total ion concentration in the solution (Manalu, 2014). From several research results, the value of the solution's electrical conductivity is also influenced by temperature and pH. The conductivity value will follow the temperature increase. The increase in temperature will cause the ions to move faster, and the electrical conductivity value will also be higher so that the water quality will worsen (Arlindia and Afdal, 2015; Irwan and Afdal, 2016; Sumarno *et al.*, 2017).

The TDS, conductivity, pH, and temperature values at Situ Gede are still within the specified normal limits. The Situ Gede's pH value range was tended to acidic. These results are not much different from the previous studies, ranging from 6.6 to 6.7 (Heri and Priadie, 2008). The pH condition is presumably influenced by the pile of organic matter at the bottom. Situ Gede's pH was still sufficient for aquatic biota and is included in PP's Class II quality standard. 82 of 2001, namely 6-9 and the limitation of fish's living needs, 5-9 (Novotny and Olem, 1994). From this study, it can be seen that in terms of trophic status, Situ Gede had the potential for fisheries carrying capacity. The fertility of Situ Gede can be a source of regeneration of fish. Likewise, from the study of water quality, in general, Situ Gede still had sufficient water quality for fish life. The oxygen level in Situ Gede was quite high. Plankton as natural food in Situ Gede was also sufficiently available to support fish growth (Hikmatullah *et al.*, 2012). Aquatic plants in the situ's edge area are fish spawning areas. Rumpon station has a relatively high abundance of aquatic plants.

The water quality results of Situ Gede also show that it is suitable for the development of capture fisheries and freshwater fish aquaculture. However, some factors must be considered in developing land for aquaculture, particularly water sources (water discharge and quality) and sufficient water availability throughout the year (Kulla *et al.*, 2020).

Another factor in aquaculture is paying attention to good water quality management and handling fish diseases (Undap and Tumbol, 2016). Currently, the fishery activities of Situ Gede are only limited to household needs or local community consumption and recreation/ fishing. In Situ, Gede lives various types of fish. The composition of Situ Gede fish species is dominated by Cyprinidae (57.14%), Bagridae (14.29%), Cichlidae (14.29%), and Channidae (14.29%). The fish are caught by the community/fishers using hook and line, cash net, gill net, and seine net (Suryati *et al*., 2019). Decreasing water levels during the dry season and high sedimentation are the main problems in Situ Gede fisheries. These conditions lead to a lack of habitat for aquatic organisms and a reduced supply of fish.

Regarding an effort to develop and preserve the Situ Gede fishery function, the local government has conducted regular restocking in Situ Gede (Suryati *et al*., 2019; Adji, 2020). Situ Gede fisheries development needs to be directed towards maintaining the ecosystem's quality and contributing to economic growth and community welfare. Therefore, the development of the fisheries sector will be strategic if there is a relationship with the aspects of the community's social, economic, cultural, and aspirations. In determining the fisheries development strategy in Situ Gede, development needs to prioritize expanding existing resources (natural resources, human resources, artificial resources/infrastructure, institutions, technology, and capital) to achieve sustainable development.

Conclusion

The trophic status of Situ Gede belongs to the eutrophic level, which means that the water quality is sufficient to support the survival of fish. Situ Gede has potential for fisheries carrying capacity because the waters' fertility can be a source of fish regeneration. Moreover, the water quality of Situ Gede is still is suitable for the aquatic organism. Therefore, Situ Gede waters have the potential to develop capture fisheries, recreational fisheries, and aquaculture.

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