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Analysis of Productivity Plankton and Trophic Status Beratan Lake Ecosystem Tabanan Regency, Bali Province

Sang Ayu Made Putri Suryani [a]
I Wayan Arya [b]

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Abstract

Beratan Lake is used for fish cultivation activity, tourism, agriculture, and disposal activity. Utilization level is too high and makes lake ecosystem disturbed especially phytoplankton. Phytoplankton existence in water is acting as primary production and act to determine water quality on physical or chemical. The purpose of this research is to know plankton productivity and trophic status ecosystem Beratan Lake. Beratan Lake utilization that too high will impact in ecological pressure at lake ecosystem like decreasing water productivity and quality. The result of the research can conclude that water premier productivity of Beratan Lake is too low especially in cultivation fish territory that has phytoplankton abundance is 4585 individuals per ml that make Beratan Lake is classified to a lake that its trophic status is oligotrophic. The variety of phytoplankton and zooplankton that found in Beratan Lake shows low variety where it only found 5 classes and 11 species of phytoplankton and also 2 classes dan 3 species of zooplankton.

Author correspondence:
Sang Ayu Made Putri Suryani,
Water Resource Management, Warmadewa University Terompong Street 24
Denpasar Bali. 80239, Indonesia
Email address : *suryanip@rocketmail.com*

1. Introduction

Bali island has an area of relatively small compared to other provinces in the country of Indonesia, in which the area of Bali as a whole is 5,636.66 km2 has four lakes are spread over three districts, namely Lake Batur in Bangli district, Buyan Lake and Tamblingan in Buleleng and Beratan Lake in Tabanan district. Beratan Lake is one of them had a utilization rate is very complex both on the periphery/boundary of the lake or on the body of water, to aquaculture fish, tourism, including water tourism, especially the speed boat, agriculture, and disposal of drainage, the entry waste from domestic activities is not impossible to happen.

[a] Warmadewa University, Bali, Indonesia
[b] Warmadewa University, Bali, Indonesia

The lake is located at the altitude of 1,231 m above sea level has an area of 3.8 km2, water depths up to 22 m, with a volume of 0.049 km3. The utilization rate is so high the level of disturbance and pollution of the lake ecosystem was certainly very high and the lake suffered fairly heavy ecological pressure. The area is used for fish farming activities, with an area of approximately 20 hectares. Agricultural activities that use different types of fertilizers both organic and inorganic, as well as a variety of drugs for combating pests, which in turn slowls the residue in the soil will be washed into the lake, pollution of the lake will affect the dynamic relationships in the ecosystem of the lake involving several components. These components can be seen from two different aspects, namely from the aspect of the trophic level and aspects of life. From the aspect of the trophic level, the ecosystem consists of components autotrophic and heterotrophic components, the emphasis on the level of energy transfer. While aspects of life, the ecosystem consists of components biotic and abiotic components that are closely linked and have a reciprocal relationship with each other.

Phytoplankton presence is very important in the water and aquatic environment for acting as primary producers in aquatic ecosystems. As primary producers will certainly determine the lives of other organisms in the water both macro and micro-organism organisms. The existence of phytoplankton in the waters in addition as primary producers are also very instrumental in determining water quality both physically such as determining the color of the water and also chemically affect water chemistry parameters through biochemical processes.

From these facts, it is necessary the presence of phytoplankton in the water which is determined by the number or the density and diversity of phytoplankton itself. Bodies are experiencing ecological pressure will greatly affect the diversity of phytoplankton that lives in it. Therefore, please note the diversity of phytoplankton as primary producers in the waters of Beratan Lake remember this lake has experienced a fairly heavy ecological pressure.

Another negative impact of pollution of the waters of the lake can not only cause loss of economically and ecologically a decrease in primary productivity and aquatic biological productivity can also lead to loss of biodiversity, notably endemic lakes. By knowing the productivity primary through the density and diversity of phytoplankton and zooplankton, the possibility of the discovery of plankton poisonous or harmful trophic level chain, conditions of water quality parameters, it can be used as a reference to determine the status of ecology of the Beratan Lake is still good, already interrupted or severely disturbed or damaged. Particularly in the development of aquaculture (20 Ha).

2. Materials and Methods

The method used in this research is a descriptive exploratory method of conducting a series of activities taking water samples to be analyzed biological parameters such as phytoplankton and zooplankton as an object under study is the presence of phytoplankton and zooplankton abundance and species concerned. From the data obtained is then performed by descriptive analysis. Descriptive research is research that tries to give a systematic overview of the situation, problems, phenomena and provide information. Exploratory research is a study of an object to explore something if the knowledge of researchers of the object is still very little or limited.

In this case, conducted a survey to determine the sampling point, hereinafter referred to the station. Each sampling stations which have been determined to have the characteristics of the habitat types that vary with the goal of obtaining diversity of phytoplankton different and knowing the possibility of growing plankton toxic or harmful, so as to know the level of fertility at each station and the influence of the type of habitat in the surrounding marine environment.

Types of data collected in the implementation of this research are data in the form of qualitative and quantitative data. The purpose of the quantitative data is the data source that is capable in the form of numbers, such data is more objective. While the purpose of the qualitative data is the data source.

According to Sachlan (1982), phytoplankton density is calculated using the arithmetic formula plankton as follows:

$$K = \frac{Bcg}{\sum BVcg} \times \frac{BV}{DV} \times \frac{1}{Vfw} \times \sum specimen$$

K : Abundance or density
Bcg : Broad of cover glass 18mm x18 mm = 324 mm
BVcg : Broad visual field πr2 (3.14 x 0:52 = 0.785mm^2)
BV : Bouquet volume 100ml

DV : Drops volume 0.05ml
Vfw : Volume of filtered water (20 liters / 20, 000 ml)

3. Results and Discussions

3.1 Phytoplankton Abundance

The observation of samples in the research area and after counting the abundance of phytoplankton at each station then obtained abundance/density of phytoplankton as shown in Table 1 below.

Table 1
Phytoplankton abundance at each station (individual/ml)

Terri-tory	Station	Observations To			Total	Average
		I	II	III	Individual / ml	Individual / ml
West	I	4.310	4.769	4.494	13.574	4.524
Middle	II	4.402	4.310	4.310	13.024	4.341
East	III	3.210	3.301	3.210	9.722	3.240

Source: Adapted from Primary Data, 2016

From Table 1 it can be seen that more and more towards the East side, namely from the first station to station III shows that there significant differences between the West and the Middle East region of Beratan Lake. Abundance in the lowest East side than in the central and western side, it is caused by several factors such as the intensity of solar radiation by different

In addition to requiring the sunshine in the biological process phytoplankton main thing that is required is a nutrient or nutrients, the supply of nutrients for phytoplankton in addition sourced from the bottom of the lake at the time of stirring the water, as well as more supplied from the mainland. Because the eastern side is the foot of the mountain and the forest then the possibility of the supply of nutrients from the forest area is less than from the West and North which is an agricultural area and settlements. It is also one of the low abundance of phytoplankton at Station III in comparison with the station I and II.

When viewed from the side difference of sampling sites are in the middle of the lake to the periphery is on all stations are no differences abundance that means, it does show that the distribution of phytoplankton from the middle to the edge of the lake is relatively the same.

Agricultural wastes into the lake will result in increased nutrient lakes that enable phytoplankton to grow faster even might be blooming. Referring to the statement then it is possible at the station I and II of this abundance/phytoplankton higher density than the surrounding region III station is forest, as seen in Table 1 the abundance of phytoplankton on each station.

Judging from phytoplankton abundance of data it can be stated that the results of research on the lake objections belong to the less fertile waters or oligotrophic, where the highest density of only 4.585.99 phytoplankton cells / ml, that the waters of the phytoplankton density below 5000 cells/ml classified as oligotrophic waters (waters less fertile), phytoplankton abundance of 5000-15000 cells/ml classified mesotrophic waters (average fertility), and above 15 000 cells/ml is eutrophic waters (waters are very fertile).

With these conditions it is possible that the addition of nutrients lake by agricultural activities around Beratan Lake not proven to cause the waters become fertile, it may be due to nutrients entering the lake more stuck in blood littoral and more widely used by aquatic plants that were there, so that the water plant is growing very rapidly. Abundance of phytoplankton in the waters is largely determined by its ability to breed, where the proliferation of phytoplankton is mostly done by way of cell division, in which cell division is the process is largely determined by the environmental conditions and the type of phytoplankton, environmental conditions in question is the availability of enough nutrients, pretty good sunlight penetration and physical and chemical quality of water that is optimal.

3.2 The Abundance of Zooplankton

Zooplankton as primary consumers in the waters, where these organisms are organisms that eat the phytoplankton, the zooplankton presence or abundance either in relation to the number and type also determine the abundance of phytoplankton in the waters. Although not all of phytoplankton could be eaten by zooplankton. It is known that some types of phytoplankton cannot be eaten by zooplankton, because of the morphology and physiology of phytoplankton, size, composition and zooplankton feeding mechanism, as well as other abiotic factors. From observations at each station obtained abundance/density of zooplankton as shown in Table 2 below.

Table 2
Zooplankton abundance at each station (Individual/ml)

Territory	Station	Observations To			Total	Average Individual / ml
		I	II	III		
West	I	825	733	733	2,293	764
Middle	II	458	737	825	2,017	672
East	III	366	366	458	1,192	397

Source: Adapted from Primary Data, 2016

From Table 2 shows that the distribution of the abundance of zooplankton population together with the abundance of phytoplankton distribution, namely the density decreases from the first station to station III. As well as the lowest densities of phytoplankton also occurred at the station III. The occurrence of this is caused by the nature of zooplankton which owns a relatively active movement to move in search of food, the zooplankton will move in the direction in which the availability of food is high, in this case, the zooplankton will move toward an area where a high density of phytoplankton.

If the zooplankton density is high enough it will be able to reduce the population and abundance of phytoplankton, but in Beratan Lake this will not happen because of the abundance of zooplankton relatively low so as not to have a big impact on reducing the amount of phytoplankton by the predation of zooplankton. If the level is high then an automatically predatory abundance of phytoplankton will be inversely proportional to the abundance of zooplankton, while from the above data zooplankton to phytoplankton abundance is directly proportional. This shows the level of predation is not too high. Besides the high level of predation caused by the abundance of prey is also determined by the type and size similarity existing phytoplankton. The existence of zooplankton does not necessarily impact directly on the existence of phytoplankton, there are other types of phytoplankton does not like or do not want to be eaten by zooplankton, so that phytoplankton was not like by zooplankton usually grows rapidly and dominates the kinds of other. However, the abundance of zooplankton also can change rapidly due to various things in their environment.

Zooplankton organisms are particularly vulnerable to changes in water quality and extremely strong against substances that are toxic polluting waters. Predation factor in the food chain has a great effect in a population where the food chain, especially in the process of predation allows happen crisscross one another (food web), which at some point will accelerate the decline of zooplankton in the waters.

3.3 Diversity of Phytoplankton

The diversity of phytoplankton during the study were observed every week did not show differences in diversity in every period of observation. The diversity of phytoplankton found is comprised of 5 classes and 11 species, which consists of Diatoms class (2 species), Chlorophyta class (4 species), Cyanophyta class (2 species), Desmideacea class (2 species), and Xantophyta class (1 species).

Judging from the diversity of phytoplankton found in Beratan Lake, especially in areas that are plotted as fish farming is relatively very low, compared with Tondanau lake has a variety of phytoplankton reached 32 genera (Gaspar et al, 2010) and in the waters of the island of Hope 72 species (YS Garno, 2008).

The low diversity of phytoplankton is strongly associated with the level of fertility of the lake, and the level of pollution of the lake. In terms of fertility, because Beratan belongs to the oligotrophic lakes (lakes infertile), it is

natural that the diversity of phytoplankton are also very low. In waters less fertile conditions then phytoplankton adaptable and able to compete alone can grow well while those unable to adapt and compete will die.

Besides the fertility factor then possible contaminants, especially chemical pollution is also very striving towards diversity of phytoplankton can grow and develop. Human activities occurring simultaneously produce changes in environmental conditions such as differences in biology and trophic structure of communities of aquatic organisms, including plankton as a source of primary productivity. Referring to the statement then in addition to the pollution factor fertility factor by human activity is possible the low diversity of phytoplankton in Beratan Lake. The most prominent pollution is pollution by oil due to the large speed boat as tourism facilities operating there. The water vehicle fuel potentially lead contamination. In addition to the comparison of nutrients, phytoplankton dominance is also determined by predation by zooplankton. It is known that some types of phytoplankton cannot be eaten by zooplankton, because of the morphology and physiology of phytoplankton size, composition and mechanism eat zooplankton and abiotic factors other than known that the condition density of phytoplankton was high and types vary, zooplankton will make the selective feeding against type, shape, and size of phytoplankton were about to eat With the type of phytoplankton that cannot be eaten by zooplankton and their ability possessed zooplankton selectivity, the types of phytoplankton are left because it is not eaten or not selected will flourish and dominate the phytoplankton community waters. In accordance with the statement of the low diversity of phytoplankton is very likely because of selective feeding by zooplankton were there. Furthermore, it is said Observing the above description it can be presumed that the combined effects of nutrients and zooplankton in a phytoplankton community will always cause a change in the structure of the phytoplankton community, both in the state of phytoplankton community structure of the constituent changed or fixed. The fact that phytoplankton is the primary producer, the community structure easily changed by changes in physical and chemical properties and biological ecosystem; the presence of phytoplankton in the waters not only can be used as a biological parameter in the analysis of the quality status of the marine environment; but can also be used as a biological indicator in determining the level of contamination. A biological indicator that the low diversity of phytoplankton in Beratan Lake, especially in the area of fish farming has signaled that the lake has experienced pollution, by various activities either in the lake or from outside the lake.

3.4 Diversity of Zooplankton

As well as phytoplankton, zooplankton diversity found in the current study is relatively low and there is no difference in the diversity of each period of observation. As for the zooplankton diversity is composed of two classes and three species namely Rhotatoria class (1 species) and Rhizophora class (2 species).

Zooplankton as primary consumers in the waters of life is very dependent on the availability of phytoplankton as their food source. If the abundance of their food source is low then it will make the zooplankton will be difficult to meet the needs of feed so it will be many who experienced death and automatically abundance also low, things like that that most likely occurred in Beratan Lake.

In normal circumstances, aquatic ecosystems phenomenon of the relationship between the abundance of phytoplankton to zooplankton usually happens relationship where high phytoplankton abundance when zooplankton abundance of low value and high-value zooplankton abundance in the period when phytoplankton abundance is low and will always alternate turns. This relationship can be disrupted if the existence of the things that interfere with or damage the environment ecological processes, for example, one of them due to pollution.

Phytoplankton and zooplankton are very vulnerable to changes in the ecosystem of the lake, then its existence either includes biomass density and variety in the waters will be influenced directly by the situation or the circumstances of the lake itself or from outside the lake. Barriers to penetration of sunlight coming through the waters of the lake and the pressure due to the influx of various pollutants will determine phytoplankton populations which are also striving directly or indirectly on zooplankton population. Excessive influx of organic material into the lake, for example, due to the use of the lake's border area livestock farming settlements and other domestic activities will influence the growth of phytoplankton and zooplankton populations.

The low abundance and diversity of phytoplankton can also be used as a biological parameter. The aquatic ecosystems are already experiencing ecological pressure by certain pollutants. Beratan Lake already indicated to have occurred water pollution by fuel vessels who are operating in there is one of the causes of the low diversity of zooplankton, because zooplankton-zooplankton certain to live,

Abundance or density and diversity of zooplankton in the waters is easily changed according to the state of the waters. Zooplankton organisms are particularly vulnerable to changes in water quality and extremely strong against substances that are toxic polluting waters. Predation factor in the food chain has a great effect in a population where the food chain, especially in the process of predation allows happen crisscross one another (food web), which at some point will accelerate the decline of zooplankton in the waters.

Two classes of zooplankton found that Rotatoria and Rhizopods classified as zooplankton that does not have a very important role a role in aquatic ecosystems, both its role in the food chain as well as its role as a food source that is preferred by the larvae and juveniles. In an aquatic ecosystem zooplankton, which has an important role is that most of the class of crustacean.

Zooplankton is plankton that is of animal origin, very disparate types and consists of various larval and adult form that represents the entire phylum animal. However, from the point of only one class of zooplankton ecology are very important, which is a sub-class of copepods (crustacean class, arthropods phylum). Copepods are small crustaceans that dominate holoplanktonic zooplankton. These small animals are very important for the ecosystem as a primary herbivore in the waters. Thus, copepods act as a chain of very important between primary production of phytoplankton to the small and large carnivores.

3.5 Poisonous Plankton Diversity

The observation of the toxic plankton indicates a very low diversity, where a toxic plankton is dominated by phytoplankton from Phyrophyta class that consists of only one genus and two species namely *Gonyaulax catenata* and *Gounyalax polydra*. Both species of plankton are toxic plankton species that are common in freshwater.

In favorable circumstances, the plankton was very easy to multiply by splitting themselves. In the blooming conditions or a very high population in this organism, waters can cause brown to reddish color on the surface of the waters. Under these conditions can cause death to the fish that eat them and even can cause poisoning in humans who consume fish or shellfish that feed on plankton Gounyalax happen to a lot of this.

Plankton contains a paralytic toxin, neurotoxic, hemolytic, and hemagglutinating. Toxins are effectively accumulated continuously in the flesh biota filter feeder (shellfish) in locations blooming. Shellfish meat containing the toxins, if consumed will cause a headache, joint pain, cramps in the lips and tongue, convulsions and more serious toxicity.

Although the abundance and diversity of plankton poisonous found relatively low the presence of plankton species that are toxic This provides the potential at some point there will be blooming caused by several things, namely the entry of nutrients into surface waters, these nutrients can come from waste both industrial waste, household, agriculture, tourism, and others. The entry of waste containing these nutrients will increase the amount of toxic plankton is including causing blooming. This causes changes in the diversity and community structure of plankton. A body of water will be disrupted if there is one type of plankton in number to dominate. For example, if a type of plankton populations have increased, this will disrupt the lives of other organisms.

In biological terms, plankton population increase is referred to as "blooming plankton". This plankton blooming usually cause changes in the color of the waters red, brown, green or blue. This color change depending on what type of plankton that dominates. Examples of the water changes to red when the type of phytoplankton such as *Ptychodiscus brevis*, *Prorocentrum sp*, *Gymnodinium breve*, *Alexandrium catenella* and *Noctiluca scintillans* abundant in the waters. Blomming impact plankton in a body of water will cause the oxygen content in a body of water will be drastically reduced, causing aquatic organisms such as fish die. Often in cases of mass death of fish in a body of water caused by a case of blooming plankton.

3.6 Water Quality

As well as supporting parameter measurement performed several water quality parameters that are closely related to the presence of plankton in the waters of the lake and was instrumental in determining the primary productivity of the lake, while the water quality parameters observed parameters of temperature, pH, dissolved oxygen, ammonium, and nitrate.

Water quality parameters are showed no difference, this is likely caused by the mixing of water which is quite often the case by the many speed boat passing causing mixing large enough and the mass transfer of water which is

quite often the case on the Central to the side of 20 Ha plotted for fish farming is an area where the speed boat began to turn both from the East and West side, where the speed boat maneuvers curved this raises the water surface waves are quite large. Because the number of speed boat to be operating quite a lot so stirring very regularly occur

The average temperature ranges between 24.6ºC are a relatively normal water temperature to the water in the highlands. Beratan Lake in addition to being on the plateau opportunity to gain relatively little sunlight as in the east are the foothills of Mount Mangu which inhibits sunlight in the morning, as well as in the west are the hills and mountains. In addition, the number of hours of exposure at relatively few locations this lake because of frequent dropped fog mainly before noon until late afternoon, so an increase in temperature due to the penetration of sunlight very little happened. Temperatures have direct and indirect effects on phytoplankton. The immediate effect of tolerance organism to the state of temperature,

At temperatures warmer always encountered a high abundance of phytoplankton. The light intensity affects the rate of photosynthesis and growth of algae, as an important factor for the life aquatic organisms, extreme temperature changes will disrupt the lives of aquatic organisms can even be death.

The degree of acidity (pH), is a measure of hydrogen ion concentration in the water and the atmosphere shows whether react acidic or alkaline. Fluctuations in pH are strongly influenced by the process of respiration because of the carbon dioxide gas made. The more carbon dioxide from the process of respiration, the pH will be lower. But on the contrary, if the higher photosynthetic activity will make higher pH. The degree of acidity (pH) affect the availability of other forms of carbon in the waters. At pH 4-6 then the carbon is formed carbonic acid (H_2CO_3), a pH of 6-9 is formed bikarbonanat (HCO_3) while pH > 9 form of carbon that is available is carbonate (CO_3).

pH in the lake waters objections at the time of sampling shows waters belonging to the category of acid with a value 5, pH relatively acidic waters of this ecosystem is certainly not good for the continuity of ecological processes. Acidic waters at the time of sampling are likely to also give effect to the low abundance of plankton and the diversity of species in this Beratan Lake. Plankton is able to grow in an atmosphere of pH waters like this certainly is capable of adapting and even then not many. This low pH allegedly caused also by the regular occurrence of stirring the water so that the water at the bottom rose to the surface. In general, the water at the bottom is usually more acidic than surface because at the bottom and the bottom of the lake occurred processes of decomposition of organic materials, which generally take place in situations of low oxygen. Decomposition process of organic matter in semi-aerobic and anaerobe high tendency to produce acid.

Dissolved Oxygen (DO), is an important parameter in a body of water. Dissolved oxygen is important for the aquatic organism is aerobic, as well as determine the metabolic rate and respiration of the whole aquatic ecosystem, it is also very important for the survival and growth continuance water biota. The presence of oxygen in the water is determined by the abundance of phytoplankton. It's close relation to the content of chlorophyll in phytoplankton that produces oxygen during photosynthesis.

Levels of dissolved oxygen (DO) at 9 ppm at the time the research is quite normal levels for public waters. Oxygen levels are relatively high is caused by two things: the first is the production of oxygen by photosynthesis process run optimally, although not reach the maximum point, it is associated with phytoplankton diversity dominated by Chlorophyta class, where plankton species are the types of phytoplankton have chlorophyll high enough so that it can perform its function as a producer of oxygen through photosynthesis. In addition to photosynthesis, Suplai oxygen may also be caused by the diffusion of oxygen from the air to water, this occurs by the result of the mixing of water in the lake surface by speedboat.

Relatively high nitrate 15 ppm alleged by the due processes of washing when it rains in the mainland region that contains the remains of organic and inorganic fertilizer so that no indication of the enrichment of water by these processes. Nitrite as parameters are likely to cause toxicity to aquatic organisms has not yet been the case. Nitrite levels were undetectable (0 ppm) showed no occurrence of decomposition of nitrate to nitrite by nitrification bacteria was not much going on. Nitrate is an abundant element in the cells of living creatures after carbon, hydrogen, and oxygen, in which nitrogen is important for the majority of chemical reactions. Aquatic plants and phytoplankton easier to use nitrogen in the nitrate form, then all nitrogen will available if it has been in the form of nitrate. The formation of nitrate is highly dependent on the presence of oxygen and bacteria Nitrobacter in charge of changing the nitrite to nitrate in aerobic.

Value BOD5 (Biological Oxygen demand) showed a high enough value means that the utilization of oxygen by organisms in the water is high enough, but judging from the abundance of zooplankton that is not too high likely oxygen is also utilized by microorganisms other than zooplankton eg, bacteria that are aerobics. The high BOD This is a sign that the special for aquatic organisms are in desperate need of oxygen such as fish, especially the fish, are

reared in a net bag floating at risk oxygen deficiency in certain situations, such as at night because at night the production of oxygen is low.

4. Conclusion

From the results of the research activities have been carried out it can be concluded that the waters of Beratan Lake primary productivity are very low, especially in the area/zone so that fish farming Beratan Lake belongs to the oligotrophic lakes or waters that are not fertile. It can be seen from some of the following:

1) Highest phytoplankton density 4,585 individual/ml and zooplankton in 2,293 individuals/ml, both were under 5,000 individuals/ml belong to the low density of the stagnant water.
2) The diversity of phytoplankton and zooplankton were found in Beratan Lake showed a low diversity where there are only 5 classes and 11 species of phytoplankton and 2 classes and 3 species of zooplankton.
3) Beratan Lake found toxic plankton from phyrophyta class, there are 2 species such as *Gonyaulax catenate* and *Gounyalax polyhedra*, with a very low density, which is not on any observations found this plankton. Although the density is very low the plankton is potentially posing a threat at any time and can cause problems, especially the possibility of blooming of plankton in the event a situation that is possible this plankton grow and develop rapidly.
4) Water quality parameters in the range are not good for the survival of aquatic ecological processes such as pH relatively acidic waters with a value 5 are the less optimal impact on biological processes of aquatic organisms both the micro and macro level. BOD5 relatively high waters reached 6 ppm which indicates that the possibility of a lack of oxygen for aquatic organisms is common at certain times, especially at night.

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Statement of authorship

The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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Biography of Authors

Name : Dra. Sang Ayu Made Putri Suryani, M.Si
Address : Jl. Narakusuma Gang VI No. 4 Denpasar
Occupation : Lecturer Aquatic Resource Management, Agriculture Faculty, Warmadewa University
Education :
1. Biology Science, Airlangga University, Surabaya
2. Molecular Biology, Brawijaya University, Malang
On-Going Ph.D. at Udayana University, Denpasar
Email: suryanip@rocketmail.com

Name : Ir. I Wayan Arya, M.P
Address : Jl. Diponogoro IIA No. 5 Tabanan
Occupation : Lecturer Aquatic Resource Management, Agriculture Faculty, Warmadewa University
Education :
1. Aquatic Resource Management Department, Agriculture Faculty, Warmadewa University
2. Biotechnology, Udayana University