PHYSICOCHEMICAL PROPERTIES OF WATER CHARACTERIZATION IN PETITENGET TEMPLE ESTUARY, BADUNG REGENCY

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ABSTRACT

A water quality deterioration has been predicted in the estuary area near a tourism spot, namely Petitenget Temple. It is located on the north side of Badung Regency, Bali Province. Brownish color and odor from the water were found in the preliminary study. There were 4 samples along the river that is ended up in the estuary of Petitenget Temple. This study aims to respond to the regional regulation about environment quality standards and deterioration level. Laboratory analysis was conducted to measure physical and chemical parameters. The result shown that the concentration of suspended solid was in the range of 7 – 18 mg/L, the temperature was in the range of 27^0C – 29^0C, pH of 6,2-7,3 and 9,2-12,5 NTU for turbidity. Chemical parameters shown the range of COD was 22,68-61,50 mg/L, BOD 11,42 – 26,74 mg/L, 0,45-1,35 mg/L for nitrogen in form of ammonia, 0,20 - 0,68 mg/L for orthophosphate, iron was 0,04 – 0,87 mg/L and there was no lead (Pb) detected. Based on the discussion, the physicochemical characteristic of water in the estuary of Petitenget Temple belonged between Class II and III. According to these results, the water along the estuary of Petitenget Temple was polluted and a treatment approach is urgently needed.

Keywords: chemical characteristic, physical characteristic, water quality, water pollution

Introduction

Water quality is an important concern regarding the river environment quality monitoring. The dynamic changes of water quality in the river are caused by some factors, such as land utilization and several activities that discharge the wastewater to the stream. The massive change of land utilization, especially around the riverbanks, implies the high demand for land for settlement, industrial, agriculture, or any commercial purposes. The waste disposal around the river becomes one of the reasons for water quality reduction and possibly change the water utilization pathway (Suriawiria, 2003).

In terms of water resources, the water has to be performed 3 requirements, they are quantity, quality, and have to continue. Some issues regarding these requirements, such as the number of water resources do not meet the high demand of the population and the low water quality factor which makes the water treatment have to be improved and more cost are needed. The massive growth of economic sectors has exploited the resources and rise the negative impact in reverse. It potentially harms the other population in the ecosystem that needs the water resources to be sustained (Effendi, 2003).

A water quality deterioration has been predicted in the estuary area near a tourism spot, namely Petitenget Temple. It is located on the north side of Badung Regency, Bali Province. It is a temple area that is used as daily worshipping for the Hindus community also opened for tourist visits. According to the preliminary observation, the river water was showing brownish color, sometimes with white foams, and releasing bad odor. It is confirmed that this area is surrounded by some public commercials, such as spa, hotels, villa, restaurant, laundry, and settlement. The waste discharge from those sources possibly decreases the water quality, especially if there is no any treatment before the disposal. Even today, the domestic wastewater from the households are disposed to the drainage or river stream without proper treatment. There some problems caused by water contamination, such as eutrophication, rising of water treatment cost, decreasing the additional value of water, waterborne diseases to human and livestock, oxygen depletion, and undesirable changes in the aquatic ecosystem.

In order to have a deeper explanation, a water characteristic measurement has been conducted in this study. It is an important work to do to clearly understand the recent condition of the water ecosystem in Petitenget Temple area. Besides, it also aims to respond to the regional regulation about environment quality standards and deterioration. The results will be implied the water classification based on the current regulation. The water quality regulation has become stricter leading to better environmental quality monitoring. It is important to determine the water characteristic to define its impact on stream water.

Physicochemical characteristics in river water are highly diverse from a compound to various complex polymers. Thus, characteristic of overall substances is important to explore the knowledge in deciding the best strategy to manage the water ecosystem. Consequently, it is critical to conduct a systematic analysis of river water quality. In general, the physicochemical parameters, such as temperature, pH, solid content, chemical oxygen demand (COD), biological oxygen demand (BOD), dissolved oxygen (DO), nitrogen and phosphate content, and other microelements (Akpor *et al.,* 2011).

Huang (2010) has been reported that the organic content in water quality showed that fiber was the largest content and followed by protein and sugar. Thus, characteristic is not only influenced by the wastewater but also solid waste, including trash, garbage, and others that are thrown away by the irresponsible people.

Domestic activities, agriculture, and massive urbanization led to an increase in the nitrogen and phosphorus discharge to the water system. More often, the effluent from a domestic wastewater treatment plant failed to meet the national standard for effluent quality (Wang *et al.,* 2013). Excess nutrients, mostly N and P is the main cause of eutrophication which results in oxygen depletion, biodiversity reduction, fish kills, odor, and increased toxicity

Water will be the most strategic resource within the next decades as all creatures need water to sustain. The information on water quality specifically in a certain water ecosystem provides an opportunity to improve the water quality itself and creating a sustainable water utilization. This study aims to determine the water quality in the estuary of Petitenget Temple and classify the water quality according to the regional regulation of water quality threshold.

Methods

Sampling Point

This research was located in the estuary around the Petitenget Temple, Badung Regency, Bali Province. There were 4 sampling points to take the water sample along the river which is ended up at the estuary. Those sampling points were representing the upstream area, 2 middle areas, and downstream area. The sampling locations can be seen below. The samples were taken three times on different days to see the trend of the water quality and get the average value for all parameters.

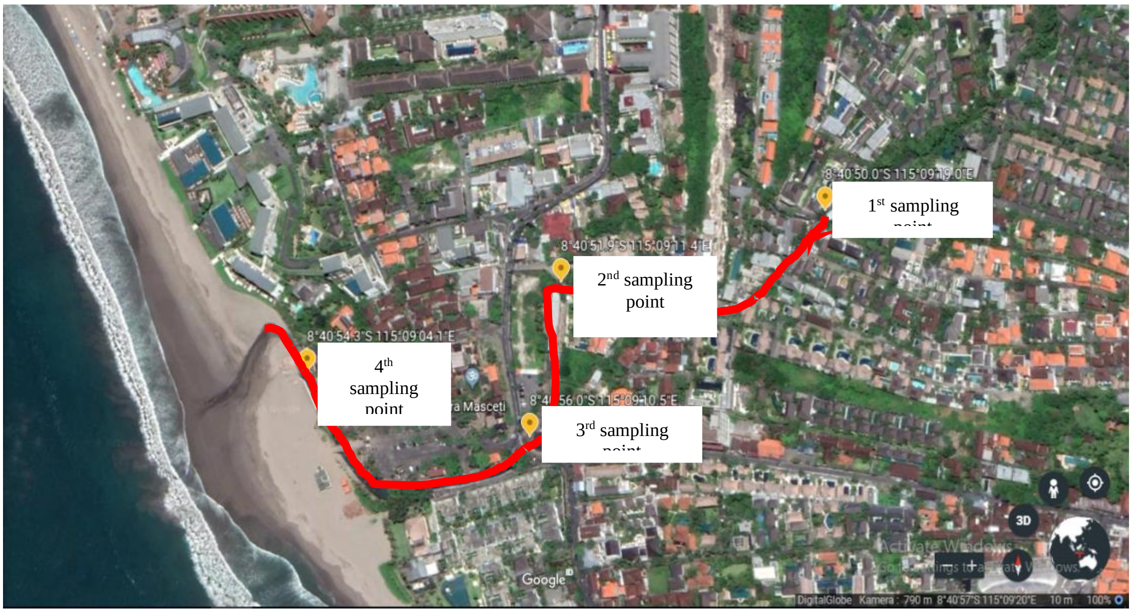

Figure 1 Sampling location along the river and estuary around Petitenget Temple

Table 1 Sampling point location

Sampling Point	Coordinate location
I	8°40'50.00"S - 115° 9'18.99"E
II	8°40'51.94"S - 115° 9'11.44"E
III	8°40'56.04"S - 115° 9'10.51"E
IV	8°40'54.28"S - 115° 9'4.13"E

The first sample was taken on March, 11th 2019, the second was on March 20th, 2019 and the last samples were taken on March 29th, 2019. There were some pollution sources have been identified along with the location, such as hotels, restaurant, service facilities, and settlement area. The samples were taken from each sampling point and delivered to the laboratory for further analysis. There were eleven parameters measured in this study that were divided into two categories: physical and chemical parameters.

Physical Parameters

The physical parameters that were measured in this study were temperature, pH, turbidity, and suspended solid. The temperature and pH were measured in situ by thermometer and pH meter respectively. Meanwhile, two others were using gravimetric method, which is the samples were vapored in 105^0 C of temperature then scaled to define the solid content of the water samples.

Chemical Parameters

There were seven parameters that were measured in this study to determine the chemical characteristic of the water samples. They have dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), nitrogen in form of ammonia, phosphate in form of orthophosphate, iron (Fe), and lead (Pb). All of these parameters were measured in the laboratory by following the standard method by APHA.

Water Quality Regulation

The results of water quality analysis were compared to the regional regulation of water quality threshold. The regulation that was used in this study was Bali's Governor Regulation Number 16/2016 about Environment Quality Threshold and Environmental Deterioration Criteria. It covers the wastewater quality that has been discharged by the sources, such as households, industrials, commercials, and any other sectors. Besides, it shows the water classification according to the water quality itself into four classes.

According to Government Regulation of the Republic of Indonesia Number 82/2001 about Water Quality Management and Water Pollution Control, the four classes of water characteristic determine the utilization of each water class as follows:

Table 2 Water classification

Class	Utilization
Class I	The water quality that belong to this class is used to water drinking resource
Class II	This water class is used to water recreational purposes, aquaculture, fish breeding, livestock, farming, and any similar activities
Class III	This water class is used to aquaculture, fish breeding, irrigation, farming, and any similar activities
Class IV	This water class is mostly used to irrigation and agricultural purposes

RESULTS AND DISCUSSION

All samples were analyzed in the laboratory and were using the Bali's Governor Regulation Number 16/2016 about Environment Quality Threshold and Environmental Deterioration Criteria as a comparison. In general, it is shown that a similar trend of the value for each parameter. The results of parameter measurement are presented in table 3 below.

According to the water quality classification, the characteristic of water in estuary Petitenget Temple belongs to Class II and III. It is aligned to the land utilization around Petitenget Temple is the tourism area with recreational attraction and also beach area.

Table 3 Physicochemical characteristic of the water sample from Petitenget Temple

Parameter	Unit	Sampling point			
		I	II	III	IV
Physical					
Suspended solid	mg/L	8.00	11.67	10.00	11.00
Temperature	^{o}C	27.33	27.33	27.50	28.67
Turbidity	NTU	11.83	10.77	10.07	10.53
Chemical					
pH	-	6.50	6.97	10.00	7.27
Dissolved oxygen (DO)	mg/L	6.16	6.60	27.50	5.63
Chemical oxygen demand (COD)	mg/L	28.66	28.49	10.07	56.62
Biological oxygen demand (BOD)	mg/L	13.74	12.85	0.00	24.93
Iron (Fe)	mg/L	0.05	0.34	7.03	0.23
Phosphate (P)	mg/L	0.35	0.50	6.48	0.66
Lead (Pb)	mg/L	0	0	59.27	0
Ammonia	mg/L	0.48	0.63	25.77	1.30

Source: Laboratory analysis

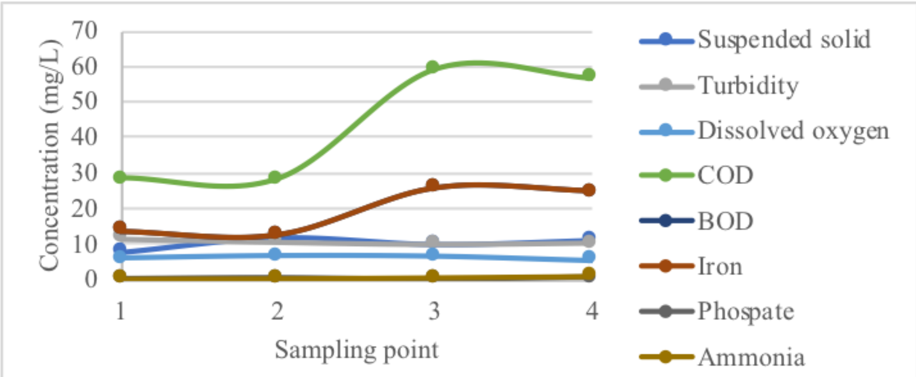

Figure 2 Concentration trend of physicochemical parameters along the sampling points

Suspended Solid

Suspended solid represents the amount of solid content in the water sample. Suspended solid potentially increase the sedimentation in the water body and promote the depletion of oxygen. It is essential for controlling the treatment process and compliance with effluent regulations (Hudson, 2010). The result showed that the concentration of solid was in the range of 7 – 18 mg/L with an average 11 mg/L in the 4th sampling point or in the downstream. Meanwhile, in the 2nd sampling point was 8 mg/L, the 3rd sampling point was 11,67 mg/L as the highest and in the upstream was 8 mg/L and also the lowest concentration.

Suspended solid plays an important role as a medium of any heterogenic chemical reaction. It also promotes sedimentation in the water body. The higher amount of suspended solid possibly interferes with the sunlight penetration into the water. It completely bothers the photosynthetic process for the aquatic plant, algae, and phytoplankton. The gradient accumulation of suspended solid is formed by waste discharge and resuspension due to the continuous stone erosion (Permana, E. and Triyati, A. Nontji, 1990).

Some sources of solid particulate in the water body, such as solid erosion, sludge generated from aluminum oxide industry, coal refinery wastewater, sand refinery, or similar industries (Connell, G. J. Miller, 1995).

Temperature and pH

The temperature of the river water in Petitenget Temple area was in the range of 27^0C – 29^0C. In general, the water temperature is in the range of 28^0C – 31^0C (Nontji, 2005). The lowest temperature was found in the upstream area, meanwhile, the highest one shown by the downstream area. It might indicate that the upstream has less input that impacts the temperature rather than the downstream.

Temperature is one of the important factors in the water body, especially for aquatic life. It supports the metabolism activities and the diversity of aquatic organisms (Nontji, 2005). This factor is influenced by the season, air circulation, climate, latitude, and the depth of the water body. The increase of temperature is causing the rise of organic decomposition by the microorganism (Effendi, 2003). Also, it leads the stratification in the water body and has a role in dissolved oxygen circulation (Kusumaningtyas et al., 2014).

pH represents the acidity of an element that shown by the concentration of hydrogen ions. It is one of parameters that used to control the water quality balance (Simanjuntak, 2009). The pH value affects the phytoplankton community and productivity of aquatic life.

The pH measurement in this study showed that it was in the range of 6,2-7,3. In the upstream, the average temperature was 6,5, meanwhile, the sampling point 2 and 3 was 6,79 and 7,03, respectively. The highest temperature in this study was shown by the downstream area that was 7,27.

Overall, these values were in the range of pH threshold for Class II, which is 6-9.

Turbidity

The turbidity in this study has been measured as total dissolved solids (TDS). The value of TDS represents the sediment and turbidity level in the water. The turbidity of water in the estuary Petitenget Temple was measured in the range of 9,2-12,5 NTU. The highest turbidity was found in the upstream while the lowest was in the downstream. The water in the estuary was shown brownish color because of the sediments.

Chemical Oxygen Demand (COD)

COD is a number of oxygens that are consumed by oxidizable matter (a microorganism or chemical processes) in the wastewater (Islam *et al.*, 2014). The COD will always be higher than the BOD because the COD represents the substances that are both chemically and biologically oxidized. The ratio of COD:BOD figures the proportion of organic material that is exists in water. Some polysaccharides, such as cellulose, can only be degraded anaerobically, so they will not be involved in the BOD (Akpor and Muchie, 2011). COD is more resistant to the treatment process and may accumulate include humid residues, detergents, phenols, cyanide, residual hormones, pharmaceuticals, and pesticides (Hudson, 2010). High organic matter can lead the high oxygen consumption by aerobic bacteria and competing with the other aquatic organism.

The laboratory analysis for COD is shown that the COD in the estuary of Petitenget Temple was 22,68-61,50 mg/L. This value is out of the COD threshold which is 25 mg/L for Class II categories. The highest COD concentration was found in the downstream area. It determined that there was more discharge accumulation that increases the organic matter in the water body.

Biological Oxygen Demand (BOD)

BOD is the amount of biodegradable organic matter in the water body. BOD usually indicates as 5 days oxidation of biodegradable organic matter at 20^0C used by a microorganism. BOD might possibly create oxygen depletion in the water body and lead to nuisance odor and fish kills. BOD is one of the important factors in determining water pollution. The higher of BOD number, the higher the organic matter is contained in the water.

The BOD in the estuary of Petitenget Temple was in the range of 11,42 – 26,74 mg/L. The lowest BOD was found in the upstream and 2^{nd} sampling point, while the 2 highest were found in the 3^{rd} sampling point and the downstream with 25,77 mg/L and 24,93 mg/L, respectively. Unfortunately, those values were significantly out of the BOD threshold which is 3 mg/L for Class II. Even for Class IV, the BOD threshold is 12 mg/L. It means that the water in the estuary area was polluted and urgently need any purification process. According to Salmin (2005), the condition of water in estuary Petitenget Temple was in the high level of pollution (BOD> 20 mg/L).

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the total number of oxygen molecules that are dissolved or stored in the water. The DO is importantly needed by the most aquatic life for respiration, metabolism, growth, and reproduction. Besides, it is also used to oxidize the organic matter that is contained in the water (Hutabarat dan Evans, 1985).

The DO measurement in this study resulted in the range of 5,44-6,85 mg/L. The average of DO concentration along the sampling point 1-4 was 6,16 mg/L, 6,60 mg/L, 6,48 mg/L, and 5,63 mg/L, respectively. The dropped DO in the downstream area shown that the rising of organic matter in the area. It might be caused by the discharge from any sources.

Nitrogen and Phosphate

Nitrogen and Phosphate are belonging to the nutrient element that exists in the water body and plays an important role in plant growth. Nutrient concentration is also important in determining water characteristics and water pollution. High nutrient content increases the risk of eutrophication in a water body and oxygen depletion. The concentration of nutrients should be reduced to a level protective of the receiving stream (Shon *et al.,* 2007).

Nitrogen sources in domestic wastewater are food waste, soap, and fertilizer. The incomplete nitrogen cycle, ammonia is oxidized to nitrate, creating an oxygen demand and low dissolved oxygen in surface waters. Nitrogen in the form of ammonia is toxic to fish and exerts an oxygen demand for receiving water by nitrifiers (Bonnin *et al.*, 2008; Akpor and Muchie, 2011). Phosphate appears in the water body as orthophosphate, polyphosphate, and organically bound phosphorus. The last two components counted usually for up to 70% of the influent phosphate Microbes utilize phosphorus during cell synthesis and energy transport (Kladitis *et al.*, 1999; Alarest and Sartika, 1987; Widiadmoko, 2013). Phosphate pollution comes up from the use of fertilizer in agriculture.

Nitrogen in form of ammonia and phosphate in form of orthophosphate were measured in this study. The results showed that the concentration of ammonia was in the range of 0,45-1,35 mg/L. The highest ammonia concentration was found in the downstream area with 1,30 mg/L and the lowest was in the upstream. It described that along the way to the downstream area, there might be waste discharged and contained nitrogen compounds due to the lack of treatment facilities. Meanwhile, the phosphate analysis showed that the phosphate concentration was in the range of 0,20 - 0,68 mg/L. The average of phosphate concentration from the upstream to the downstream was 0,35 mg/L, 0,50 mg/L, 0,23 mg/L, 0,66 mg/L, respectively. Some of these numbers were higher than the phosphate threshold on the Class II categories. In this case, it might raise the risk of eutrophication. According to Anhwange (2012), the maximum of phosphate concentration is 0,1 mg/L.

Iron (Fe) and Lead (Pb)

Iron is an essential element that needed by the organism in certain amount. The high number of irons in the water is potentially causing toxication, arthritis, cancer, diabetic, diarrhea, hepatitis, and insomnia (Parulian, 2009). The concentration of iron in the sampling points (1-4) were found, 0,05 mg/L, 0,34 mg/L, 0,22 mg/L, 0,23 mg/L, respectively. The range of iron concentration was found 0,04 – 0,87 mg/L. Meanwhile, there was no lead detected in all water samples.

Conclusion

Based on the discussion, the physicochemical characteristic of water in the estuary of Petitenget Temple belonged between Class II and III. It determined that physical parameters were under Class II categories while other chemical parameters were mostly higher. This water class is used to aquaculture, fish breeding, irrigation, farming, and any similar activities. According to these results, the water along the estuary of Petitenget Temple was polluted and a treatment approach is urgently needed.

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