EVALUATION OF WASTEWATER TREATMENT IN NUSA DUA TOURISM AREA AND THEIR CHALLENGES TO ALGAE BLOOM

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ABSTRACT

The wastewater treatment plant (WWTP) in the Nusa Dua area has implemented a stabilization pond to reduce organic matter and nutrients. Because it has been operating since 1980, it is necessary to evaluate the existing conditions. The aim of this study was to determine the percentage of organic and nutrient reduction from the WWTP system. Organic removal in the form of BOD and COD parameters were 71.84% and 75.11%, respectively. Meanwhile, nutrient parameters in the form of NH3-N, TN, and TP have a percentage of 83.64%; 59.41%, and -375.81%, respectively. TP is the only parameter that has increased, causing a problem which is caused by the explosion of algae population in the reservoir. TP allowance should be a concern in choosing advanced treatment.

Key word: wastewater; organic; nutrient; alge; reservoir; treatment.

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INTRODUCTION

Nusa Dua is an area in Bali with less productive land conditions, but its location is very strategic because it is close to the airport and the beach. Nusa Dua is an area with a low population density, so it is relatively easy to carry out regional development planning. Therefore, the government established a masterplan for a tourism area centered in Nusa Dua so that tourism activities do not interfere with the comfort of the Balinese natives and that the resulting wastes are easier to collect for management. One of the efforts made is wastewater management. All wastewater generated in the Nusa Dua area, including hotels, restaurants, and swimming pools, will be accommodated in a collection pit in each building. Then the wastewater will be flowed by gravity to the nearest Lift Pump Station (LPS) and pumped to the Wastewater Treatment Plant for processing.

The wastewater treatment system in Nusa Dua Tourism Area using a waste stabilization pond (Darwin et al., 2019). A stabilization pond treats wastewater with natural processes because it utilizes microorganisms' metabolic processes to decompose pollutants in wastewater. Stabilization ponds are widely applied in tropical and developing countries because they have an appropriate temperature and do not require high operational and maintenance costs. The treated wastewater must meet the quality standards stipulated by the Governor of Bali Regulation Number 16 of 2016. The quality of treated water must comply with the class III water quality standard, designated as irrigation water, fish farming, and livestock. This study was conducted to determine the efficiency of organic and nutrient parameters in the Nusa Dua Tourism Area's wastewater treatment system. An analysis of the existing conditions of waste in wastewater treatment is also carried out and its problems.

RESEARCH METHODS

This research was conducted using field observations and interviews. Field observations were made to determine the wastewater treatment system carried out in the study location. Besides, secondary data collection was also carried out to determine the quantity of wastewater and the quality of existing wastewater. A literature study was also conducted to compare the existing conditions with ideal conditions in wastewater treatment.

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RESULT AND DISCUSSION

The WWTP was built in 1976 with a capacity of 10,000 m^3/day and had been operating since 1980. The systems applied to treat wastewater are a stabilization pond and a Dissolved Air Flotation (DAF) unit with a total area of about 15 Ha. The yield of treated water is distributed as irrigation water for watering plants worldwide, with the highest sales in the dry season, ranging from 4,500 m^3/day. Wastewater generated from the Nusa Dua area comes from domestic activities such as waste of toilets, washbasins, laundry, swimming pools, and kitchens. The wastewater then passes through the grease trap and is collected in a collection pit before being pumped into the main sewage pipeline. The main sewage pipe will flow gravitationally to the nearest lift pump station (LPS) and pumped to the lagoon, approximately 2 km north of the area.

The treatment system applied is a Waste Stabilization Pond. Figure 1 shows the stabilization pool scheme, consisting of 3 cells: cells IA and IB cells, cells IIA and IIB, and cells III. Cell I consists of two parts, namely cells IA and cell IIB, separated by a fiberglass layer at the top, which functions as an oil trap. Oil and other debris that floats will be cleaned by officers manually. After passing through cell I, the water will flow to cell IIA.
Cell II consists of two parts, namely IIA cells and IIB cells. There is an oxidation process in IIA and IIb cells and suspended solids' formation due to heterotrophic algae and bacteria's metabolism. IIB cells have a larger area than IIA cells so that the oxidation process will be more optimal. Tilapia and tilapia were placed on IIA and IIB cells as biological indicators. Cell III functions to neutralize wastewater before it is distributed to DAF. The residence time in this stabilization pond is 33 days, with a minimum residence time requirement of 28 days.

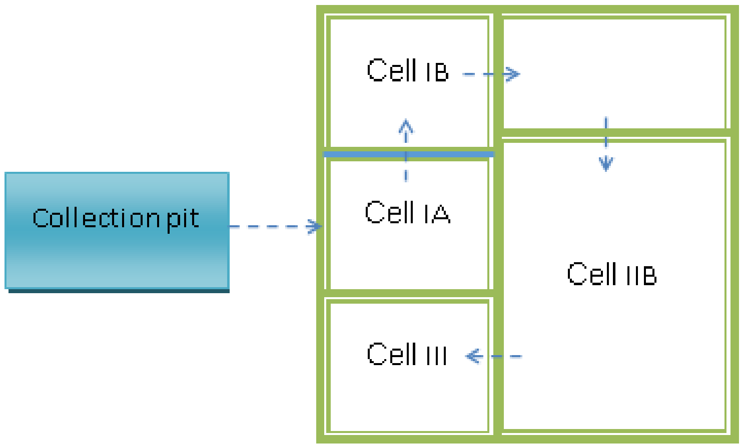

Figure 1. Existing waste water treatment system with WSP

The wastewater treatment system ends in cell III of the stabilization pond. According to the Bali Governor Regulation Number 16 of 2016, the water is treated in the Dissolved Air Flotation (DAF) unit to improve water quality to be used as irrigation water. Water is mixed with chemicals such as aluminum sulfate, cationic polymer, and NaOCl, which act as a coagulant and flocculant so that algae and other small solids can clot. Clumped solids can be easily lifted by the bubbles generated on the DAF unit so that they float. The solid is then pushed with a scrapper and separated by a weir and collected in a sludge tank. The water that comes out of the DAF unit will enter the reservoir and ground tank, ready to be distributed to consumers by installing irrigation water pipes as water for watering plants in the Nusa Dua tourism area.

The organic content parameters used were BOD and COD. Table 1 shows the average removal of BOD and COD in the stabilization pond system. Overall, the organic allowance in the stabilization pond has a reasonably good percentage. The funding for BOD was about 71.84% and for COD was around 75.11%.

Table 1. The Efficiency Removal of Organic Parameters in the WSP System

Parameters	Concentration (mg/L)		Removal Efficiency (%)
	Influent	Effluent	
BOD	72.88	20.53	71.84
COD	185.85	46.25	75.11

The nutrient parameters measured included free NH_3-N, total nitrogen (TN), and total phosphate (TP). Table 2 shows the average nutrient removal in the WSP system. The nutrient removal in the stabilization ponds shows a reasonably high figure for nitrogen. The percentage of free NH_3-N removal was 83.64%, followed by a total nitrogen removal of 59.41%. However, total phosphate value increased to 375.81%. High levels of nutrients in wastewater can cause an explosion in the algae population so that proper handling of nutrient and algal parameters is needed in WWTP (Sofiyah & Suryawan, 2021; Afifah et al., 2020; Fadhilah et al., 2020; Ariesyady et al., 2016).

Table 2. The Efficiency Removal of Nutrient Parameters in the WSP System

Parameters	Concentration (mg/L)		Removal Efficiency (%)
	Influent	Effluent	
NH_3-N	18.15	2.97	83.64
TN	19.83	8.05	59.41
TP	0.51	2.41	-375,81

The value of organic content in anaerobic ponds has an upward trend. This indicates that the processing that occurs in the anaerobic pond is not running perfectly. Meiring et al. (1968) states that the design criteria for volumetric BOD loading are 100-400 g/m^3.day, while the US Environmental Protection Agency (EPA) design criteria Volumetric BOD loading in existing conditions is 7 g/m^3.day. Volumetric BOD loading smaller than the design criteria can cause anoxic reactions in anaerobic ponds (Khatri, 2009). As a result, the processing that occurs in anaerobic ponds cannot run properly. In a facultative pond, the presence of algae will break down the organic content contained in wastewater. The value of the organic content in the facultative pond decreased by 74%. The value of nutrients such as nitrogen and phosphate also reduced, indicating algal activity in the facultative pond. Maturation ponds usually only have a small organic removal capacity (Khatri, 2009). The organic allowance in the maturation pond has shown enough, with the average organic funding for BOD and COD is 53% and 28%.

In anaerobic ponds, free ammonia removal and TN rates were not much different, namely 25.2% and 20.4%. Meanwhile, TP removal has a negative value, which means that the total amount of phosphate in the anaerobic pond increases. Research shown by Khatri (2009) shows that low pH conditions can cause an increase in the TP parameter. In the facultative pond, the nutrient removal rate was better than in the anaerobic pond due to algae's presence. In their life cycle, algae absorb nutrients to carry out their metabolism. The removal of NH_3-N, TN, and TP in this pond was 85.85%, 49.01%, and 78.62%, respectively. In the maturation pond, the nutrient allowance does not have too large a number. Average nutrient allowances for NH_3-N, TN, and TP were 23.5%, 27.8%, and 53.4%. The removal of nutrients in wastewater is highly dependent on the parameters of dissolved oxygen and the titration of sunlight if the microorganisms used are algae (Afifah et al., 2019, Suryawan et al., 2019).

Based on observations and interviews, algae only grew in IB cell pools, IIA cells, and reservoirs. According to its characteristics, algae are supposed to grow in IIA cells. IIA cells are facultative ponds, which have aerobic and anaerobic areas. An aerobic area is an area that has a lot of oxygen content. The oxygen content is produced by the photosynthesis process carried out by algae. Therefore, the observation of algae in IIA cells was not carried out.
At the edge of the IB cells pool, the water's surface is covered with a duckweed plant. Duckweed is a plant similar to algae. Duckweed is a small, floating, green plant. Duckweed belongs to the

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Lemnaceae family, which is an aquatic plant. This plant causes the pond to be anaerobic because it consumes a lot of dissolved oxygen. Duckweed is very effective at absorbing carbon, nitrogen, phosphorus, and pathogenic bacteria. However, duckweed does not carry out a metabolic process that uses and processes these substances but only holds them back. When duckweed dies, the substances that have been retained will return to the wastewater (Pocock, 2013). Therefore, duckweed must be cleaned before dying to remove any substances that have stuck to the duckweed. The duckweed located on the edge of the pond also makes it easier for officers to clean duckweed. Figure 2 shows the algae growing in the reservoir. Algae that grow are green and only appear during the day. In the morning and evening, the algae do not appear to the surface, and the water looks clear. Chlorophyta class algae dominate the algae that appear in the reservoir because they have a green color. Based on the interviews with local officers, it was found that there were fish in the reservoir pond that accidentally appeared in the pond in the reservoir pond. Based on visual observations, green organisms that grow in reservoir pools resemble green algae (*Chlorophyta*), which are not toxic to living things, and *Cyanobacteria* bacteria are poisonous to living things. Based on Pratiwi et al., (2019) research in the reservoir pool, the most common type of green algae is the *Sphaerocystis schroeteri* species. This species is usually used as fish food and indicates that it is algae growing in the reservoir.

Algae that enter the reservoir come from the stabilization pond. Algae can be prevented and minimized by positioning the outlet pipe in the stabilization pond. The facultative pond (cell II) outlet pipe must be placed at a certain depth to avoid the transfer of algae from the facultative pond to the next pond. Another alternative that can be done is to install a weir (trap) before the outlet pipe to trap and prevent algae from entering the outlet pipe (Mara & Pearson, 1998).

One of the factors that support algae growth is the availability of sunlight. The number of algae can be reduced significantly by creating a dark zone that inhibits algae growth (Chen et al., 2009). This method is called light shading. Chen et al. (2009) researched a lake in China. The research was conducted with the lake into three parts. In the first and second sections, the water's surface is covered with a black cloth with a light-shading ratio of 99%. Whereas in the third part, it is used as a control variable. The water temperature at the time of the study was 31 °, not much different from the temperature at 30°C.

Research using light shading can reduce the amount of algal biomass by 80%. The COD organic value concentration can also be reduced by 94.5% from 30.9 mg/L to 1.7 mg/L. However, the light shading method that inhibits the photosynthesis process by algae can result in a lack of dissolved oxygen and a decrease in pH. Therefore, aeration is needed to cover the lack of dissolved oxygen.

The light-shading method's obstacle is that it requires a cloth large enough to cover a large pond. Therefore, reducing algae using the light-shading method can be made by covering the first reservoir water's surface with a dark black cloth with a light shading ratio of 99%. The water will remain for several days in the first reservoir. Then the water will flow into the next reservoir pool. Algae that have died will fill the water layer in the first reservoir pool. Some of the algae that have died will float on the water's surface and be collected by installing a weir (barrier) on the top of the water surface in the first reservoir. Some dead algae will float in the water and be collected by installing a net on the first reservoir pool's outlet pipe.

Figure 2. The existing condition of algae abundance in the WWTP system

CONCLUSION

Organic removal in the form of BOD and COD parameters was 71.84% and 75.11%, respectively, and nutrient parameters in the form of NH3-N, TN, and TP have 83.64%; 59.41%, and -375.81%, respectively. Wastewater treatment design is needed to reduce the TP concentration following stakeholder needs to make it better. Research on the use of algae is also required to obtain the sustainability of WWTP products. The use of algae can use refuse-derived fuel (RDF) or conversion to biodiesel.

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