THE EFFECT OF SPIRULINA SP. POPULATION DENSITIES TOWARD REDUCTION OF BOD5 AND COD OF BEEF CATTLE SLURRY

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Abstract

Spirulina is blue-green microalgae grows abundantly on organic matters rich water bodies. In normal condition the algae uses up the organic matters effectively and improves the quality of water through decreasing of biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD); while in overpopulated condition the algae may worsens water quality. This characteristic has shown that the algae can be used to improve water quality up to certain population density. However, until now this algae has not been used to improve the quality of liquid waste particularly come from beef cattle production. Therefore, the objective of study was to determine the effect of Spirulina population densities toward the reduction of BOD_5 and COD of beef cattle slurry. This study was done experimentally based on Completely Randomized Design with four treatments of population density in term of dilution factors, viz.D1 = 10^0, D2 = 10^{-1}, D3=10^{-2} and D4= 10^{-3}. Each treatment was in four replicates. The effect of the treatments were analyzed by ANOVA, and the effect among treatments were differentiated by mean of Duncan's Multiple Range Test. The result shows that Spirulina reached its maximum growth rates mostly on the 8th day. The treatments significantly ($P< 0.5$) influenced the biomass of the blue-green algae. The 10^{-2} dilution factor (D3) gave the highest biomas production, that is 0.243 g/L. The result also shows that the treatments significantly ($P< 0.05$) gave different effect toward BOD_5 and COD of beef cattle slurry. The 10^{-2} dilution factor also provided the highest reduction rate of BOD_5 and COD, i.e., 85.74% and 75.92% respectively. This findings suggest that Spirulina can be used to treat beef cattle liquid waste, in addition to obtain its biomass production.

Key words: *beef cattle, BOD5 and COD, liquid waste, Spirulina.*

INTRODUCTION

Demand for meat increases continuously with the increase of population and quality of life. This phenomena positively support the growth of local beef cattle husbandry in Indonesia. Unfortunately, the animal husbandry growth also provides some negative impacts to the environment such as water pollution due to unwise disposal of feces, urine of beef cattle either in the solid or liquid form (slurry). Beef cattle feces contains high amount of organic matter principally protein, carbohydrate and fats that represented by biochemical oxygen demand 5 days ($BOD5_5$) and chemical oxygen demand (COD). The oxygen demand can be up to 31,000 mg/L and 268,000 mg/L respectively (Cramer, et al., 1971 in Merkel, 1981). Those amounts of oxygen are required to stabilized the waste biologically and chemically. Therefore, if untreated waste water with high BOD_5 and COD discharged into aquatic environment, the waste may deplete the natural oxygen source of water and develop septic conditions (Tchobanoglous, Burton and Stensel, 2004). This can lead to shortage the aquatic organisms life.

On the other hand, there are alot of aquatic organisms that naturally can grow in the polluted water up to certain condition. One of them is *Spirullina sp*. (*Arthospira sp*.), blue-green microalgae that had been proved having an ability to grow in rich organic matter liquid wastes (Venkataraman, 1983 in Sukmaningrum et al., 1997). This microalgae use nutrient in the liquid wastes to produce its biomass. Consequently, it reduce BOD_5 and COD of wastes. The reduction may up to 95% and 80% respectively (Doke, et al., 2004). Besides, *Spirulina sp.* were also known as a supperfood due its high content of protein (65-70%), polyunsaturated fatty acids, vitamins and minerals (Hongsthong and Bunnag, 2009). Therefore, growing *Spirulina sp.* in beef cattle slurry may solve water pollution problem as well as produce biomass of the microalgae.

However, until nowadays there are no information concerning the use of *Spirulina sp*. to reduce the BOD_5 and COD of beef cattle slurry as well as to obtain its biomass.

MATERIALS AND METHODS

Spirulina sp. used in this study was a pure culture from the Institute of Ecology, while the beef slurry was obtained from the UPPL, Faculty of Animal Husbandry, Universitas Padjadjaran, Indonesia. The experiment was caried out based on Completely Randomized Design with four treatments of population density in term of dilution factors, viz. D1 = 10^0 dilution, D2 = 10^{-1} dilution, D3=10^{-2} dilution and D4 = 10^{-3} dilution. Each treatment was performed in four replicates. Before being diluted, the slurry was filtered to remove the coarse components. After that, every treated slurry (1000 ml) was put into 1500 ml bottle, where 100 unit/ml of *Spirulina sp.* was added afterward. All slurries were aerated and placed on a bench under 40 watt tube lamp. Variables measured in this experiment were temperature, pH, as well as BOD_5 and COD. The effect of the treatments were analyzed by ANOVA, and the effect among treatments were differentiated by mean of Duncan′s Multiple Range Test.

RESULTS AND DISCUSSIONS

The temperature of the slurries during the experiment was relatively constant of 27°C, which was in the range of optimal temperature for *Spirulina sp*, namely 20 – 30°C. The pH of the slurries are varies depend on the dilution factors. The highest pH was found in 10^0 dilution (8.8), followed by 10^{-1} dilution (8.0), 10^{-2} dilution (7.8) and 10^{-3} dilution (7.5). Those pH were also in the range of optimum pH for *Spirulina sp*., that is 7-9 (Couteau, 1996). Furthermore, Haryati (2008) reported that pH lower than 7 and higher than 10.5 will alter the growth of microalgae.

BOD and COD was used to measure the oxygen equivalent of the organic material in waste water that can be oxidized biochemically and chemically. Usually, the BOD/ COD ratio of waste water were 0.3 – 0.8. If the ratio is equal to 0.5 or greater, the waste can be treated easily by biological means, and if lower than 0.3 the waste may contain toxic substances or acclimated microorganisms may required in its stabilization. (Tchobanoglous, Burton and Stensel, 2004). The result shows that the BOD/COD ratios are in the range of 0.37 – 0.68, so that cattle slurry can be treated using *Spirulina sp.* without acclimation to stabilize the waste.

The growth of *Spirulina sp*. affected by dilution factors (Figure 1).

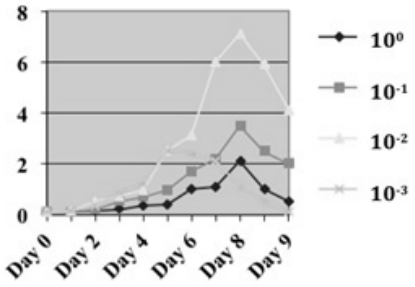

Figure 1. Growth of Spirulina sp. in beef catlle slurries (104 sel/ml)

Figure 1 showed that the highest maximum growth of the microalgae was resulted by 10^{-2} dilution (7.1 x 10^4 sel/ml), and consecutively followed by 10^{-1} dilution (3.5 x 10^4 sel/ml) and 10^0 dilution (2.1x10^4 sel/ml) and 10^{-3} dilution (1.1 x 10^4 sel/ml). In the same order, those dilution produce Spirulina sp. biomas of 0.243 g/L, 0.141 g/L, 0.081 g/L and 0.25 g/L. Slurry with 10^{-1} dilution and 10^0 dilution are slightly more alkaline than 10^{-2} dilution. This increasing pH may reduce CO_2 concentration--the main nutrien for the microalgae in the medium (Jordan, 2001). Therefore, the growth of *Spirulina* in both slurries become slower. While slurry with 10^{-3} dilution may contain less CO_2 due to high dilution. In this case, CO_2 had been used up in shorter period.

The results of BOD_5 measurement are presented on Figure 2. BOD_5 of the slurries are varying by dilutions. Beef cattle slurry with 10^0 dilution indicates the highest BOD_5 (1534.37 mg/L), followed by 10^{-1} dilution (924.94 mg/L), 10^{-2} dilution (595.86 mg/L), and 10^{-3} dilution (223.25mg/L).

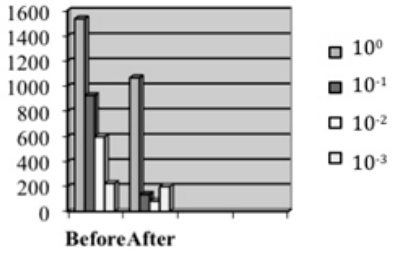

Figure 2. BOD5 of Beef Cattle Slurries differenciated between dilutions

The result of ANOVA indicates that dilutions significantly ($P< 0.05$) influence the reductions rate of BOD_5 and COD in the slurry. The results of Duncan's Multiple Range Test show that the 10^{-2} dilution significantly ($P< 0.05$) reduce BOD_5 of the slurry (85.73%) higher than 10^{-1} dilution (85.33%), 10^{0} dilution (30,56%) and 10^{-3} dilution (10.81%) as presented on Table 1.

Table 1. Reduction of BOD55 content of Beef Cattle Slurry by Spirulina sp.

Treatment	BOD55 before (mg/L)	BOD55 after (mg/L)	Reduct-ion (%)	Signifi-cant 0.05
D1	1534.37	1065.41	30.56	c
D2	924.94	135.7	85.33	b
D3	595.86	84.96	85.74	a
D4	223.25	199.12	10.81	c

Slurry with 10^{0} dilution contains more total solid than the others. Bacteria in this slurry consumed and converted organic matter into bacterial biomass and CO_2. First, the activities of bacteria increased CO_2 concentration which leads to increase the biomass productivity, and then decreased the slurry pH resulting in negative impact upon microalgal physiology. As pH decreased, CO_2 become limited and the growth of microalgae were also altered (Rifka Aisyah, 2012). Therefore, the reduction rate of BOD_5 in no dilution was lower than in other dilutions. While in 10^{-2} dilution which has lower pH and lower total solid as well as bacteria, *Spirulina sp* used the organic matter sparingly with bacteria, so that it grows faster and reach maximum growth higher than in other dilutions. Hence, the BOD_5 reduction was also higher.

BOD_5 of beef slurry resulted from 10^{-2} dilution (84.96 mg/L) lower than its standard according to the Decree of Ministry of Environment, Republic of Indonesia No. 51/MENLH/10/ 1995, that is 100 mg/L. It means that in term of BOD_5 contents *Spirulina sp*. can be use to improve the quality of beef cattle slurry.

The results of COD measurement are presented on Figure 3. Slurry with 10^{0} dilution has the highest COD (3568.3 mg/L), and then 10^{-1} dilution (1465.75 mg/L), 10^{-2} dilution (878.95 mg/L) and 10^{-3} dilution (598.18 mg/L). The result of ANOVA proves that the dilutions significantly influence COD of beef cattle slurry.

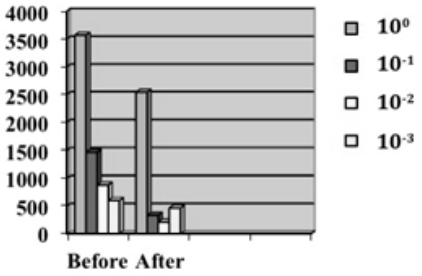

Figure 3. COD contents of Beef Cattle Slurries differenciated between dilutions

Furthermore, Duncan's Multiple Range Test results show that 10^{-1} dilution provides the highest COD reduction (77.30%), which is not significantly ($P> 0.05$) different with 10^{-2} dilution (75.92 mg/L), but significantly ($P< 0.05$) higher than 10^{0} dilution and 10^{-3} dilution (Table 2).

COD and BOD are closely related, because COD measures non biodegradable matter as well as ultimate biodegradable organics (Burke, Singh and Theodore, 2005). Therefore, the reduction rate of COD caused by the dilutions are along with the BOD reductions. According to the Decree of the Ministry of Environment of Republic of Indonesia No. 15/MENLH/10/ 1995, COD of industrial effluent is not allowed to be more than 300 mg/L. Hence, in term of COD, *Spirulina sp*. can be used to improve the quality of beef cattle slurry.

Table 2. Reduction of COD content of Beef Cattle Slury by Spirulina sp.

Treatment	COD before (mg/L)	COD after (mg/L)	Reduct-ion (%)	Significant 0.05
D1	3568.3	2540.15	28.81	b
D2	1465.75	332.64	77.30	a
D3	878.95	211.68	75.92	a
D4	598.18	462.21	22.73	c

CONCLUSIONS

The quality of beef cattle slurry can be improved biologically using *Spirulina sp*. without any acclimation. The population density of *Spirulina sp.* in term of dilution that produced the highest reduction of BOD_5 and COD is 10^{-2} dilution, with the reduction rate of 85.74% and 75.92% respectively. The dilution also produce the highest *Spirulina sp.* biomass of 0.243 g/L.

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