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EFFECTIVITY OF LEMNA MINOR ON BOD REDUCTION IN LIQUID WASTE OF TOFU

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Abstract
Cibuntu tofu industry is one of the tofu liquid waste producers. Tofu liquid waste contains high organic compounds so that it is highly potential to pollute a waters. The main parameter that can indicate the occurrence of pollution by tofu liquid waste is BOD (Biological Oxygen Demand). Phytoremediation is an alternative in the treatment of liquid waste using water plants. Lemna minor has the ability to absorb pollutants directly in a waters. The method used in this research was experimental method with 4 treatments and 3 replications followed by observations of decreased BOD, daily growth rate and changes in fresh weight using statistical analysis. absorption ability of Lemna minor to decrease BOD concentration ranged from 0.86 mg / L - 2.56 mg / L. The highest reduction in BOD was in treatment C (Biomass Lemna minor 5 gr) of 2.56 mg / L while the lowest was in treatment D (Biomass Lemna minor 8 gr) of 0.86 mg / L. Treatment C is the best treatment in reducing the BOD concentration in tofu liquid waste.

Keywords: BOD, Phytoremediation, Lemna minor, Tofu Liquid Waste

INTRODUCTION

Liquid waste is one of the aquatic environmental problems that needs to be taken seriously considering the carrying capacity of nature to self purification the pollution burden is now increasingly heavy. If the liquid waste is sustainly accumulate on the surface, there will be a process of decomposition of organic material in the liquid waste so as to produce an unpleasant odor. It will disrupt the aesthetics and trigger the emergence of various germs caused by the growth of pathogenic bacteria (Endro *et* al. 2010).

According to Agnes (2013), liquid waste of tofu industry is one of the pollutants that can reduce environmental quality. Concentration of tofu liquid waste to NH_3 which can pollute the environment and is dangerous. The damage caused was higher than the recovery power, so that over time the environmental conditions would get even worse.

Cibuntu tofu industry is one of the tofu liquid waste producing industries in Bandung. Cibuntu tofu industry is located in Babakan Ciparay Sub-District, Bandung Kulon District, Bandung. Cibuntu tofu industry has been established since 1970 with 60 craftsmen. Waste generated from this industry is directly transfered to water bodies due to the absence of WWTP (Wastewater Treatment Plant). As a result, pollutants such as NH3 defile the waters which can disrupt the activity of living things (Anonymous 2011).

To overcome the adverse effects of tofu waste pollution, a method of management of waste is needed before it is discharged to water bodies so that it is less dangerous. Some technologies such as RBC (*Rotating Biological Contactor*) or by using biofilter can be used to handle tofu waste. These technologies have weaknesses, namely the cost is quite expensive, so we need another alternatives that can be used to handle tofu industry liquid waste at a low cost (Agnes 2013).

One alternative that can be used is by using the phytoremediation method. According to Juhaeti *et* al. (2009), phytoremediation is the use of plants to remove pollutants from contaminated soil or waters. Phytoremediation is easy to apply and can effectively convert liquid waste quality into valuable biomass (Mkandawire and Dudel 2007). One of the aquatic plants that can be used as a phytoremediator is *L. minor*.Ducks Weed (*L. minor*) is a small aquatic plant that lives free floating in freshwater and one of 13 species of the Lemna clan included in the Lemnaceae tribe (Hasan and Chakrabarti 2009). This plant species lives cosmopolitan in the tropics, especially in stagnant waters in areas with low to moderate altitude. According to Hasan (2009), lemna can be used for waste treatment because the growth rate is high and able to absorb directly contaminants such as NH_3. Based on this information L. minor has the ability to improve water quality. Therefore, the authors are interested in conducting research on the effectiveness of *L. minor*.

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METHODS

The study was conducted at the University of Padjadjaran Aquatic Resources Laboratory in August 2019. The material used in this study were the *L. Minor* as a test plant, tofu liquid waste, aquades, Phenol disulfonic acid, NH_4OH 10%, $SnCl_2$ reducing agent, NH4-molybdate solution, $MnSO_4$ 50% solution, O_2 reagent solution, concentrated H_2SO_4 solution and Na-thiosulfate solution. The tools used were Jerry 20L, Aquarium 18L, Camera, Analytical Scales, Aquarium 5 L, Duran Bottles, Winkler Bottles, Pipettes, DO Meters, pH meter, Thermometers, UV-Vis Spectrophotometers, Incubators, Burettes, Drop Pipes, Volume Pipettes, Ball pipette, measuring cup, beaker, Erlenmeyer, Funnel, Magnetic stirrer, Label paper, Filter paper and Stationery. The method used was an experimental method. There are 4 treatments with each treatment carried out 3 replications as follows.

1. Treatment A: 3 L of liquid waste after dilution without water plants.
2. Treatment B: 3 L of liquid waste after dilution plus 3.0 gr *L. minor*
3. Treatment C: 3 L of liquid waste after dilution plus 5.0 gr *L. minor*
4. Treatment D: 3 L of liquid waste after dilution plus 8.0 g *L. minor*

Research procedures include initial preparation and test samples. The parameters of this study are the reduction in BOD, changes in fresh weight, daily growth rate and water quality. Analysis of the data used was Analysis of Variance / Analysis of Variance (Anova), with F Test. The experimental design used was a completely randomized design (CRD). The F statistical test basically shows whether all independent variables included in the model have a joint influence on the dependent variable (Kuncoro 2003). Fhit <Ftab accept H0 if there is no relation between the two variables on the catch and Fhit> Ftab reject H0 if there is a relation between the two variables. If there is a difference between the treatment continued with the Duncan Test to determine the absorption of L. minor to decrease BOD in tofu liquid waste. Water quality data including temperature, pH, DO, Nitrate, Phosphate and BOD were analyzed in a comparative descriptive method.

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Result and Discussion

Decline in BOD

The reduction in BOD was calculated using the formula from Dwinanto (2009). During the study, each treatment experienced a significant decrease in BOD. The highest reduction in BOD was obtained in the C1 treatment which was 2.72 mg / L while the lowest BOD reduction was obtained in the D1 treatment by 0.32 mg / L. The decrease in BOD during the study can be seen in the following graph.

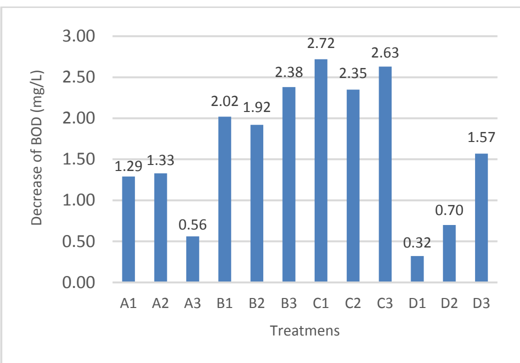

Figure 1. Decrease of BOD

Treatment A had a small BOD reduction value compared to other treatments. That was due to the absence of organisms that can decompose organic compound in tofu liquid waste. According to Husin (2003), the presence of organic compounds causes the liquid waste of tofu industry to contain high BOD, COD and TSS.

Treatment B, C and D have a large rate of decline due to *L. minor* as a phytoremediator can decompose organic matter. According to Datko et al. (1985), *L. minor* can absorb organic compounds directly and utilize them as amino acid ingredients that can be used in their growth and development.

Treatment	Average	Notation
A	-1,06	a
B	-2,11	b
C	-2,57	b
D	-0,86	a

Table 1. Average Decreased BOD

Result of statistical test showed that treatment A has significant difference with both treatment C and B but has unsignificant difference with treatment D.

Fresh Weight Change

Fresh weight changes were made to determine the difference between fresh weight at the beginning and end of the research. Changes in fresh weight are calculated using the formula from Juswardi (2010). Percentage changes in measured fresh weight during the research ranged from 43.33% -60.00%.

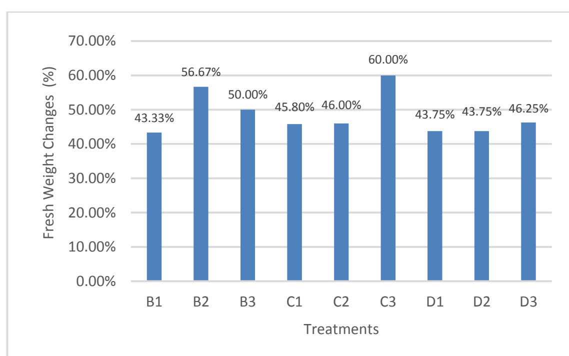

Figure 2. Fresh Weight Changes

Treatment B with the addition of *L.*

minor biomass of aquatic plants as much as 3.0 grams occurred an increase in fresh weight on average by 50% from the beginning to the end of the study. L. minor used in treatment B did not experience a significant death but increased instead. An increase in fresh weight was caused by the presence of light which plays an important role in the process of photosynthesis (Sudjadi 2005). Treatment C and D experienced a decrease in fresh weight at the end of the study. The decrease in fresh weight in treatments C and D was due to a high death rate of L. minor and a dense population (Akbar *et.* al 2011).

Treatment	Average	Notation
B	50	a
C	50,60	a
D	46,25	a

Table 2. Average reduction in fresh weight

Statistical test results showed that each treatment was not significantly different from the other treatments. Treatment D is the best treatment with a low percentage value. This showed that L. minor in treatment D can absorb organic compounds in tofu liquid waste well without inhibiting its growth rate (Hasan 2009).

Daily Growth Rate

Daily Growth Rate is an illustration of the increase in fresh weight during the study. The measured daily growth rate during the study ranged from 9% - 25%.

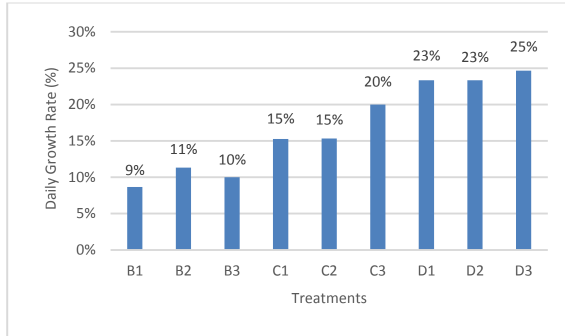

Figure 3. Daily Growth Rate

Based on the results of the study, the treatment B, C and D experienced an increase in the daily growth rate on day 5. According to Landesman *et*. al (2005), the growth and development of Lemna sp. at optimal conditions it could be doubled in two days. All treatments experienced growth marked by an increase in fresh weight. The presence of nutrients and the resistance of *L. minor* to tofu liquid waste causeed *L. minor* to experience growth and increase in fresh weight.

Day 10 on treatment B, C and D experienced a significant decrease in fresh weight. The color of *L. minor* leaves in all three treatments has started to turn yellowish and most of it had turned pale. In addition, the size of the plant gets smaller and the leaves fall out so that they accumulate underneath and settle. It was because the resistance of *L. minor* to pollutants decreases and inhibits its growth (Tanghu *et* al. 2011).

Treatment	Average	Notation
B	10,00	a
C	16,67	b
D	23,67	c

Tabel 3. Average Daily Growth Rate

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Statistical test results showed that each treatment was significantly different from the other treatments. Treatments C and D are the best treatment with a high percentage value. It showed that *L. minor* in treatments C and D utilize organic compounds in the waste so that they experienced growth and increase in fresh weight (Landesman *et.* al 2005).

Temperature

Temperature is one of the parameters in determining the quality of a waters. During the research temperature varies between 21,6^{0}C – 22,2^{0}C. The highest temperature range was in the D2 treatment at 22,2^{0}C while the lowest temperature was in the B3 treatment at 21,6^{0}C.

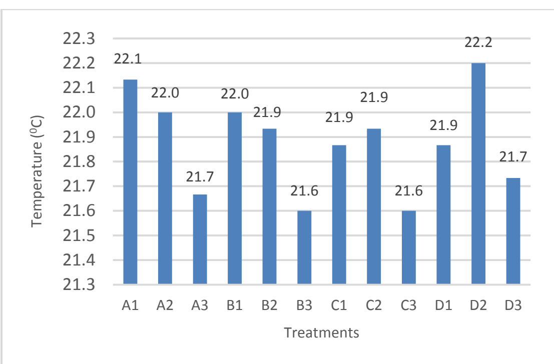

Figure 4. Temperature

Based on the graph above, *L. minor* in all treatments could grow at temperatures ranging from 21,6^{0}C – 22,2^{0}C, which means that the temperature in the research media was still within the tolerance range. Treatment A and B experienced a significant temperature drop from the beginning to the end of the study. Treatments C and D increased on the 10th day and then decreased on the 15th day. A decrease in temperature occurred almost every time the measurement eventhough not too significant. According to Leng *et*. al (1994), *L. minor* is able to grow well in temperatures of 6^{0}C - 33^{0}C. This statement is in accordance with the results of the study that in research media *L. minor* aquatic plants grow in a temperature range of 21,60^{0}C - 22,20^{0}C.

pH

The pH value of the measured tofu liquid waste varies from 4,86 – 7,58. The highest pH range was obtained in the C3 treatment while the lowest pH value was obtained in the A1 treatment.

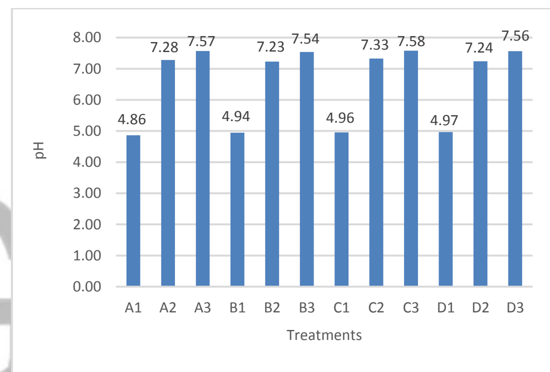

Figure 5. pH

The measured pH range on day 5 and day 10 for treatments A, B and C decreased while treatment D was increased. It was due to the decomposition of organic compounds, namely protein into alkaline amonia. Decomposition of organic compounds was is carried out by aerobic bacteria to produce NH_3. According to Alaerts *et* al. (1987) in Dhahiyat (1990), the results of oxidation from ammonification will form CO_2, H_2O and NH_3. The measured pH range on the 5th and 10th days on average did not eppropite the standards set for the liquid waste quality standard that is 6-9.

The measured pH of tofu liquid waste on the 15th day ranged from 7,54 –

7,58. The pH range in this observation was in accordance with the standards specified for the liquid waste quality standard in the Minister of Environment Regulation of the Republic of Indonesia No. 5 of 2014, namely 6-9.

DO

The dissolved oxygen (DO) concentration ranged from 5,49 – 6,27 mg / L. The highest DO concentration of 6,3 mg / L was in the A3 treatment while the lowest DO concentration was in the D2 treatment.

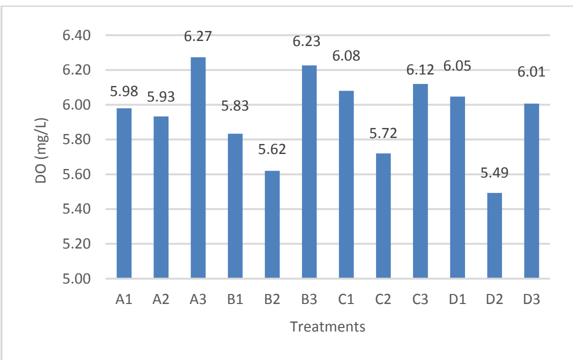

Figure 6. DO

Overall treatment A had the highest DO concentration compared to the other three treatments. That was caused by the presence of L. minor in treatments B, C and D. According to Wijayanti (2007), the concentration of dissolved oxygen can be influenced by the process of respiration of aquatic biota and the process of decomposition of organic matter by microbes.

The measured DO value has accordanced the standard according to the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 which is more than 3 mg / L. According to Jenie et al. in Yusuf (2008), in waters the dissolved oxygen content of 3 - 5 mg / L has been fulfilled for the life of aquatic organisms because in anaerobic conditions in the waters can be prevented so that life in it can take place.

Nitrate

Nitrate is the main form of nitrogen in natural waters and is the main nutrient that is useful for the growth of phytoplankton and other plants. Based on the results of the study, the measured nitrate concentration ranged from 0,326 to 0,445 mg / L.

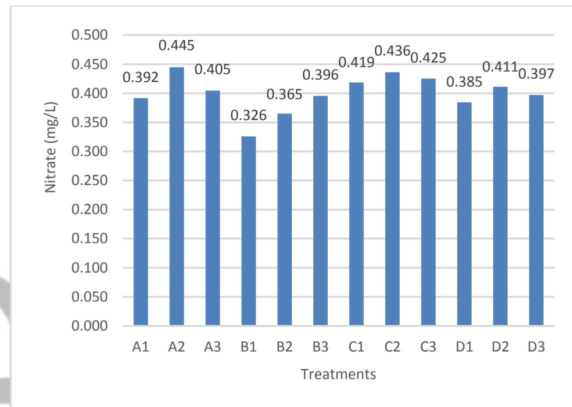

Figure 7. Nitrate

Overall, each treatment has a high nitrate concentration at the beginning of the research but there was a significant decrease in the research of the 10th day and the 15th day. That was caused by *L. minor* which played a role in the phytoremediation process as a biological liquid waste treatment plant (Lisnasari 1995).

According to Zimmo *et*. al (2005), *L. minor* is effective in fixing nitrogen in polluted waters. *L. minor* can utilize nitrates dissolved in the research media through nutrient uptake at its roots.

Phosphate

Based on the results of the study, the measured phosphate concentration ranged from 0,662 – 1,341 mg / L.

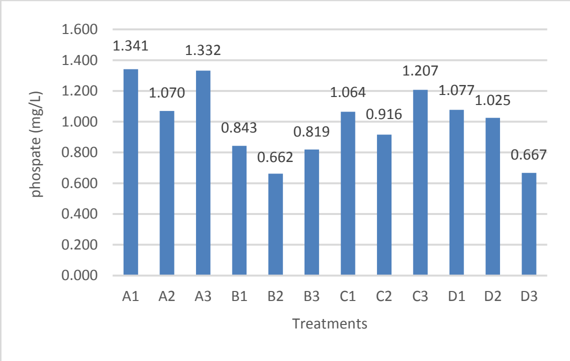

Figure 8. Phosphate

The function of phosphate in plants for root growth, strengthening the stem and accelerating the growth of leaves. According to Thompson and Troeh (1978) in Aleel (2008), phosphate is needed by plants for the formation of cells in the root tissue and buds that are growing and strengthens the stem so that it does not easily fall into natural ecosystems.

Almost every week the concentration of phosphate in each treatment has decreased. This is because *L. minor* is a remediation plant that is able to assimilate organic compounds and inorganic compounds contained in tofu liquid waste. According to Romimohtarto *et*. al. (2005), the decrease in phosphate is also caused by high light intensity which influences the process of photosynthesis so that plants utilize phosphate directly in the form of phosphorus.

BOD

BOD is the oxygen requirements needed by microorganisms in the process of decomposition of organic matter. The measured BOD concentration during observation ranged from 8,92 – 15,67 mg / L.

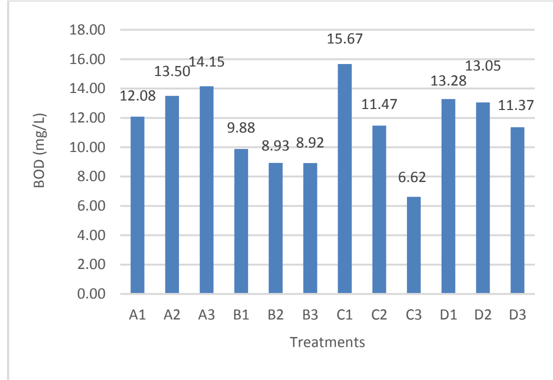

Figure 9. BOD

Each treatment decreased on the 10th day except treatment A. This was due to the high organic compounds which had to be decomposed in the research media and the lack of bacterial population that could decompose the organic material. BOD concentrations on the 15th day in treatments B, C and D decreased but in treatment A experienced a significant increase. The occurrence of the decrease caused by bacteria available in the media can decompose organic matter. According to Datko *et* al. (1985), *L. minor* can absorb organic compounds directly and utilize them as amino acid ingredients that can be used in their growth and development. It showed that the BOD content in the tofu liquid waste already accordanced the liquid waste quality standard requirements specified in the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 which is below 50 mg / L.

CONCLUSION

The results showed that treatment C, namely *L. minor* biomass of 5,0 gr / L of wastewater was the best treatment with a reduction in BOD of 2.56 mg / L.

SUGESTIONS

L. minor water plants can be used as phytoremediators in tofu liquid waste and applied to the Wastewater Treatment Plant (WWTP) to reduce excess BOD concentrations before being polutted into water bodies.

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