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UTILIZATION OF WATER HYACINTH (EICHHORNIA CRASSIPES) AS PHYTOREMEDIATION PLANT IN VANNAMEI SHRIMP AQUACULTURE SEWAGE TREATMENT

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ABSTRACT

The trending shrimp aquaculture in Poncosari Village, Srandakan, Bantul, D. I. Yogyakarta caused several problems including river and coastal area pollution. Meanwhile, water hyacinth (Eichhornia Crassipes) is easy to find and often considered to be a weed. Therefore, the utilization of this plant will be beneficial to improve its economic value. This research aimed to identify the efficiency of water hyacinth with mass variations of 0.5 kg; 1 kg; and 1.5 kg in decreasing the levels of COD, TSS, and dissolved ammonia in Vannamei shrimp aquaculture sewage. This study divided the samples into four groups consisting of one control group (C) and three treatment groups (0.5 kg; 1 kg; and 1.5 kg). The treatment effects were observed and tested every other day for 8 days in the laboratory. The analysis results indicated a decline in COD, TSS, and dissolved ammonia at 60.39%, 88.5%, and 16.48% respectively. In conclusion, the treatment showed that water hyacinth was able to decrease the concentration of COD, TSS, and dissolved ammonia in the phytoremediation process for Vannamei shrimp aquaculture sewage even though the percentage was relatively small.

Keywords: COD; Dissolved Ammonia; TSS; Vannamei Shrimp; Water Hyacinth

1. INTRODUCTION

The rise of shrimp aquaculture in Poncosari Village, Srandakan, Bantul, D. I. Yogyakarta has led to such problem as land, river and coastal area pollution. If the contamination persists and increases, the worst impact will be the loss of land for shrimp aquaculture that also means depriving one of the society's economic sectors.

One of the efforts to reduce the content of ammonia in Vannamei shrimp aquaculture sewage can be made through a biological process involving plants which is also known as a phytoremediation process. As an effort to use plants and their parts to reduce environmental pollution, phytoremediation has been increasingly implemented for both organic and non-organic waste.

Water Hyacinth (Eichhornia Crassipes) is an aquatic plant living in fresh water and absorbing water nutrients for its growth. The mass absorption of nutrients causes water hyacinth to take in liquid waste, N-nitrate, and a variety of metals. The researchers attempted to study this plant as an effort to assess its capacity and other types of organic waste or even toxic compounds in the waste (Djenar and Budiastuti, 2008).

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This study aims to determine the concentration of Vannamei shrimp aquaculture sewage using the parameters of COD, pH, suspended residue (TSS) and dissolved ammonia, to identify the efficiency of the decrease in COD, suspended residue (TSS) and dissolved ammonia levels in a Vannamei shrimp aquaculture sewage treatment using water hyacinth for the phytoremediation process, and to provide an alternative to easy and economical Vannamei shrimp aquaculture sewage treatment using a simple technology and accessible materials.

2. METHODOLOGY/ EXPERIMENT

This research was an experimental study using laboratory-scale wetland media measuring 1.825 m long, 0.60 m wide and 0.25 m deep divided into four groups, including one control group (C) and three treatment groups with different plant masses (0.5 kg; 1 kg and 1.5 kg). The study was conducted at the Water Quality Laboratory in the Environmental Engineering Department of the Faculty of Civil Engineering and Planning of Islamic University of Indonesia using wastewater samples taken from the Vannamei shrimp aquaculture in Poncosari Village, Srandakan, Bantul, DIY.

The research objects were the Vannamei shrimp aquaculture sewage taken in effluent area using a grab-sample method and the water hyacinth obtained from a shallow pond around the Vannamei shrimp aquaculture regardless of differences in the number of plant clumps and age. The test was executed every two days for eight days at the Water Quality Laboratory of the Environmental Engineering Department in the Faculty of Civil Engineering and Planning of Islamic University of Indonesia. This experiment observed the decrease in the concentration of COD, TSS, and dissolved ammonia parameters.

The collected data were then analyzed by taking into account the decreased level of concentration of each parameter in eight days, and the efficiency of decrease was then calculated. The analysis results were used to provide an alternative to wastewater treatment of Vannamei shrimp aquaculture that is easy and economical by using a simple technology with obtainable materials.

3. RESULTS

The experimental research was conducted to monitor the level of COD, TSS, and dissolved ammonia parameters in Vannamei shrimp aquaculture sewage. The measurement results were used to determine the efficiency of water hyacinth in treating Vannamei shrimp aquaculture sewage. In this study, the control group was the sewage without water hyacinth, while the treatment groups consisted of the first treatment group (X1) with sewage containing 0.5 kg of water hyacinth, the second treatment group (X2) with sewage containing 1 kg of water hyacinth, and the third treatment group (X3) with sewage containing 1.5 kg of water hyacinth. The first research stage was acclimatization of water hyacinth aiming to regulate the plant condition, so it could adapt to the sewage. The acclimatization was done by placing water hyacinth in a basin containing clean water for 24 hours before the plant was transferred into the treatment bath.

The research indicated that there was a difference between the preliminary observation results and the results during the study. The COD level at the initial observation was 31

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mg/l whereas the study resulted in 140.93 mg/l. Meanwhile, the initial observation showed 168 mg/l of TSS level, but the level in the study was 1546 mg/l. In addition, the dissolved ammonia at the preliminary observation was 13.3 mg/l, while in the study it was 4.37 mg/l. This fact was due to the difference in the sampling time between the preliminary observation and the study in which the age of sewage was different as well.

COD is defined as the required amount of oxygen to oxidize organic compounds in water, so COD parameter reflects the amount of organic compounds chemically oxidized. COD test is used to calculate the quantity of organic material that can be oxidized using strong oxidizing chemicals in acidic media. COD level in wastewater decreases in accordance with the decreasing concentration of organic material in the wastewater; therefore, appropriate treatment is required to reduce both the quality and quantity of the organic material concentration in the water (Metcalf and Eddy, 1991). A research stated that in the root zone of plants, oxygen delivery from the leaves occurs and causes the formation of oxygen zone, which raises the population of micro-organisms in the root zone by 10-100 times, aiding the absorption of pollutants in treated wastewater (Kunaefi and Ilyani. 1998).

The test results showed a decrease in the concentration of COD in the Vannamei shrimp aquaculture sewage. The removal percentage at the 0.5kg mass variation of water hyacinth was 44.69%, and the concentration of COD decreased from 140.936 mg/l on the initial day to 77.95 mg/l on day 8. Meanwhile, the decrease in COD concentration for the 1kg mass variation of water hyacinth was 50.12%, in which the concentration declined from 140.936 mg/l to 70.29 mg/l on the eighth day. In addition, the removal percentage at the 1.5 kg mass variation of water hyacinth was 60.39% with COD concentration of 140.936 mg/l on the first day and 55.82 mg/l on day 8. The decrease in COD concentration level is illustrated in Table 4.1.

Table 4.1 Observation Data for COD Concentration and COD Decrease

TIME (DAY)	0.5KG (MG COD/L)	1KG (MG COD/L)	1.5KG (MG COD/L)
0	140.93	140.93	140.
2	119.65	97.53	92.42
4	113.70	89.026	79.65
6	96.68	82.212	76.25
8	77.95	70.29	55.82
REMOVAL	**44.69%**	**50.12%**	**60.39%**

The ability to reduce the concentration of COD in Vannamei shrimp aquaculture sewage can be seen in Figure 1. In addition to the obtained removal percentage, this study also discovered reduction values in milligrams of COD/gram of plant. The decrease with mass comparison data is presented in Table 4.2.

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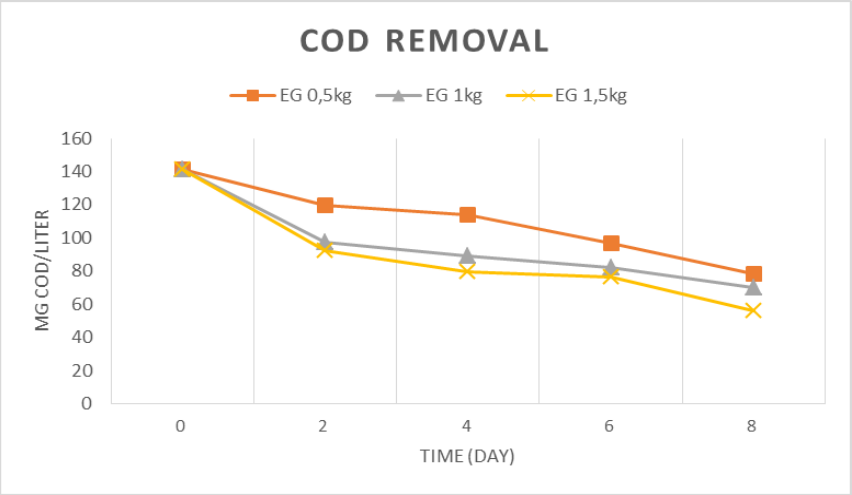

Figure 1. COD Decrease in Vannamei Shrimp Aquaculture Sewage

Table 4.2 Calculation of COD Decline by Water Hyacinth

VOLUME (L)	0.5KG = 500 GRAM		COD ABSORBED (MG/L)	1KG = 1000 GRAM		COD ABSORBED (MG/L)	1.5KG = 1500 GRAM		COD ABSORBED (MG/L)
	Initial (mg/l)	Last (mg/l)		Initial (mg/l)	Last (mg/l)		Initial (mg/l)	Last (mg/l)	
26.806	140.936	92.780	48.156	140.936	70.298	70.638	140.936	55.830	85.106
TOTAL COD ABSORBED	1.291 gram			1.894 gram			2.281 gram		
COD DECREASE PER GRAM PLANT	2.582 mg COD/g water hyacinth			1.894 mg COD/g water hyacinth			1.52 mg COD/g water hyacinth		

The sharpest COD concentration decrease in the Vannamei shrimp aquaculture sewage occurred in the phytoremediation pond with 1.5 kg of mass variation as much as 60.39% compared to the initial COD level. The data indicated that greater number of water hyacinths led to faster COD level decline of the sewage. It was caused by the water hyacinth that has the ability to absorb organic contents of the Vannamei shrimp aquaculture sewage. In addition, water hyacinth is easy to obtain although it is a type of weed, so if this plant is utilized as phytoremediation, particularly for Vannamei shrimp aquaculture sewage, it will raise the value and support environmental quality improvement. The post-phytoremediation dead water hyacinth can be repurposed as organic fertilizer to give added value to agriculture.

For innovating community, water hyacinth can be exploited for commercial purposes while maintaining environmental sustainability. Innovations in water hyacinth utilization can be classified as a green innovation because not only does it function economically but it also gives a positive impact on the environment (Hajama, 2014).

The suspended residue in sewage will generally decrease due to sedimentation factor affected by gravity. Yet, water hyacinth will be able to capture suspended solids in wastewater through its root system (Husin, 1983).

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The test results indicated a decrease in the concentration of Total Suspended Solid (TSS) in the Vannamei shrimp aquaculture sewage. The removal percentage at the 0.5 kg mass variation of water hyacinth was 83.12%, in which the concentration of TSS decreased from 1546 mg/l to 261 mg/l on day 8. The TSS decrease at the 1 kg mass variation of water hyacinth was 88.42% with the concentration of TSS declining on day 8 from 1546 mg/l to 179 mg/l. Also, the removal percentage at the 1.5 kg water hyacinth mass variation of was 71.54% indicating a decline in the concentration of TSS from 1546 mg/l to 440 mg/l on the eighth day.

Table 4.3 Observation Data of TSS Concentration and TSS Decrease

TIME (DAY)	0.5KG (MG TSS/LITER)	1KG (MG TSS/LITER)	1.5KG (MG TSS/LITER)
0	1546	1546	1546
2	677	540	641
4	403	419	593
6	302	197	535
8	261	179	440
REMOVAL	**83.2%**	**88.42%**	**71.54%**

The ability to decrease the concentration of TSS in Vannamei shrimp aquaculture sewage is described in Figure 2. In this study, apart from the obtained removal percentage, the value of TSS reduction in milligrams of TSS/gram of plant was also found. The data of decrease with mass comparison is outlined in Table 4.4.

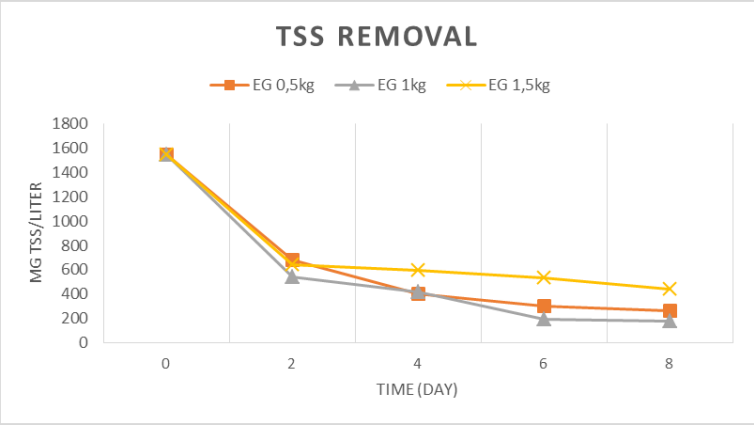

Figure 2. TSS Decrease in Vannamei Shrimp Aquaculture Sewage

Table 4.4 Calculation of TSS Decrease by Water Hyacinth

VOLUME (LITER)	0.5KG = 500 GRAM		TSS DECREASED (MG/L)	1KG = 1000 GRAM		TSS DESCREASED (MG/L)	1.5KG = 1500 GRAM		TSS DECREASED (MG/L)
	Initial (mg/l)	Last (mg/l)		Initial (mg/l)	Last (mg/l)		Initial (mg/l)	Last (mg/l)	
26.806	1546	261	1285	1546	179	1367	1546	440	1106
TOTAL TSS REDUCTION (GRAM)	34.446 gram			36.644 gram			29.647 gram		
THE DECREASE IN TSS PER GRAM PLANT	68.89 mg TSS/g water hyacinth			36.64 mg TSS/g water hyacinth			19.76 mg TSS/g water hyacinth		

The difference in the quantity or mass of water hyacinth does not necessarily affect the level of TSS concentration reduction in Vannamei shrimp aquaculture sewage. This is because of such physical factors as gravity and water movement in the pond that influence the sedimentation process although the roots of water hyacinth also have the ability to bind suspended particles in Vannamei shrimp aquaculture sewage.

The test results showed a decrease in the concentration of dissolved ammonia in the Vannamei shrimp aquaculture sewage. The removal percentage at 0.5kg mass variation of water hyacinth was 16.48% with the concentration of dissolved ammonia decreasing on day 8 from 4.37 mg/l to 3.65 mg/l. In addition, the removal percentage at 1kg mass variation of water hyacinth was 8.24% in which the dissolved ammonia concentration declined from 4.37 mg/l to 4.01 mg/l on day 8. Meanwhile, the removal at 1kg mass variation of water hyacinth reached -0.92% (considered as 0%) because the concentration of dissolved ammonia decreased from 4.37 mg/l on the first day to 4.41 mg/l on the eighth day.

This study aimed to determine the effectiveness of the decrease in dissolved ammonia using water hyacinth in Vannamei shrimp aquaculture sewage. Although there was an increase in the level of dissolved ammonia at the beginning of the experiment, the experimental data showed that only the 1.5 kg mass variation was unable to reduce the level of dissolved ammonia compared to the initial concentration in the Vannamei shrimp aquaculture sewage. The data of TSS concentration reduction can be seen in Table 4.5.

Table 4.5 Observation Data of Dissolved Ammonia Concentration and Its Decrease

TIME (DAY)	0.5 KG (MGNH4OH/LITER)	1 KG (MGNH4OH/LITER)	1.5 KG (MGNH4OH/LITER)
0	4.37	4.37	4.37
2	7.94	8.74	8.74
3	6.04	6.43	7.27
4	5.92	4.77	5.49
5	4.67	4.38	5.26
8	3.65	4.01	4.41
REMOVAL	16.48%	8.24%	-0.92%

The ability to reduce the concentration of dissolved ammonia in Vannamei shrimp aquaculture sewage is illustrated in Figure 3. This study found not only the removal percentage of dissolved ammonia but also the reduction value in milligrams of NH4OH/gram of plant. The decrease with mass comparison is presented in Table 4.6.

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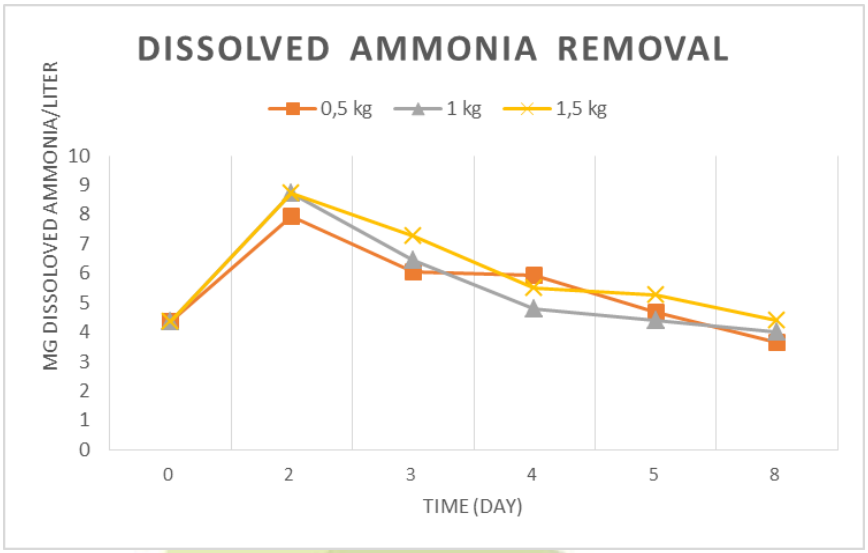

Figure 3. Dissolved Ammonia Decrease in Vannamei Shrimp Aquaculture Sewage

Table 4.6 Calculation of the Decrease in Dissolved Ammonia by Water Hyacinth

VOLUME (LITER)	0.5KG = 500 GRAM		NH_4OH DECREASED (MG/L)	1KG = 1000 GRAM		NH_4OH DECREASED (MG/L)	1.5KG = 1500 GRAM		NH_4OH DECREASED (MG/L)
	Initial (mg/l)	last (mg/l)		Initial (mg/l)	last (mg/l)		Initial (mg/l)	last (mg/l)	
26.806	4.37	3.65	0.72	4.37	4.01	0.36	4.37	4.41	-0.04
TOTAL NH_4OH ADSORB (GRAM)	0.019 gram			0.010 gram			-0.001 gram		
THE DECREASE OFNH_4OH PER GRAM PLANT	0.038 mg NH_4OH /g water hyacinth			0.01 mg NH_4OH /g water hyacinth			0 mg NH_4OH /g water hyacinth		

Water Hyacinth already has the N content, so when it is put into wastewater, it will certainly increase the level of dissolved ammonia. The decrease in nitrogen compound is caused by the ability of the plant to absorb the compounds that become nutrients for its growth (Rahmaningsih, 2006).

The data showed that the most visible decrease in the level of dissolved ammonia in the effluent of Vannamei shrimp aquaculture occurred with 0.5kg mass variations as much as 16.48% of the initial dissolved ammonia. Also, the efficiency of decrease reached 0.038 mg NH_4OH/g water hyacinth. Therefore, the differences in the mass of water hyacinth as well as nitrogen content in it greatly affected the effectiveness of dissolved ammonia reduction in the effluent of Vannamei shrimp aquaculture sewage.

4. DISCUSSION

Vannamei shrimp aquaculture sewage has a high level of COD, TSS, and dissolved ammonia concentration and exceeds the quality standards outlined in the Yogyakarta Governor Regulation No. 7 of 2010 regarding the effluent of fish and shrimp aquaculture as much as 125 mg COD/l, 50 mg TSS/l, and 0.5 mg NH4OH/l of wastewater. Therefore, a special treatment is required to prevent the effluent from polluting the land, river, and coastal environment. Until recently, most of the Vannamei

shrimp aquacultures belonging to the local inhabitants do not have proper sewage treatment due to financial limitation.

An applicable alternative solution is to build a simple yet effective wastewater treatment to reduce the parameter concentration that exceeds the quality standards. The results of this study as an alternative solution for a simple shrimp aquaculture wastewater treatment had yet to decrease the concentration exceeding the quality standard parameters, particularly for the dissolved ammonia parameter. Therefore, an additional wastewater treatment is necessary to support this research by considering the cost aspect as well.

The addition of a conventional aeration pond at the initial state will support the process of COD and TSS concentration reduction. After passing this pond, the Vannamei shrimp aquaculture sewage is channelled into a wetland containing water hyacinth that can significantly decrease the concentration of COD, TSS, and dissolved ammonia. The wetland containing water hyacinth is simply made with adjustable size depending on the existing land and built similarly to normal ponds. The bottom is covered with neither concrete nor plastic to allow a direct contact with the ground. It aims to provide extra nutrients for water hyacinth to be able to live much longer. Based on this research, water hyacinth could only survive for nine days then it wilted and rotted afterwards.

Water hyacinth has great adaptability to a variety of things around it and can reproduce quickly. It is able to live in soil constantly covered by water that contains a lot of nutrients. In addition, its resistance allows it to live in acid soil and wet ground. The adding of nutrients or food for water hyacinth is naturally done by leaving the bottom of the pond uncovered so that the wastewater has a direct contact with the soil which is important to extend the lifetime of water hyacinth in Vannamei shrimp aquaculture sewage (Sastroutomo, 1991).

5. CONCLUSION

This research resulted the following conclusions: 1) It was discovered that the Vannamei shrimp aquaculture sewage had 140.93 mg/l of COD concentration; 1546 mg/l of TSS concentration; and 4.37 mg/l of dissolved ammonia concentration; 2) Optimum COD concentration reduction occurred in the 1.5 kg mass variation as much as 60.39%; 3) Highest reduction of TSS concentration was experienced by the 1 kg mass variation as much as 88.42%; 4). Maximum decrease in dissolved ammonia concentration was reached by the 0.5 kg mass variation as much as 16.48%; 5). As a simple alternative solution for Vannamei shrimp aquaculture sewage treatment, the research results had yet to fully decrease the parameter concentrations that exceed the quality standard, particularly for the dissolved ammonia parameter. Therefore, an additional wastewater treatment that does not only support this study but also consider the cost aspect is required.

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