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Research

THE PHYTOREMEDIATION TECHNOLOGY IN THE RECOVERY OF MERCURY POLLUTION BY USING WATER HYACINTH PLANT (*EICHHORNIA CRASSIPES*) FOR WATER QUALITY OF IRRIGATION

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ABSTRACT

Water pollution by heavy metals such as mercury (Hg), lead, cadmium, cobalt, zinc, arsenic, iron, copper and other compounds, originally spread in small concentrations. But in the next process, it will experience an accumulation or concentration so that at certain concentrations, it can cause the negative impact on the environment. The results from the previous research showed that the water hyacinth plant (*Eichhornia crassipes*) has the highest ability in reducing heavy metal pollution of mercury. The objective of this research is to analyze the ability of the water hyacinth plant (*Eichhornia crassipes*) in reducing the concentration of metal with variety of water flow rates. This research was conducted to test the water hyacinth plant (*Eichhornia crassipes*) in some discharge water sources which contaminated with mercury in the downstream of gold mining in Batang Hari River on a laboratory scale with a continuous flow. The result of this research revealed that the water hyacinth plant (*Eichhornia crassipes*) can lower the concentration of heavy metals Hg to the limit of water quality for irrigation. The elimination efficiency levels from heavy metals mercury ranged between 49.9% and 54.2%. In addition, heavy metals mercury with phytoremediation of water hyacinth also did not affect to the levels of dissolved oxygen (DO), temperature and TSS (Total Suspended Solid).

INTRODUCTION

The increasing of population growth rates from time to time make the need of water for human grows. It has caused many negative impacts on the availability and quality of water in form of pollution and environmental damage. Water pollution by heavy metals such as mercury, lead, cadmium, cobalt, zinc, arsenic, iron, copper and other compounds, originally spread in small concentrations, but in the next process, it will lead to an accumulation. So, at certain concentrations, it can cause the negative impact on the environment.

The observation from various rivers in West Sumatra Province was found that many gold mining used mercury One of the causes of environmental pollution by Mercury was a gold processing tailings disposal where it was processed in the amalgamation. The previous research (Rusnam: 2014) conducted in Dharmasraya District, in Batang Hari River, has discovered that the existence of heavy metal pollution by Mercury was as a result of gold mining, whereas the river is a source of irrigation. The recovery action (remediation) on contaminated land is needed to be done as the effort to reduce the impact of heavy metals pollution on the environment, plants and aquatic biota. There are many techniques that can be conducted to the recovery (remediation) of contaminated land; one of them is a Phytoremediation that utilizes water plant as a cleaning agent. Some types of plants are able to work as agents of phytoremediation, such as Water

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Lilies (*Salvinia molesta*), Water Hyacinth (*Eichhornia crassipes*) and Water Lettuce (*Pistia stratiotes*). These are the types of aquatic plants that are often found in rivers, beaches, swamps or lakes in West Sumatra. These plants have an ability called with *hiperacumulator*, which is relatively resistant to a wide range of contaminants and able to accumulate in tissues with a sizeable amount. Based on the types of the three crops, Water Hyacinth (*Eichhornia crassipest*) has the highest capability in reducing heavy metal pollution of mercury, (Rusnam and Efrizal: 2013).

This previous research used a method of batch (stagnant water). On this occasion, the researchers examine the ability of water hyacinth plant (*Eichhornia crassipes*) in reducing the concentration of heavy metals mercury with a continuous flow method and use contaminated water of heavy metals mercury. This study is expected to be implemented directly by the people whose consume water polluted which consists of mercury. With regard to the previous discussion, so the researchers propose a research entitled **"The Phytoremediation Technology in the Recovery of Mercury Pollution by Using Water Hyacinth Plant (*Eichhornia crassipes*) For Water Quality of Irrigation".**

MATERIALS AND METHODS

This research was conducted on June until August 2015 on the ability of water hyacinth plants (*Eichhornia crassipes*) with a variety of flow rates by using mechanism as a continuing flow. The experiment was conducted with the flow pattern of the horizontal sub-surface flow to determine the efficiency of a decreasing in the concentration of heavy metals mercury at the best conditions of the three variations of flow rates (debit). This study used an experimental method in laboratory scale and utilized water hyacinth plants (*Eichhornia crassipes*) as the fastest aquatic plants in reducing mercury concentrations. Water that was treated to be recovered came from Batang Hari River and it contaminated with mercury. The study used as many as 9 units of reactor. The function of reactors was to drain three water flow rates with three replications. Water hyacinths plants were planted in all reactors. The difference in each reactor was in the flow of water discharge. Reactor sized at 70 cm × 60 × 40 cm and it was divided into three spaces at one reactor. The first space sized at 15 cm × 60 cm × 40 cm, which has a function as an inlet to maintain laminar flow. The second space as a process space with the size of 40 cm × 60 cm × 30 cm and the last, outlet space, served to hold water from the process and it resulted through the tap of outlet space before it was released.

The reactor which was used has a function as the place of processing solution composed of filter media and equipped with water hyacinth plants. The reactor in the form of rectangular tubs was made of transparent fiber glass.The reactor was equipped with some supporting equipment as follows:

1. Solution tub bath, used to accommodate the solution during the process in the reactor. The solution tub bath has the form of a plastic cylinder with a diameter of 100 cm and a volume of 250 liters.
2. Outlet tap, has a function to drain the result solution into a bucket of processed reactor as placeholders. Diameter of outlet tap was ½ inch;
3. Small bucket for 3 liters, has a function to accommodate effluent of the processed result in the reactor.

Then, the sample of water hyacinth plants (*Eichhornia crassipes*), taken from in the swampy area that proliferated in golf field Gadut, Padang. The height of plants were ± 30 cm. These plants were very easy to live and quickly to adapt. The installation of reactor was parallel to the solution tank and it was placed on the elevation that was higher than the reactor. Therefore, it could drain the solution gravitationally. There was only an outlet pipe at the pipe reactor phytoremediation because at the inlet's flows through the reactor, it is adjacent to the edge of the tank solution. There were two borders between the growing medium of water hyacinth plant, inlet, and a container prior to the outlet pipe. Each reactor outlet was equipped with a bucket.

Reactor conditioning was conducted to determine if the reactor has been in a steady condition, means the condition of the reactor is ready for the trial. A steady condition includes the acclimatization water hyacinth. According to Hardyanti (2006), the stages of water hyacinth plants acclimatization were done by growing plants in water for 3 days then it came to the increasing of its height from 1-2 cm. The observation of each treatment was carried out every 10 minutes and it was started at the 10th as well to determine the tendency of a decreasing in the concentration of Hg. Observations will be complete if the water was treated in a storage container runs over.

The analytical method that would be used for the analysis of metal concentrations of Hg was the absorption method that used inductively coupled plasma mass spectrometry (ICP-MS). An analysis of other parameters such as the measurement of dissolved oxygen (DO), temperature used a DO meter and TSS. The result of data experiments will be processed and discussed. The data included DO, temperature, concentrations of Hg and TSS. The efficiency of an ability to use water hyacinth plants in the reduction for Hg used a continuous flow. The magnitude of the efficiency can be calculated by the following equation:

$$\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100\%$$

With:

η = Removal efficiency (%)

C_{in} = Hg concentration in the initial solution (mg/l)

C_{out} = Hg concentrations in solution at equilibrium (mg/l)

RESULTS AND DISCUSSION

The reduction trend of heavy metal mercury during the observation to a speed of 50 ml/sec can be seen in Figure 1.

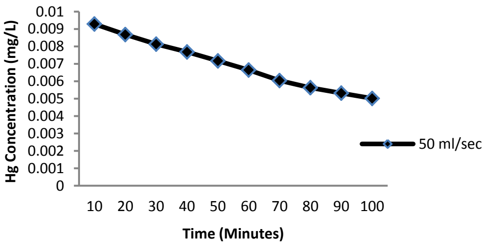

Figure 1: Graph reduction of mercury concentration (Hg) with debit 50 ml/sec.

Figure 1, it can be seen that the trend of decreasing in concentration of mercury always occurs constantly from the 10th minute until the 100th minute. Reduction in mercury shows a similar pattern from time to time. This means that the treatment of phytoremediation with water hyacinth plant is one option to decrease the concentration of mercury in water body. In the debit of 50 ml/sec, it is evident that the expected quality standards (0.005 mg/L) for irrigation water quality could be achieved at the 90th minutes and it is then continued to decrease concentrations of mercury.

The level of heavy metal removal efficiency of mercury can be obtained from the reduction of the initial concentration to a final concentration which is divided by the initial concentration and multiplied by one hundred percent.

The percentage rate of removal efficiency of mercury to a speed of 50 ml/sec can be seen in Figure 2.

In Figure 2, it can be seen that the percentage level of concentration of Hg is removal efficiency with a debit of 50 ml/sec. Along with a decrease in the level reduction in the concentration of heavy metals Hg, the level of the reduction also increases from the initial to the end of sampling. The level of reduction for heavy metals mercury is quite high and at the end of sampling, namely the 100th minute, it has reached 54.2%.

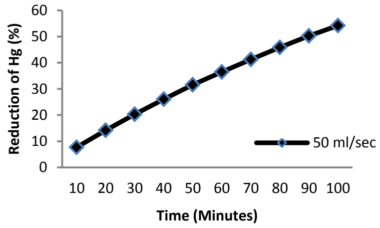

Figure 2: Graph percentage of reduction (Hg) by debit of 50 ml/sec.

The reduction trend of heavy metal mercury during the observation to a speed of 50 ml/sec can be seen in Figure 3.

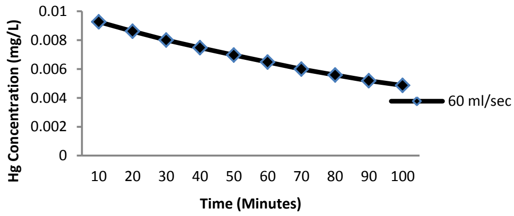

Figure 3: Graph Reduction of Mercury concentration (Hg) with Debit 60 ml/sec

In the Figure 3, it can be seen that the reduction trend in concentrations of mercury is also always occurs constantly from minute 10 to minute 100 as well as on the lower discharge or on the flow of 50 ml/sec. However, the reduction of mercury still shows a similar pattern over time. It means that the treatment phytoremediation with water hyacinth plants remains one option to a lower concentration of mercury in the water body. The level of heavy metal removal efficiency of mercury and to a speed of 60 ml/sec can be seen in Figure 4.

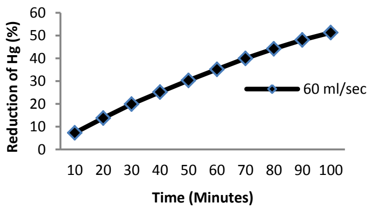

Figure 4: Graph percentage of reduction (Hg) by debit of 60 ml/sec.

It can be seen that the percentage level of removal efficiency of Hg concentrations with a debit of 60 ml/sec. In the same as the discharge of 50 ml/sec, the level of reduction for mercury also increases from the initial decision to the end of sampling. The level of reduction for heavy metals mercury is still quite high and at the end of sampling, namely the 100th minute, it has already exceeded 50%, where it is at 51.3%.

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The reduction trend of heavy metal mercury during the observation to a speed of 70 ml/sec can be seen in Figure 5.

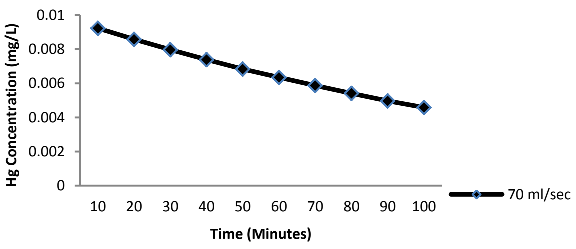

Figure 5: Graph reduction of mercury concentration (Hg) with debit 70 ml/sec.

From Figure 5, the reduction trend in concentrations of mercury also occurs on debit of 70 ml/sec with the similar pattern to a debit of 50 ml/sec and 60 ml/sec. It always occurs constantly from minute 10 to minute 100. It means that the treatment of phytoremediation with water hyacinth plants with the three treatments of debits might be the one option to reduce the concentration of mercury in the water body.

The level of heavy metal removal efficiency of ercury and to a speed of 70 ml/sec can be seen in Figure 6. Based on Figure 6, it can be seen the percentage of the level of concentration of Hg removal efficiency with a debit of 70 ml/sec. In the same with the discharge of 50 ml/sec and 60 ml/sec, the level of reduction for mercury also increases from the initial to the end of sampling. Even though it declines in the level of reduction for heavy metals mercury at 70 ml/sec compared to two prevous treatments (50 ml/ sec and 60 ml/sec), but the level of the reduction at the end of the sampling is still quite high at 49.9%.

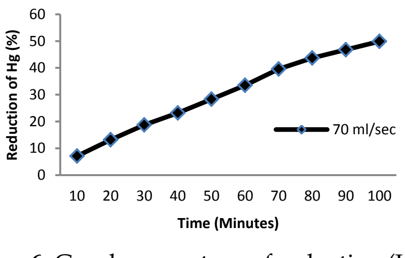

Figure 6: Graph percentage of reduction (Hg) by debit of 70 ml/sec.

The fluctuations of DO for the three treatments can be seen in Figure 7. It appears at treatment with the lowest flow 50 ml/sec contains the lowest oxygen and the treatment with the highest speeds (70 ml/ sec) contains the highest oxygen. The lowest oxygen which is contained in the container is caused by the lack of oxygen that goes into the container from the outside. It is as a result of a low flow velocity at a low debit when it is compared to the larger debit.

Although there are some fluctuations in the amount of DO during the observation but DO concentration is above the quality standard limits to water class 1 and 2. This case refers to Government Regulation No. 82 Year 2001 on the Management of Water Quality and Water Pollution Control is between 4 mg/l - 6 mg/l. When comparing with the levels of dissolved oxygen, it is required to the growth of the plants; the oxygen levels in the water which are contained in the container are very well. It means that there is no influence to the oxygen levels as a result of treatment with phytoremediation using water hyacinth plants.

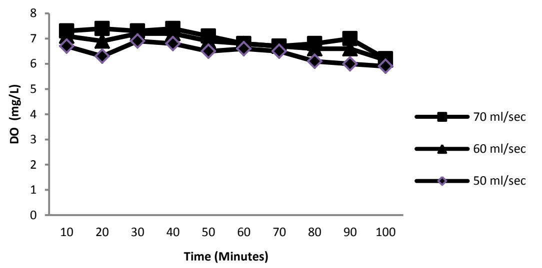

Figure 7: Graph fluctuations of dissolved oxygen (DO) during observation.

The fluctuations of the temperature during the observations at three discharge treatments can be seen in Figure 8.

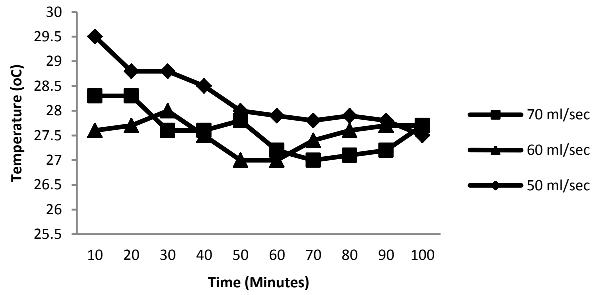

Figure 8: Graph temperature fluctuations during observation.

It gives the presence of temperature fluctuations during the observation. The highest fluctuation is visible on the smallest debit, 50 ml/sec, the same as the dissolved oxygen levels that occurs in the discharge of 50 ml/sec. But the value of the range temperature in the preliminary process is very small and stable. The significant different of the value does not affect the decrease in the concentration of mercury.

TSS fluctuations during the observations on the three discharge treatments can be seen in Figure 9. It refers to the fluctuation of TSS for observation. The highest fluctuation can be seen in the three debits which are treated, where it increases in minute 30th, but then it decreases in the minute 40th. For all the treatments, there was an increase at the end of the observation.

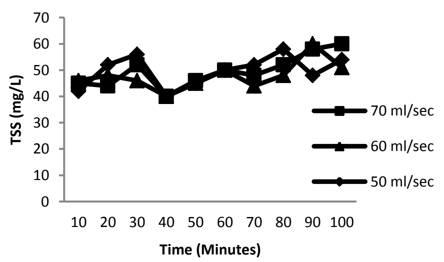

Figure 9: Graph fluctuations of TSS during observation.

CONCLUSIONS

Based on the results of the study, it can be obtained some conclusions as follows:

1. Water hyacinth plants (*Eichhornia crassipes*) can lower the concentration of heavy metals Hg to a limit water quality for irrigation.
2. The efficiency of the heavy metals mercury's elimination ranges between 49.9% and 54.2%. The highest efficiency which is obtained in the treatment with the smallest debit or at 50 ml/sec is equal to 54.2%. And the lowest efficiency which is obtained in the treatment with the greatest debit or at 70 ml/sec is in the amount of 49.9%.
3. Besides it lowers the levels of the heavy metals mercury , the treatment with phytoremediation of water hyacinth also did not affect to the levels of dissolved oxygen (DO), temperature and TSS.

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