

EFFECTIVENESS OF BATCH AND INTERMITTENT EXPOSURE OF CONSTRUCTED WETLAND SUB SURFACE SYSTEM IN PB METAL DEGRADATION IN LABORATORY LIQUID WASTE USING COSTUS SPICATUS PLANT

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ABSTRACT

There are several types of built-up wetland systems, including subsurface runoff wetlands, surface runoff wetlands, and hybrid runoff wetlands. Among the three types, in this study, subsurface flow constructed wetlands were selected because they have the advantage of having smaller land requirements compared to other types of artificial land. In addition, this type of wetland is not mosquito-friendly because there is no standing water on its surface. This study used a batch and intermittent exposure system. The purpose of using this exposure system is to find out a good exposure system in removing Pb metal. Based on the results of the research and discussion, it can be concluded that the effectiveness of the batch exposure system is higher than the intermittent system, this is determined by the effectiveness of the highest Pb absorption in the batch system of 98.39% and the highest intermittent system of 91.06%.

Keywords: batch, intermiten, wetland, pb metal waste

INTRODUCTION

Laboratory liquid waste contains hazardous and toxic contaminants. One of the hazardous and toxic materials is heavy metal. Heavy metals are pollutants that have harmful effects because they accumulate in environmental components. Heavy metals in low concentrations are generally toxic to living things. Heavy metals enter the body tissues of living things through the respiratory tract, digestion, and penetration through the skin.

One of the wastewater treatment systems that can reduce heavy metals by considering small-scale and inexpensive technology to be applied to laboratory wastewater is artificial wetland technology (Setiyanto et al., 2016). An artificial wetland is an engineered system, which has been designed and built by utilizing natural processes involving plants, soil, and microbial groups to assist in treating wastewater (Indrayani & Triwiswara, 2018). The advantages of artificial wetlands compared to conventional sewage treatment facilities that use chemicals are lower investment, operation and maintenance costs (Tjandra Setiadi & Eng, n.d.) There are several types of built-up wetland systems, including subsurface flow wetlands, surface runoff wetlands, and hybrid flow wetlands (Herlambang, 2006). Among the three types, in this study, subsurface wetlands were chosen because they have the advantage of having smaller land requirements compared to other types of artificial land. In addition, this type of wetland is not mosquito-friendly because there is no standing water on its surface.

Several flow systems that can be used in artificial subsurface wetlands are batch systems and intermittent systems. Batch system is a system without flow in the reactor. So there is no inflow or outflow. In batch flow, the concentration of reactants/contaminants will decrease not as a function of distance, but will be replaced by a function of time (Amalia et

al., 2017). The time function can be expressed in HRT (td or exposure time). Intermittent operation is water supply with intermittent rotation, which means giving the reactor dry time without providing wastewater during operation. The principle of intermittent exposure is to provide waste at the desired inundation height with a predetermined discharge time. Furthermore, the provision of waste is stopped until the puddle in the reactor runs out. After the puddle is finished, the reactor is irrigated again.

Intermittent exposure applies inundation and drying cycles, where inundation is the application of wastewater and drying is a drying process by not providing wastewater. Drying by opening the outlet hole and no water is introduced into the reactor. Drying is done by removing the water in the reactor through the outlet. A natural aeration process will occur during this inundation and drying cycle (Vera et al., 2014). Aeration on the media can improve redox conditions thereby increasing removal efficiency (Kumar & Dutta, 2019). Aeration can increase biological activity and stimulate the nitrification mechanism of denitrification. Intermittent exposure conditions allow air to fill the pores of the substrate, so that the transfer of oxygen from the atmosphere to the system takes place more quickly (Araya et al., 2016). Diffusion of oxygen will take place very quickly and into the roots and biofilms formed.

Generally, the exposure system used is a batch system, so the authors are interested in comparing the absorption effectiveness of batch and intermittent systems. This can later be used to determine the effectiveness of removing heavy metals Pb and Cd in each of these systems.

RESEARCH METHOD

The initial stage of this research is to drain the liquid waste into a 15 liter constructed wetland reactor which already contains gravel and soil media. Variations in the exposure system are carried out in batch and intermittent systems. The batch exposure system is carried out by draining wastewater and then leaving it in the reactor for 14 days. The selection of 14 days was based on research (Izzati et al., 2019) which was the highest degradation time of Pb and Cd metals using the *Cheilocostus speciosus* plant which was still 1 genus with the *Costus spicatus* plant on the 4th day, 5 days processing time. In addition, this also refers to the Cipta Karya guidelines (2017), namely the processing time of dissolved pollutants in artificial wetland systems ranges from 5-14 days. (Rahmadyanti & Febriyanti, 2020) stated that it takes at least 24 hours to reduce organic matter, bacteria, and toxic materials in artificial subsurface wetlands. Sampling time is carried out every 2 days, so that later it is expected to know the highest/best degradation time of Pb and Cd metals in analytical laboratory liquid waste.

The intermittent exposure system was carried out with a comparison of inundation and drying cycles (F/D). Intermittent exposure is the reactor is fed with wastewater (flooding) intermittently with a time lag where the reactor is allowed to dry without being given waste water (drying). Flooding by entering water into the reactor with the outlet hole closed. The state of inundation is carried out with the reactor given waste water, then the water is held in the reactor for a period of inundation for 2 days. Drying by opening the outlet hole and no water is introduced into the reactor. Drying is done by removing the water in the reactor through the outlet. The reactor was then left empty of wastewater for a 1 day drying period. The process of draining wastewater is carried out so on (Mangkoedihardjo & April, 2012). The intermittent system used was F/D 2:1 (2 days of flooding and 1 day of drying) which was carried out for 14 days. The application of 2:1 (F/D) is carried out because the longer the contact time of the waste with the treatment system, the greater the organic matter that is eliminated through the biodegradation mechanism (Tangahu & Ningsih, 2016). This is

evidenced by research (Mangkoedihardjo & April, 2012). that F/D 2:1 the pollutant removal result is higher than F/D 1:2. Wastewater sampling was taken ± 200 mL to proceed to the analysis stage according to the specified parameters.

RESULT AND DISCUSSION

This study used a batch and intermittent exposure system. The purpose of using this exposure system is to find out a good exposure system in removing Pb metal. The results of the analysis of wastewater samples after the sub-surface flow process was built with a batch exposure system using the *Costus spicatus* plant for 14 working days extended to the 15th day can be seen in Figure 1. The research data showed a decrease in Pb concentration after the subsurface flow process. wetlands built.

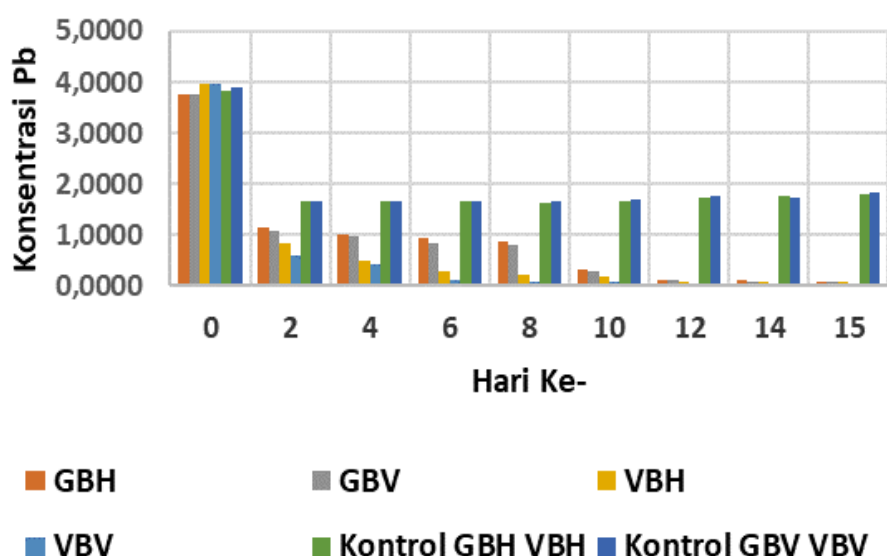


Figure 1 Decreasing of Pb . Metal Concentration Batch Exposure System

The decrease in heavy metal levels occurred drastically on the second day, because the growing media was able to absorb heavy metals. This is evidenced by the control reactor which also experienced a drastic decrease in heavy metals. The next day the concentration of heavy metal Pb continued to decrease until the 15th day, but the concentration of heavy metal in the control reactor fluctuated with conditions that lead to stable or no sharp increase or decrease. This indicates that the plant has begun to absorb heavy metal Pb from the growing media. According to (Priyanto & Prayitno, 2007), when plants absorb heavy metals, they will form reductase enzymes in their root membranes. This reductase functions to reduce metals which are then transported through a special mechanism in the root membrane. In addition to the formation of reductase enzymes, the process in the roots also contains rhizobacter bacteria. The role of rhizobacter bacteria is to decompose organic or inorganic compounds found in roots (Putra et al., 2018). Pb metal that enters root cells is then transported to other plant parts through xylem and phloem transport networks. To increase the transport efficiency of metals bound by chelating molecules. The chelate molecules formed in the roots are called phytosiderophores. Phytosiderophores formed will bind to metals and carry them into root cells through active transport (Caroline & Moa, 2015). In the leaves, the process of phytovolatilization occurs. Phytovolatilization is the process of absorption of pollutants by

plants, then these pollutants are converted into volatile materials and then transpiration by plants. Pollutants released by plants into the air can be the same as the form of the initial pollutant compound, it can also be a different compound from the initial compound (Nur, 2013).

On the 14th to the 15th day, heavy metal Pb still decreased, but the decline was not sharp. This shows that plants are still able to absorb heavy metal levels in wastewater, but will enter the saturation point phase. The saturation point is the maximum time a plant can tolerate absorbing contaminants.

The results of the percentage removal of Pb and Cd with intermittent exposure systems can be seen in Figure 1. The percentage removal data shows the removal of Pb and Cd in each reactor.

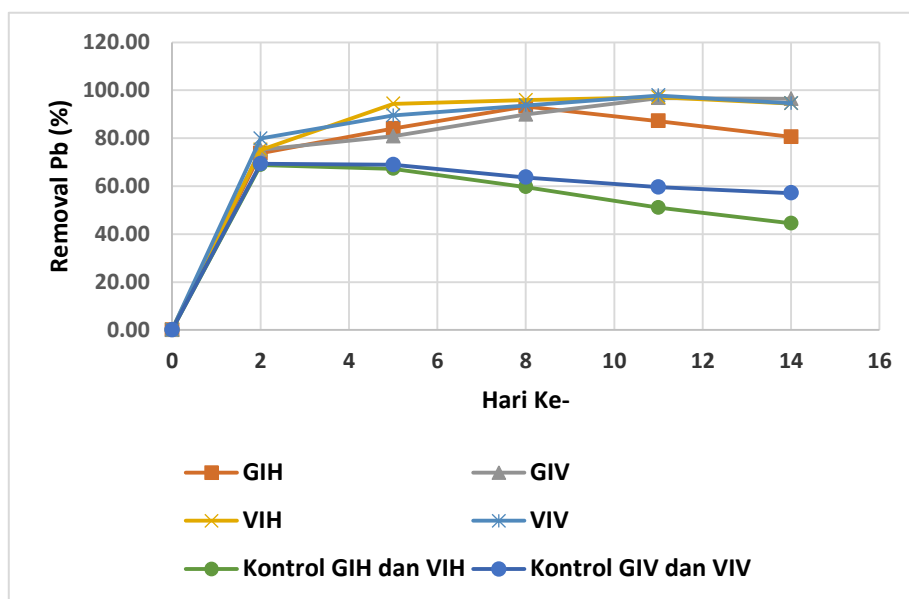


Figure 2 Percentage of Pb Metal Removal in Intermittent System

Based on Figure 2 on day 2 the percentage of removal of Pb metal shows a high removal in the range of 70% to 80%, a large percentage of removal also occurs in the control reactor. This happened because of the role of the media in absorbing Pb. metal

The increase in the removal value in each reactor started from the 5th day of observation. This is due to the synergistic relationship between plant species in reducing Pb in the phytotherapy reactor. Plants also begin to play a role in absorbing heavy metals in the soil through plant roots with the help of rhizobacter bacteria and reductase enzymes. In the root process also formed a chelating substance called phytosiderophores. Phytosiderophores formed will bind to metals and carry them into root cells through active transport. After the metal is brought into the root cells, then the metal is transported through the xylem and phloem transport network to other plant parts, namely stems and leaves.

On day 6 to day 11 the percentage of Pb removal increased, this was due to the drying cycle of 1 day per inundation for 2 days. The drying cycle allows air to fill the pores of the substrate, resulting in a faster transfer of oxygen from the atmosphere to the system. The drying cycle will also provide an opportunity for the plant to recover from exposure to the effluent. Diffusion of oxygen will take place very quickly and enter into the roots and biofilms formed (Behrends et al., 2001). Sufficient oxygen capacity is needed in the roots as energy in metabolic processes to remove heavy metals by plants (Waluyo, 2018). The rapid

diffusion of oxygen also aids in the aerobic decomposition of contaminants (Kadlec & Wallace, 2008). The percentage of removal in almost all reactors decreased after day 11 for the generative phase and day 14 for the vegetative phase. This reduction in removal is thought to be because the plant will enter the saturation point phase, so that removal is not carried out in maximum conditions.

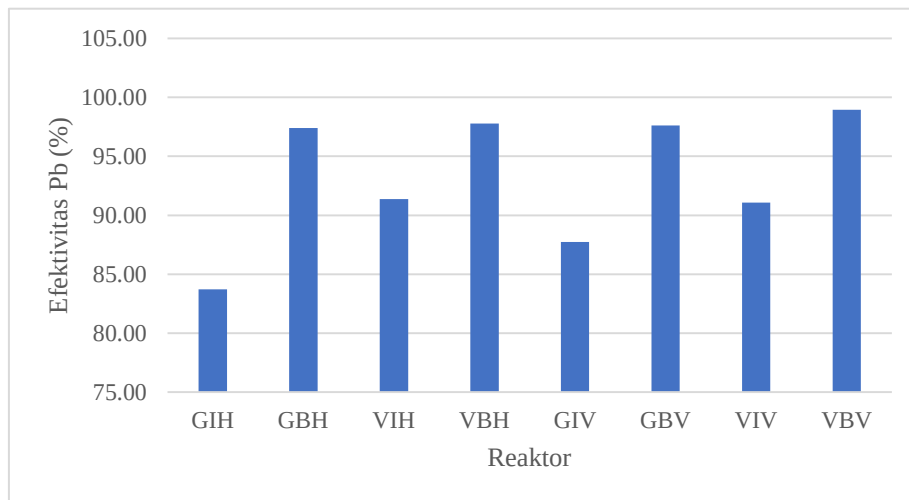


Figure 3. Effectiveness of Pb in Batch and Intermittent Systems

Description:

(a)-0 = Control

(b) VBH = Vegetative, Batch, Horizontal; VBV = Vegetative, Batch, Vertical

(c) GBH = Generative, Batch, Horizontal; GBV = Generative, Batch, Vertical

(d) VIH = Vegetative, Intermittent, Horizontal; VIV = Vegetative, Intermittent, Vertical.

(e) GIH = Generative, Intermittent, Horizontal; GIV= Generative, Intermittent, Vertical.

Based on Figure 3, it can be seen the results of the comparison of the effectiveness of Pb absorption with intermittent and batch exposure systems. In the Pb discharge load, all the highest absorption effectiveness from the comparison of batch and intermittent systems were batch systems with variations in vegetative-vertical, vegetative-horizontal, generative-vertical and horizontal generative phases. The system with batch exposure became a system that removed higher Pb than the intermittent exposure system. The batch system can remove Pb which is higher than the intermittent system because the batch exposure to the phytotherapy process that occurs has a longer detention time of 14 days. The intermittent exposure system was also carried out for 14 days but the removal value was smaller than the batch. This is presumably because the flooding process which is carried out once every 2 days is less than optimal in removing Pb metal compared to the batch system, so that the accumulated output that comes out still contains Pb metal with higher levels than the batch system.

One of the environmental problems caused by the presence of liquid waste is pollution in water bodies, rivers and groundwater. To overcome this problem, one of them is the Constructed Wetlands system with most studies using water hyacinth plants. Several studies regarding the reduction of Pb in liquid waste using water hyacinth plants were research conducted by (Abdullah, 2007; Mayasari, 2007).

The purpose of the study (Abdullah, 2007) was to determine the level of reduction in the concentration of Lead (Pb) contained in the liquid waste of the Piyungan TPA with Constructed Wetlands using water hyacinth plants and to determine the absorption capacity of water hyacinth plants to the content of Lead (Pb) in the waste. Piyungan landfill liquid. By using the SSA (Atomic Absorption Spectrophotometry) method. Based on the test, it was found that the decrease in Pb in the Piyungan TPA liquid waste on the 12th day was 0.0501mg/L at 100% concentration, 0.0295mg/L at 75% concentration, 0.0267mg/L at a concentration of 50% and 0.0041 mg/L at a concentration of 25%.

As for the research conducted (Mayasari, 2007) it was found that the greatest absorption was at a 50% waste concentration, which was 0.0000824 mg/gr. The absorption efficiency during the 12-day detention time was 3.9833% under normal conditions, 10.8782% at 25% wastewater concentration, 11.5019% at 50% wastewater concentration, 9.5803% at wastewater concentration 75% and 8.2737% at 100% wastewater concentration.

In this study, the authors seek renewal by conducting research using the *Costus Spicatus* plant in reducing Pb in Liquid Waste. The use of the *Costus Spicatus* plant with a batch exposure system is more effective than the intermittent system, this is determined from the highest Pb absorption effectiveness in the batch system of 98.39% and the highest intermittent system of 91.06%.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the effectiveness of the batch exposure system is higher than the intermittent system, this is determined from the effectiveness of the highest Pb absorption in the batch system at 98.39% and the highest intermittent system at 91.06%.

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