PHYTOREMEDIATION POTENTIAL

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PHYTOREMEDIATION POTENTIAL OF *Salvinia molesta* FOR ORGANIC MATTER COFFEE LIQUID WASTE

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ABSTRACT
Coffee liquid waste contains organic matter which can be at risk of increasing water pollution levels. The results of the preliminary research carried out showed that the level of pollution due to coffee liquid waste exceeded the quality standard, with the results of the BOD test results being 23 ppm and COD 72 ppm, so we need a way to reduce pollution. Phytoremediation is a method of natural waste handling using certain plants in collaboration with microorganisms in the media (soil, sand, water) so that it can change contaminants to be reduced or harmless. This study aims to determine the effectiveness of *Salvinia molesta* phytoremediation in reducing BOD and COD levels. The research design used a completely randomized design (CRD) with four treatments with three replications. The research data were tested using the Analysis of Variety Prints and the Duncan's Multiple Distance Test continued test. The results showed that the effectiveness of *Salvinia molesta* in reducing BOD levels was found in P3 obtained by an average of 8.37 ppm (63% decrease) and reducing COD levels by an average of 25.37 ppm (73%). Based on these results, it can be concluded that P3 is effective in reducing BOD and COD levels of coffee liquid waste.

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1. INTRODUCTION

Coffee liquid waste comes from the result of coffee processing. Production of coffee is the industrial process of converting the raw fruit of the coffee plant into the finished coffee. These processes generate a lot of solid wastes (by-products) and waste water (Cruz, R, 2014). Coffee processing includes stripping in a rotating cylinder by spraying water along with the coffee cherries to be peeled. That is a lot of beans and when they are only used once and thrown away, it also contributes to a huge amount of waste (Group, E. F. 2013). Then the water washing process is carried out to facilitate the peeling of the coffee skin and remove the mucus layer contained in the coffee beans. This washing water causes liquid waste if discharged into water bodies or the environment can cause pollution. Coffee liquid waste has the characteristics of a thick color, pungent smell, high BOD and COD (Rukmawati, 2015).

Based on a preliminary study on the BOD and COD content in coffee liquid waste, the results obtained BOD levels of 23 ppm and COD levels of 72 ppm. These results exceed the quality standard. Based on Government Regulation of the Republic of Indonesia No. 82 of 2001 concerning Water Quality Management and Water Pollution Control, the levels of BOD and COD are above the established quality standards, which are 3 ppm and 25 ppm, respectively. The high levels of BOD and COD can cause river pollution.

Biological Oxygen Demand (BOD) is the amount of dissolved oxygen needed by microorganisms in water to decompose organic matter. The BOD value can be used to estimate the amount of organic matter in waste water that can be oxidized and will be decomposed by microorganisms through biological processes. Meanwhile Chemical Oxygen Demand (COD) is the amount of oxygen needed to chemically oxidize organic matter, both those that can be degraded biologically and those that are difficult to degrade biologically into CO2 and H2O (Fikri, 2014). The high levels of BOD and COD in the waters cause a deficit of oxygen so that it interferes with the life of aquatic organisms, and ultimately causes the death of aquatic organisms. (Nursyafitri, 2019).

There are many conventional technologies based on physical and chemical processes that are available to remove organic matter from the aquatic environment, but most of them combine costly and complex processes of implantation and maintenance (Fazi et al. 2016; Nicomel et al. 2016). One of the waste treatment methods to

reduce organic matter is the phytoremediation method. Phytoremediation technique is a system in which certain plants cooperate with microorganisms in the media (soil, coral, water) to convert pollutants into less or harmless ones. These plants can filter, adsorb organic particles and adsorb metal ions contained in wastewater through plant roots which may be used as remediators of water contaminated with sewage. Phytoremediation takes advantage of the ability of some plants to absorb and accumulate toxic elements in their tissues and includes several processes namely, phytoextraction, phytostabilization and rhizofiltration (Jasrotia et al. 2017; Sarwar et al. 2017).

Aquatic macrophytes are reported to be more effective in waste water treatment in comparison to terrestrial plants because of their faster growth, larger biomass production, relative higher capability of pollutant uptake, and better purification effects due to direct contact with contaminated water (Singh et al., 2012). Usually aquatic plants perform rhizofiltration, where contaminants are removed by absorption and adsorption being accumulated in the roots (Dawete and Byrne 2016).

Salvinia molesta has the ability to absorb toxic elements from water, such as lead, mercury (Kumari et al. 2017), and As (Hariyady et al. 2013). *Salvinia molesta* is most often found in stagnant or slow flowing waters such as lakes, slow-flowing rivers or streams, wetlands, rice paddies, irrigation channels, ditches, ponds and canals (EPPO, 2016). *Salvinia molesta* plant is a type of aquatic plant that has the potential as a phytoremediator to reduce environmental pollution. *Salvinia molesta* is able to absorb nutrients and water-soluble contaminants through its roots. *Salvinia molesta* unique morphology has two types of leaves, namely floating leaves and sinking leaves. *Salvinia molesta* is a floating and free-living pteridophyte. Each plant is composed of two floating oblong-shaped green leaves and a set of submerged long and filiform brown leaves, covered with hairs that absorb water and nutrients, and act as a root (Miranda and Schwartsburd 2016). The second type of leaf that sinks has a root-like shape, hangs, splits and is divided and downy, does not contain chlorophyll and functions to capture nutrients from water such as roots (Soerjani et al. in Nurafifah, 2016). Based on the results of existing research, the *Salvinia molesta* plant was able to reduce the BOD and phosphate of domestic waste reaching 86.35% and 71.71% after 3 days of the research period (Rahmawati, 2016).

The coffee processing industry does not yet have a sewage treatment system and the condition of the liquid waste produced contains organic matter that can increase BOD and COD levels. So there needs to be an effort to reduce the levels of BOD and COD in coffee liquid waste. Therefore, it is necessary to conduct research to examine the effectiveness of *Salvinia molesta* phytoremediation in reducing BOD and COD levels in coffee liquid waste.

2. RESEARCH METHOD

Study used an experimental research design with a completely randomized design (CRD) with four variations of *Salvinia molesta* plant biomass, namely P0: 0 g, P1: 50 g, P2: 75 g, and P3: 100 g with three replications. The tools and materials used are jerry cans, treatment, thermometers, pH meters, and DO meters. The sample of this research is coffee liquid waste. Coffee liquid waste required for one treatment is 5 L. *Salvinia molesta* plants are acclimatized for one week in order to adapt to the new environment. Then the plants were contacted with coffee liquid waste for 6 days from the time the *Salvinia molesta* as put in the treatment tub. Analysis of the data used in this research is using analysis of variance.

3. RESULTS AND DISCUSSION

The results of the research on the phytoremediation of coffee liquid waste showed that the levels of BOD and COD in the coffee liquid waste before treatment were 220 ppm and 644 ppm, respectively. While the results of the analysis of BOD and COD levels can be seen in Figure 1.

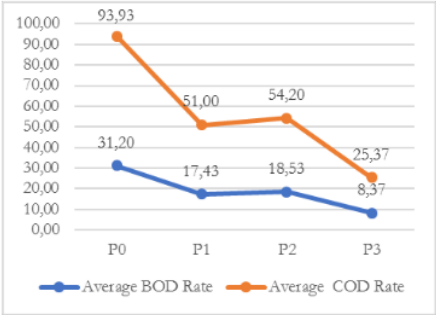

Figure 1. Decrease in BOD and COD levels on day 6

Phytoremediation of *Salvinia molesta* on day 6 shows the percentage decrease in BOD levels at P0, P1, P2, P3 respectively 0%, 44%, 40%, and 73%. While the percentage decrease in COD levels at P0, P1, P2, P3 was 0%, 45%, 42%, and 73%, respectively. Statistical analysis based on homogeneity test can be seen in Table 1.

Table 1. Homogeneity test

	Levene Statistics	df1	df2	Sig.
BOD	1.697	3	8	.244
COD	1.723	3	8	.239

Table 1 shows that sig > 0.05 means that the treatment has a homogenous variance. Then a further test of variance analysis was carried out which got the results of F arithmetic > F table 5% (4.07) and > F table 1% (7.59). So these results indicate that H0 rejected and H1 is accepted which states that *Salvinia molesta* is effectively used as phytoremediation of coffee liquid waste.

The decrease in BOD and COD levels using *Salvinia molesta* in Figure 1, shows the largest average decrease, at P3 which shows a decrease in BOD and COD levels of 8.37 ppm and 25.37 ppm, respectively. It can be explained that P3 provides the best oxygen supply. In addition, the results of photosynthesis carried out by *Salvinia molesta* can also supply oxygen needs which will be used to decompose organic matter contained in coffee liquid waste.

The decrease in BOD and COD levels is in line with the increase in dissolved oxygen in the wastewater. Prior to phytoremediation, the dissolved oxygen content of coffee liquid waste was 2 ppm. On the 6th day of *Salvinia molesta* phytoremediation, dissolved oxygen levels in waste water increased to 4 ppm. This is because the source of dissolved oxygen can come from the photosynthetic activity of aquatic plants. The existence of *Salvinia molesta* plants supports the fulfillment of dissolved oxygen needs in coffee liquid waste, namely by high photosynthetic activity which will result in higher dissolved oxygen in coffee liquid waste (Ningsih, 2017).

The decrease in COD and BOD levels in coffee liquid waste using the *Salvinia molesta* phytoremediation method occurs because it has the ability to self -purify, to clean pollutants that occur naturally (Pribadi, 2016). self-purification is the process of organic waste being destroyed by microorganisms from the respiration process and obtaining stable end products such as CO2, H2O, phosphate, and nitrate (Mcgowan, 2014). *Salvinia molesta* was able to carry out a phytoremediation mechanism to reduce COD and BOD levels of coffee liquid waste on the 6th day.

According to Rahmawati (2016), the decrease in BOD and COD in phytoremediation occurs through physical and biological processes. In the physical process, it occurs through the process of deposition and capture of particle material on organic matter. The decrease in COD and BOD levels in each treatment was due to the solids starting to settle so that the waste water also decreased. In addition, some of the waste material has been oxidized and some has also been absorbed by plants so that it can reduce the value of COD and BOD.

While the biological process occurs in three phases, namely the rhizodegradation phase, the phytodegradation phase and the phytovolatilization phase. In the rhizodegradation phase, plant roots will produce exudate which will encourage the growth and metabolic activity of microorganisms in the rhizosphere. In addition, *Salvinia molesta* can increase the concentration of dissolved oxygen in coffee liquid waste through the process of photosynthesis. Oxygen will flow to the *Salvinia molesta* roots through the stems after it diffuses through the leaf pores so that a rhizosphere zone that is rich in oxygen will be formed throughout the root surface. The release of oxygen by the roots of aquatic plants causes the water or media around the root hairs to have higher dissolved oxygen, making it possible to become a micro-habitat for aerobic microorganisms to carry out decomposition activities (Suprihatin, 2014). Furthermore, the phytodegradation phase, the organic compounds contained in the waste, becomes a source of nutrients for microbes which are then converted into simpler compounds. The last phase, the phytovolatilization phase, is the absorption of organic matter by plants after the previous process and is released in the form of steam into the atmosphere. The decrease in COD and BOD levels in phytoremediation was due to the rhizodegradation phase, namely the decomposition of contaminants in water by microbial activity. Roots produce exudate that will bind to the growth and activity of microorganisms. Microorganisms that play a role in reducing levels of organic matter are aerobic bacteria (Hapsari, 2016). The phytovolatilization phase also affects the decrease in COD and BOD levels in the process of releasing contaminants into the air after being absorbed by plants. All substances have different levels of vapor pressure, which determines the degree of phytovolatilization.

The results showed that the levels of BOD and COD decreased with increasing weight of biomass in the treatment. This research is in line with that conducted by Yuliani (2013) which states that the greater the number of *Salvinia molesta* used, the greater the concentration of pollutants absorbed through plant roots. In floating aquatic species absorption occurs on roots surface and in the aerial part that is in contact with the environment

(Rezania et al. 2016). Thus, the whole plant contributes to pollutant stabilization, absorption and its removal from the water. Roots will involve microorganisms to decompose organic pollutants during the phytoremediation process. The more phytoremediator plants, the more organic matter will be absorbed and the less organic matter that must be degraded by microorganisms. The less organic matter that must be degraded by microorganisms, the higher the oxygen content in waterwaste (Muhajir, 2013).

The *Salvinia molesta* morphology was also observed in the physical condition of the *Salvinia molesta* plant during the treatment. On day 6 plant phytoremediation at P2 showed symptoms of chlorosis and necrosis that occurred due to the absorption of excess organic matter so that it could inhibit the work of enzymes that catalyze chlorophyll synthesis (Rukmi, 2014). The morphological damage of the *Salvinia molesta* is characterized by many yellowing leaves, there are damaged plants that are submerged in waste water so that they rot and the physiological processes of plants are disturbed which results in the plants being less than optimal in absorbing large amounts of pollutants. Phytoremediator plants in reducing waste levels if they are poisoned can experience chlorosis, necrosis and stunted plant growth. *Salvinia molesta* plants experience chlorosis, i.e. leaves that lose chlorophyll are characterized by yellowing of plant leaves. Necrosis is a symptom of death in plant cells which is characterized by curling of plant leaves and wrinkles (Hidayat, 2017).

4. CONCLUSSION

From the results of this research, it can be concluded as follows those variations in *Salvinia molesta* biomass have an effect on decreasing BOD and COD levels in coffee liquid waste, the more plant biomass, the lower the levels of BOD and COD in coffee liquid waste. *Salvinia molesta* is effective as a phytoremediation agent to decrease BOD and COD levels of coffee liquid waste at P3 with a decrease of 73%.

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