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**RESEARCH ARTICLE**

# Phytoremediation using *Eichhornia crassipes* and *Pistia stratiotes* to reduce Biological Oxygen Demand (BOD) and Phosphate level in wastewater

**Achmad Syifa Ul Qulub Al Arifin[1], Farrah Aini Dahalan[2*]**

[1]Departement of Public Health, Universitas Nahdlatul Ulama Surabaya, Indonesia

[2]Faculty of Civil Engineering Technology, University Malaysia Perlis, Malaysia

[*]**Corresponding author:** farrahaini@unimap.edu.my

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**Abstract**

Wastewater produced by health facilities such as Community Health Centers has great potential to pollute the environment, especially due to the high levels of Biological Oxygen Demand (BOD) and phosphate. Phytoremediation, using plants such as Eichhornia crassipes and pumice, is an efficient, environmentally friendly, and economical waste treatment method. The purpose of this study was to analyze the effectiveness of Eichhornia crassipes and pumice plants in phytoremediation tests on community health center wastewater with BOD and phosphate parameters. This type of research is a true experimental using a One group pretest and posttest design. The sample in the study was Community Health Center wastewater with a sample size of 10 L. BOD and phosphate levels were measured on days 0, 3, 6, and 9 to determine the effectiveness of phytoremediation in reducing pollutant levels. The data analysis used univariate. The results showed that BOD levels decreased significantly from 21.08 mg/L on day 0 to 10.36 mg/L on day 9 with a decrease rate of 51%. In addition, phosphate levels also decreased from 0.95 mg/L to 0.28 mg/L with a decrease of 71% after 9 days of treatment. Phytoremediation using Eichhornia crassipes and pumice wood is effective in reducing BOD and phosphate levels in Puskesmas wastewater. Suggestions for further researchers are the development of time variations and combination methods, exploration of other plants, the influence of environmental factors, larger scale tests.

**Keywords:** Phytoremediation, BOD, Phosphate, *Eichhornia crassipes*, *Pistia stratiotes*.

## INTRODUCTION

The Ministry of Environment and Forestry (KLHK) stated that the Water Quality Index (IKA) in 2022 scored 53.88, which still did not meet the target due to the increase in higher pollution loads (SJ, 2023). According to Government Regulation No. 82 of 2001, water pollution occurs when living things, substances, energy, or other components enter or are introduced into water by

human activities so that the water quality decreases to a certain level which causes it to not function according to its use.

This pollution can come from the atmosphere, soil, runoff from agricultural land, domestic, urban, industrial waste, and others (Effendi, 2003). As with health center liquid waste, namely all waste from the health center service process which includes domestic liquid waste (kitchen waste, bathroom waste), clinical wastewater (water used to wash wounds, blood, and others), and laboratory wastewater. This medical waste can cause pathogens that have a negative impact on humans and the environment, such as surface and ground water pollution, which can cause digestive tract diseases such as diarrhea, dengue fever, typhus, cholera, hepatitis A, and dysentery (Komariyah and Sugito, 2011). Therefore, every health service must manage health center liquid waste according to applicable standards (Yuwati et al., 2023).

Based on the Regulation of the Governor of East Java No. 72 of 2013 concerning the quality standards for Puskesmas wastewater, the maximum limit for liquid waste produced from Puskesmas service activities to be discharged into the environment. The determination of quality standards is intended to reduce water pollution due to untreated wastewater discharge and to identify whether the treatment system used is effective or not. The parameters measured to determine the quality of Puskesmas liquid waste consist of BOD (Biological Oxygen Demand) and Phosphate. BOD is a characteristic that indicates the amount of dissolved oxygen required by microorganisms (bacteria) to decompose or decompose organic matter under aerobic conditions. BOD is a measure of the amount of oxygen used by the microbial population contained in waters in response to the entry of organic matter that can be decomposed (Pungus et al., 2019). High BOD levels can affect the wastewater treatment process because the bacteria present can grow and develop well due to a lack of O2 so that organic matter and other pollutants cannot be decomposed properly (Paputungan et al., 2020). According to the East Java Governor Regulation No. 72 of 2013, the BOD quality standard permitted for discharge into the environment is 30 mg/L.

Phosphate is one form of chemical pollution source that mostly comes from soap or detergent washing waste produced by Puskesmas activities. Excess phosphate content can disrupt groundwater and if the water is consumed by humans it can cause kidney damage (Fitriatin et al., 2009). According to the Regulation of the Governor of East Java Number 72 of 2013 concerning Wastewater Quality Standards for Industry or Other Business Activities, the threshold value for phosphate parameters is 2 mg/L. To create a healthy and comfortable environment, environmental pollution control efforts are carried out in health service facilities in the form of providing Wastewater Treatment Plants (IPAL) (Ningrum and Khalista, 2017). Wastewater Treatment Plants (IPAL) have a great influence on Puskesmas because IPAL can minimize the dangers caused and make the quality of wastewater according to the expected standards. If the quality of wastewater does not comply with quality standards, it can result in a decrease in the level of oxygen dissolved in the wastewater. Therefore, it is necessary to evaluate the management of IPAL (Susanti et al., 2020).

Based on the results of a preliminary study at Health Center X, the Wastewater Treatment Plant (WWTP) at Health Center X has been operating for 6 years, with inspection of the quality of the liquid waste of Health Center X carried out 2 times in 1 year. The condition of the waste always meets the quality standards set by the Governor of East Java Regulation No. 72 of 2013, but in the second inspection in 2023, approaching the sixth year of WWTP operation, there were parameters that exceeded the quality standards such as BOD of 33 mg/L and Phosphate of 7.3 mg/L. This problem arises due to two main factors, namely: Lack of aeration or oxygen supply in the biological treatment process and damage to the aerator at the WWTP of Health Center X. The impact of this problem is a decrease in the efficiency of wastewater treatment, which results in an increase in BOD and phosphate levels in wastewater.

To reduce pollution caused by wastewater, wastewater treatment is a must. One effective treatment method is the biological method, such as phytoremediation, which uses aquatic plants.

This method is relatively new, cheap, easy, and effective in reducing the levels of organic matter in wastewater. Two plants that are often used in phytoremediation are pumice and *Eichhornia crassipes*. Both of these plants are able to process waste, including heavy metals, organic, and inorganic substances. They absorb organic and inorganic compounds into their structure, allowing the movement of ions through cell membranes. These plants can be used to remove phosphate and BOD (Prastikanala and Wijaya, 2023). According to previous research, phytoremediation with *Eichhornia crassipes* plants is very effective in reducing BOD and phosphate levels in laundry waste. *Eichhornia crassipes* can reduce BOD levels by up to 68.86% and phosphate by up to 77.5% (Hafidhin et al., 2023). According to previous research, it was shown that the measurement of BOD values after 14 days of the phytoremediation process of *Eichhornia crassipes* and pumice wood on Citarum River waste experienced a decrease in value in all treatments. In the pumice wood treatment, the decrease in organic matter was 36.41% while *Eichhornia crassipes* was 8.96% (Audiyanti et al., 2019). According to other studies, it also shows that *Eichhornia crassipes* can reduce phosphate levels in laundry waste from 97.5% to 37.7% (Silmi and Dewi, 2023).

*Eichhornia crassipes* has a rapid growth rate and can spread through water channels, growing in ponds, rivers, lakes, and swampy areas. This plant is able to adapt to extreme changes such as water flow, nutrient levels, pH, temperature, and water level. *Eichhornia crassipes* thrives in water containing high nutrients, especially nitrogen, potassium, and phosphate. Meanwhile, Pistia stratiotes is an aquatic plant that is often found floating in calm waters or ponds, known as an aquarium protective plant and the only member of the Pistia genus, also called apu-apu or kapu-kapu (Safitri, 2009). From this problem, it is necessary to study the phytoremediation method using *Eichhornia crassipes* and Pistia stratiotes to reduce phosphate and BOD levels in the outlet tank of the X Health Center IPAL.

## MATERIALS AND METHODS

True experimental research type. This study was conducted to determine the effectiveness of 2 plants, namely Eichhornia crassipes and pumice wood in phytoremediation tests on medical liquid waste. One group pretest and posttest, namely providing treatment and then measurements were taken with the aim of determining the effectiveness of Eichhornia crassipes and pumice wood in reducing BOD and Phosphate parameter levels in wastewater taken from the outlet tank of the X Health Center IPAL. The pretest was conducted before the phytoremediation treatment was applied to measure water conditions. This measurement can include BOD and Phosphate parameters. The posttest was conducted after the phytoremediation treatment to measure the effectiveness of phytoremediation in reducing contamination. This measurement was carried out in the same way as the pretest, and the results were compared to see if there were significant changes.

## RESULTS AND DISCUSSION

### Phytoremediation using *Eichhornia crassipes* on BOD parameter

The results of measuring the BOD levels of wastewater from Health Center X before treatment showed an average of 21.08 mg/L. After treatment, there was a gradual decrease in BOD levels. On the 3rd day, the BOD levels dropped to 18.44 mg/L, which is equivalent to a decrease of 13%. Furthermore, on the 6th day, the BOD levels decreased further to 14.81 mg/L, with a percentage decrease of 30%. On the 9th day, the BOD levels reached 10.36 mg/L, indicating a decrease of 51%. This decrease occurred in the group given *Eichhornia crassipes* treatment.

**Table 1.** Results of BOD Parameter Level Reduction in *Eichhornia crassipes* Efforts

| Day | BOD (mg/L) | Removal Percentage (%) |
|---|---|---|
| 0 | 21.08 | 0 |
| 3 | 18.44 | 13 |
| 6 | 14.81 | 30 |
| 9 | 10.36 | 51 |

Based on Table 1, it can be concluded that from the observation results from day 0 to day 9, it was found that the BOD levels decreased with the lowest average of 10.36 mg/L on day 9, which showed a decrease of 51%. While the highest average BOD level after treatment was recorded on day 3, which was 18.44 mg/L with a percentage decrease of 13

The mechanism of the phytoremediation process of *Eichhornia crassipes* plants in reducing BOD concentration levels in wastewater decreased over time for 3, 6, and 9 days in the phytoremediation process. This decrease in BOD concentration can be interpreted as a positive indicator in the context of wastewater treatment, because lower BOD indicates a decrease in organic load that can be degraded by microorganisms in water (Vigiak et al., 2019). The phytoremediation process, which utilizes *Eichhornia crassipes* plants to reduce or neutralize pollutants, has been proven effective in reducing BOD concentrations in wastewater X. Plants act as the main agents in absorbing and metabolizing organic matter, as well as increasing the activity of microorganisms that help in the organic degradation process (Masciandaro et al., 2013).

Based on the results of the measurements carried out, it is known that the average BOD level of wastewater at Puskesmas X before being given treatment was 21.08 mg/L. This is in line with research conducted by Kerubun, 2014 that the BOD level of wastewater before treatment was 68 mg/L. From the results of the study, there was a similarity in the large BOD before wastewater treatment. BOD levels are an important indicator in determining the level of water pollution by organic materials. The higher the BOD level, the greater the amount of oxygen needed by microorganisms to decompose organic materials in the water.

The decrease in BOD levels on day 3 from 21.08 mg/L to 18.44 mg/L, which is equivalent to a decrease of 13%, indicates that the treatment applied is effective in reducing the organic content in the wastewater of Health Center X. This result is in line with the research findings by Imron et al., 2019 where the treatment using *Eichhornia crassipes* plants successfully reduced BOD levels from 95 mg/L to 13.0 mg/L on the 4th day. This shows the potential for using *Eichhornia crassipes* as an effective wastewater treatment method, due to the ability of this plant to absorb and decompose excess organic matter in water. In addition, the success of these two studies strengthens the evidence that phytoremediation methods can be a sustainable solution in liquid waste management, especially in health facilities that require efficient and environmentally friendly waste management. This decrease also indicates that the wastewater treatment system applied is in accordance with local environmental conditions, so that it can achieve significant results in a short time.

The decrease in BOD levels on the 9th day from 21.08 mg/L to 10.36 mg/L, which is equivalent to a decrease of 51%, shows that the treatment applied is effective in reducing the organic content in the wastewater of Health Center X. The same results have also been reported in research Rachman, 2022 that recorded a decrease in BOD levels from 21.5 mg/L to 10.5 mg/L within nine days, a decrease of 51%. This phytoremediation method can be relied upon to improve the quality of wastewater, which is very important for maintaining a clean and healthy environment.

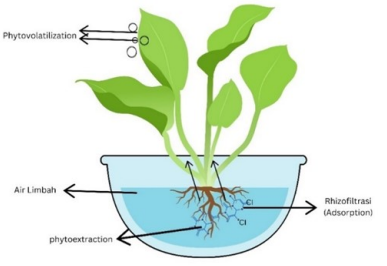


**Figure 1.** Phytoremediation process in *Eichhornia crassipes* plant

Figure 1 shows the mechanism of *Eichhornia crassipes* growth in reducing BOD levels of wastewater from Health Center X due to the phytoremediation process. Phytoremediation is a system where plants work together with microorganisms in media such as soil, coral, and water to change contaminants into less dangerous or harmless substances (Anam et al., 2013). In this case, *Eichhornia crassipes* as a remediator has the unique ability to absorb various pollutants originating from the decomposition of living things in water. In addition, this plant also produces oxygen which is very much needed by decomposing bacteria to process these pollutants into harmless substances (Rukmi, 2013). The ability to absorb pollutants by *Eichhornia crassipes* plants is facilitated by the presence of roots that contain rhizosphere microbes in them. These microbes play a role in the Rhizofiltration process, namely the process of absorption and accumulation of pollutants in the roots. Microbes that live around the roots of *Eichhornia crassipes* play an important role in the rhizofiltration process.

These microbes help in the decomposition of organic matter into simpler forms that can be absorbed by plant roots, the activity of these microbes reduces the concentration of organic matter in water, which directly lowers BOD (Vidyawati and Fitrihidajati, 2019). Rhizosphere microbes can also oxidize organic matter, converting it to carbon dioxide and water, which do not contribute to BOD. *Eichhornia crassipes* roots have the ability to release oxygen into the water through a process known as transpiration. The oxygen released by these roots increases the dissolved oxygen levels in the water, which is essential for the aerobic decomposition of organic matter by microorganisms. Increased dissolved oxygen levels help speed up the decomposition of organic matter and reduce BOD (Ni'ma and Widyorini, 2014). Based on the above research, it can be concluded that the wastewater has met the standard quality values according to the Regulation of the Governor of East Java No. 72 of 2013 concerning Wastewater Quality Standards. The low percentage of decline is influenced by the length of time the plants live with the wastewater of Puskesmas X.

*Eichhornia crassipes* reduce BOD concentrations through a phytoremediation mechanism that involves the absorption of organic matter by the roots and symbiotic activity with microorganisms. Its hairy roots absorb organic ions resulting from microbial degradation, while releasing oxygen through transpiration to support the aerobic oxidation process by decomposing bacteria (]Mutmainah et al., 2019). The large surface area of roots and leaves increases the efficiency of pollutant absorption, while root exudates provide substrates for microbes to accelerate organic matter decomposition. *Eichhornia crassipes* clump density is directly proportional to the BOD reduction, where 15 clumps were able to reduce BOD by 97.36% in palm oil effluent through adsorption and biochemical processes (Hafidhin et al., 2023). Longer exposure time (up to 9 days) increases the contact between pollutants and the root system, maximizing the absorption of organic compounds that cause BOD (Astuti and Rosemalia, 2022). This combination of physical (filtration) and biological (microbial activity) mechanisms results in significant BOD reduction, reaching 84.60-96.33% in laboratory effluents after 9 days of exposure (Malina et al., 2024).

### Phytoremediation using *Eichhornia crassipes* on phosphate parameter

Phosphate levels of wastewater from Health Center X before treatment showed an average of 0.95 mg/L. After treatment, there was a gradual decrease in phosphate levels. On the 3rd day, phosphate levels dropped to 0.73 mg/L, equivalent to a decrease of 23%. Furthermore, on the 6th day, phosphate levels dropped further to 0.48 mg/L, with a percentage decrease of 49%. On the 9th day, phosphate levels reached 0.28 mg/L, indicating a decrease of 71%. This decrease occurred in the group given *Eichhornia crassipes* treatment.

**Table 2.** Results of the Decrease in Phosphate Parameter Levels in *Eichhornia crassipes*

| Day | Phosphate (mg/L) | Removal Percentage (%) |
|---|---|---|
| 0 | 0.95 | 0 |
| 3 | 0.73 | 23 |
| 6 | 0.48 | 49 |
| 9 | 0.28 | 71 |

Based on Table 2, it can be concluded that from the observation results from day 0 to day 9, it was found that phosphate levels decreased with the lowest average of 0.28 mg/L on day 9, which showed a decrease of 71%. While the highest average phosphate level after treatment was recorded on day 3, which was 0.73 mg/L with a percentage decrease of 23%.

Based on the results of the research that has been done, it can be seen in Table 2 which shows that the initial sample results for phosphate levels were 0.95 mg/L. After 3 days of treatment, it showed a decrease in phosphate levels of 0.73 mg/L with an average percentage of 23%. The same results have also been reported in the research of Fitria and Sukmana (2019), *Eichhornia crassipes* plants were able to reduce phosphate levels from 0.95 mg/L to 0.73 mg/L within 3 days, showing a decrease of 23%. The decrease in phosphate levels on the 9th day from 0.95 mg/L to 0.28 mg/L, which is equivalent to a decrease of 71%, indicates that the treatment applied is effective in reducing phosphate levels in the wastewater of Health Center X. This study supports the results obtained by Nurhayati and Prasetya (2017), showing that *Eichhornia crassipes* is able to reduce phosphate levels from 0.93 mg/L to 0.29 mg/L in nine days, which reflects a decrease of 69% in domestic wastewater treatment.

Phytoremediation of *Eichhornia crassipes* can reduce phosphate levels because the phytoremediation process decomposes organic materials in wastewater by microbes around the roots of *Eichhornia crassipes* plants, where the process is shown in Figure 6.1. Microbes in the roots of *Eichhornia crassipes*, namely rhizosphere microbes, play an important role in decomposing organic materials in waste and reducing phosphate levels in water, supporting phytoremediation. These microbes convert organic phosphate into inorganic forms that are more easily absorbed by plants through the process of mineralization and phosphatase enzymes. Some microbes, such as Pseudomonas and Bacillus, dissolve phosphates that are insoluble in water by releasing organic acids. Rhizosphere microbes also form biofilms around plant roots, increasing nutrient absorption and phosphate retention. The combination of microbial and plant activities, such as *Eichhornia crassipes*, is effective in reducing phosphate pollution and improving water quality naturally (Raissa, 2017).

Phosphate removal in this study showed removal of 23-71%. The use of *Eichhornia crassipes* plants successfully removed phosphate by 23% on day 3 and on day 9 by 71%. The decrease in levels was influenced by the contact time of the plants with wastewater and the ability of *Eichhornia crassipes* plants to absorb phosphate levels through the roots. The results of the study showed that phosphate levels had decreased and had met the standard quality values set by the Regulation of the Governor of East Java No. 72 of 2013 concerning Wastewater Quality Standards.

The *Eichhornia crassipes* reduces phosphate concentrations in water through a phytoremediation mechanism involving the uptake of phosphate ions by plant roots. *Eichhornia crassipes* roots have a broad and fine-haired structure, allowing efficient uptake of ortho-phosphate from wastewater. In addition, these plants interact with microorganisms in the rhizosphere that aid in the phosphate

degradation process, increasing the accumulation of nutrients in plant tissues (Pii et al., 2015). This process is also supported by the plant's ability to produce root exudates that provide substrate for decomposing microbes, accelerating the decrease in phosphate concentration. Thus, *Eichhornia crassipes* serves not only as a phosphate sink, but also as a link in the microbial ecosystem that contributes to the effective treatment of wastewater (Yanti and Simanjuntak, 2024).

**Phytoremediation using *Pistia stratiotes* on BOD parameter**

The results of measuring the BOD levels of wastewater from Health Center X before treatment showed an average of 19.58 mg/L. After treatment, there was a gradual decrease in BOD levels. On the 3rd day, the BOD levels dropped to 15.71 mg/L, which is equivalent to a decrease of 20%. Furthermore, on the 6th day, the BOD levels decreased further to 10.86 mg/L, with a percentage decrease of 46%. On the 9th day, the BOD levels reached 8.95 mg/L, indicating a decrease of 54%. This decrease occurred in the group given the pumice plant treatment.

**Table 3.** Results of BOD Parameter Level Reduction in *Pistia stratiotes*

| Day | BOD (mg/L) | Removal Percentage (%) |
|---|---|---|
| 0 | 19.58 | 0 |
| 3 | 15.71 | 20 |
| 6 | 10.86 | 46 |
| 9 | 8.95 | 54 |

Based on Table 3, it can be concluded that from the observation results from day 0 to day 9, it was found that the BOD levels decreased with the lowest average of 8.95 mg/L on day 9, which showed a decrease of 54%. While the highest average BOD level after treatment was recorded on day 3, which was 15.71 mg/L with a percentage decrease of 20

The decrease in BOD levels on the 3rd day from 19.58 mg/L to 15.71 mg/L, which is equivalent to a 20% decrease, indicates that the applied treatment is effective in reducing BOD content in the wastewater of Puskesmas X. These results are in line with research conducted by Susilo and Utami (2017), the *Pistia stratiotes*is able to reduce BOD levels from 19.70 mg/L to 15.60 mg/L in three days, indicating its effectiveness in industrial wastewater treatment. This shows the potential for using *Pistia stratiotes* as an effective wastewater treatment method, due to the ability of this plant to absorb and decompose excess organic matter in water.

The decrease in BOD levels on the 6th day from 19.58 mg/L to 10.86 mg/L, which is equivalent to a decrease of 46%, indicates that the applied treatment is effective in reducing BOD content in the wastewater of Puskesmas X. The same results were also reported by Dewi and Handayani (2019), in this study, Kayu Apu succeeded in reducing BOD from 18.90 mg/L to 10.50 mg/L within 6 days, which is equivalent to a decrease of 44%. These results indicate the effectiveness of the phytoremediation method using kayu apu plants in hospital wastewater treatment.

The decrease in BOD levels on the 9th day from 19.58 mg/L to 8.95 mg/L, which is equivalent to a decrease of 54%, shows that the treatment applied is effective in reducing BOD content in the wastewater of Health Center X. This study supports the results obtained (Tampubolon et al., 2020), the decrease in BOD levels on the 9th day, showed a decrease of 91% which indicates the high effectiveness of *Pistia stratiotes* in reducing BOD levels. These results indicate that *Pistia stratiotes* has a high ability to absorb and decompose organic materials contained in wastewater. The decrease in BOD levels is due to the extensive root system and the ability of this plant to provide an ideal habitat for decomposing microorganisms that contribute to the BOD reduction process. Thus, these results support the application of *Pistia stratiotes* as an efficient and environmentally friendly alternative for wastewater treatment.

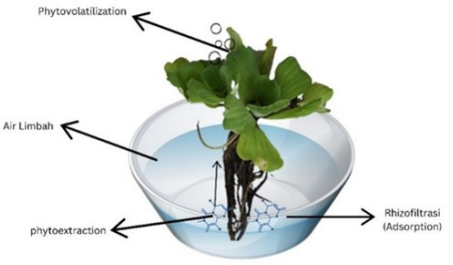


**Figure 2.** Phytoremediation Process in *Pistia stratiotes* Plant

Figure 2 shows the mechanism of the pumice plant in the reduction caused by the phytoremediation process in the pumice plant has nutrient absorption. The root system of the pumice plant produces oxygen that can be used as an energy source for a series of metabolic processes for microorganisms, the roots of the pumice plant play an active role in reducing BOD levels (Riyanto, 2023). The decrease in BOD levels can be caused by the phytodegradation process and organic contaminants that are absorbed through the roots and decomposed through the metabolic process in plants. The decrease in pollutants is caused by the phytovolatization process which is the absorption of pollutants by plants after the process and is released in the form of water vapor into the atmosphere, where this process is used by organic contaminants (Rismawati et al., 2020).

Based on this study, it can be said that the phosphate levels decreased and successfully met the standard value of wastewater quality standards. The decrease in BOD levels in wastewater is influenced by the length of time the plants stay with the wastewater of Puskesmas X. So the contact time of 9 days is the most effective for woody plants in reducing BOD levels. Although the highest decrease occurred on the 9th day of 8.95 with a percentage of 54%, on the 3rd day it also showed a decrease with a value of 15.71 mg/L with a percentage of 20% and on the 6th day it also showed a decrease in levels of 10.86 mg/L with a percentage of 46%. These results indicate that in each treatment, the *Pistia stratiotes*is effective in reducing BOD levels in wastewater.

The *Pistia stratiotes* reduces BOD concentrations in water through a phytoremediation mechanism that involves the uptake of organic matter by roots and interaction with microorganisms (Victor et al., 2016). The *Pistia stratiotes* have the ability to absorb dissolved organic compounds, which contributes to the reduction of BOD levels by removing the source of nutrients for pathogenic microorganisms. In addition, the photosynthesis process carried out by the plant's leaves produces oxygen, which supports aerobic microbial activity in decomposing organic matter (Khatoon et al., 2017). The decomposition of submerged roots and leaves also plays a role in increasing microbial biomass, which further enhances the process of decomposing organic matter. Thus, the combination of direct uptake by plants and microbial biochemical activity in the rhizosphere results in a significant reduction in BOD concentration in wastewater (Shahid et al., 2020).

### Phytoremediation using pumice wood on phosphate parameter

Phosphate levels of wastewater from Health Center X before treatment showed an average of 0.79 mg/L. After treatment, there was a gradual decrease in phosphate levels. On the 3rd day, phosphate levels dropped to 0.54 mg/L, equivalent to a decrease of 32%. Furthermore, on the 6th day, phosphate levels dropped further to 0.32 mg/L, with a percentage decrease of 59the 9th day, phosphate levels reached 0.19 mg/L, indicating a decrease of 76%. This decrease occurred in the group given the

pumice plant treatment.

**Table 4.** Results of the Decrease in Phosphate Parameter Levels in *Eichhornia crassipes*

| Day | Phosphate (mg/L) | Removal Percentage (%) |
|---|---|---|
| 0 | 0.79 | 0 |
| 3 | 0.54 | 32 |
| 6 | 0.32 | 59 |
| 9 | 0.19 | 76 |

Based on Table 4, it can be concluded that from the observation results from day 0 to day 9, it was found that phosphate levels decreased with the lowest average of 0.28 mg/L on day 9, which showed a decrease of 76%. While the highest average phosphate level after treatment was recorded on day 3, which was 0.73 mg/L with a percentage decrease of 32

Based on the results of the research that has been done can be seen in Table4 which shows that the initial sample results for phosphate levels were 0.79 mg/L. After being treated, it showed a decrease in phosphate levels of 0.19 mg/L with an average percentage of 76%. This research is in line with Ervina's research on Phytoremediation of *Pistia stratiotes* to Reduce Phosphate Levels. The most optimum results were shown by reactor F with a root length of more than 10 cm with 16 plants on day 10 with an efficiency of 75.36% BOD and Phosphate of 86.10% on day 12 (Ramadhan et al., 2017).

The decrease in phosphate levels on the 3rd day from 0.79 mg/L to 0.54 mg/L, which is equivalent to a decrease of 32%. The results of this study are in line with the research of Mustafa and Hayder, 2020 showing that *Pistia stratiotes* is able to reduce phosphate levels up to 34,28% , supporting the use of pumice plants in reducing phosphate levels in wastewater.

The decrease in phosphate levels on the 9th day from 0.79 mg/L to 0.19 mg/L, with a percentage decrease of 76%. This study supports the results obtained by Cahyani et al., 2025, Finding that Kayu Apu is able to reduce phosphate levels with a percentage decrease of 75%, which shows the ability of this plant to significantly reduce phosphate levels can be explained by the ability of its roots to absorb nutrients efficiently, as well as providing an ideal microenvironment for phosphate-decomposing microorganisms.

In Figure 2, the process of decreasing phosphate levels is due to the roots of the pumice tree having an important role in absorbing phosphate dissolved in water. Phosphate adsorbed on the surface of the roots will then be translocated to other parts of the plant, such as stems and leaves, to be used in the metabolic process. The pumice tree uses the absorbed phosphate for various metabolic processes, such as the formation of organic compounds, cell growth, and energy production. This metabolic process can change the form of phosphate into a compound that is more stable and difficult to degrade by microorganisms. In addition to the roots, the surface of the stems and leaves of the pumice tree also has the ability to adsorb phosphate. This adsorption occurs because of the electrical charge on the surface of the plant that can attract phosphate ions. Phosphate that has been absorbed by the plant can react with other compounds in the plant body, forming insoluble compounds (precipitation). This precipitation compound will accumulate in plant tissue, thereby reducing the concentration of phosphate in wastewater (Rompas, 1998).

The results of the study showed that *Eichhornia crassipes* plants successfully removed phosphate by 23-71%. On the 3rd day, phosphate decreased by 23%, on the 6th day by 49%, and on the 9th day by 71%. The decrease in phosphate levels was influenced by the contact time of the plant with wastewater and the ability of *Eichhornia crassipes* plants to absorb phosphate through their roots. The results obtained have met the standard quality values in accordance with the Regulation of the Governor of East Java No. 72 of 2013 concerning Wastewater Quality Standards. The low percentage of decrease was influenced by the length of time the plant stayed with the wastewater of Puskesmas X.

Adenosine triphosphate (ATP) plays an important role in phosphate uptake by the roots of the *Pistia stratiotes* through an active transport mechanism. This process begins when plant roots bind phosphate ions from the environment, which then require energy to move the ions against a concentration gradient (Palmgren, 1998). ATP, as the main energy source in the cell, provides the energy required to activate transport proteins in the root cell membrane. Using the energy from ATP, these transport proteins change their shape, allowing phosphate ions to move from the low concentration outside the cell to the high concentration inside the root cell. The absorbed phosphate is then used in plant metabolism, including the formation of important compounds such as RNA, DNA, and nucleoproteins that support root growth and other physiological functions (Rosawanti, 2019).

## CONCLUSIONS

*Eichhornia crassipes* plants can reduce BOD levels from 21.08 mg/L to 10.36 mg/L with a percentage of 51% in 9 days. In the phosphate parameter, there is a decrease in concentration from 0.95 mg/L to 0.28 mg/L with a percentage of 71% in 9 days. While the Kayu Apu plant can also reduce Phosphate levels from 0.79 mg/L to 0.19 mg/L with a percentage of 76% and is able to reduce BOD levels from 19.58 mg/L to 8.95 mg/L with a percentage of 54% in 9 days. Thus, *Pistia stratiotes* is more effective in reducing phosphate and BOD levels than *Eichhornia crassipes* on the 9th day.

### Author contributions

Achmad Syifa Ul Qulub Al Arifin: Conceptualization, analysis, draft writing, and editing; Farrah Aini Dahalan: Conceptualization and Data analysis.

### Conflict of Interest

There is no conflict of interest in this study.

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### Data availability

Data related to the findings of this study are available at the corresponding author.

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