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Improving Lake Water Clarity by Cultivation of Water Hyacinth (*Eichornia crassipes*)

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Abstract: Research on the use of water hyacinth (WH) to improve the quality of polluted water has been widely reported, but discussions on the ability of WH to clear turbid water are still rare. This research examines the possibility of using WH as a natural clarifier for Lake Bata. Treatments with 3 variations in the percentage of lake closure with WH cultivation (25, 50, and 75%) were applied for 40 days with 3 repetitions. Water quality and turbidity measurements were carried out every 4 days. The data was analyzed descriptively in graphical form to see a model of these changes. It was found that the pollutants Fe, Hg, nitrate, phosphate and ammonia were present in very small and safe quantities, but the water turbidity level did not meet the standards of the Indonesian Minister of Health yet. During the WH growth, the turbidity decreasing follows the equation $Y(25) = -0.114x + 28.52$; $Y(50) = -0.195x + 29.83$; and $Y(75) = -0.235x + 30.14$ for cover percentages of 25, 50 and 75% respectively, where y for the turbidity (NTU) and x for WH growth time (days). To meet turbidity standards, WH coverage percentages of 25, 50, and 75%, require cultivation periods of 32, 28, and 24 days, respectively.

Keywords: Bio absorption; Phytoremediation; Turbidity; Water quality

Introduction

There are many sources of surface water in Indonesia that cannot be utilized because the water conditions do not meet health requirements (Putrawiyanta, 2020; Novianti, 2020; Hidayat, 2008). One of them is a brick lake in Tangkit Village, Sungai Gelam District, Muaro Jambi Regency, Jambi. In this village there are more than 12 brick lakes with various sizes in width and depth. This lake was created from the impact of land excavation to meet the needs of raw materials for making bricks. The size of brick lakes ranges from 5,000-20,000 m^2 with a pool depth of 1-3 m. If the quality of lake water can be improved, there will be a lot of water available for household needs (Bathhouse and drinking water) or for freshwater fish farming. For this reason, special technology applications are needed which are environmentally friendly at low cost and can be done by villagers (Mustafa & Hayder, 2021; Undap & Tumbol, 2016; Naimullah, 2023).

Biologically, improving the quality of lake water can be done through the mechanism of absorption of mineral and metal elements as well as remediation of lake water conditions by growing WH on the surface of the lake (Huynh et al., 2021; Kasmuri et al., 2023; Rezania et al., 2015). WH has the ability to absorb Cd, Hg and Ni elements in polluted waters, lowering iron (Fe) levels, and also phosphate levels (Abbas et al., 2021; Nasir et al., 2022). WH also has the ability to absorb certain organic, inorganic and chemical

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compounds contained in domestic wastewater (Mishra & Maiti, 2017; Rezania et al., 2015).

WH cultivation in polluted lakes not only reduce the content of material polluter chemistry such as ammonia, phosphate, and nitrate but also the physical pollutants in the form of suspension soil, mud, and the other solid materials (Al-Taai, 2021; Janocha & Kluk, 2021; Tian et al., 2022; Shiferaw et al., 2023; Zhang et al., 2022). Absorbance and phytoremediation of brick lake water in this study was carried out by modifying the method of Hasani et al. (2021), a certain area of WH was grown in brick lake water for 40 days. During the growth of WH, the chemical and physical quality of the water was measured every 4 days. The results were mapped to determine the kinetics of changes in lake water quality during WH growth (Hasani et al., 2021).

This study aims to determine the effect of cultivating WH on various coverage areas to enhancement pond water clarity and determine the model for reducing pond water turbidity during cultivation. The novelty of this research is a technique to biologically increase lake water clarity by cultivating water hyacinth.

Method

Material and Chemical

This research was divided into two stages, namely the preliminary research stage which included work in the form of preparation of tools and materials as well as determination of baseline data on lake water quality before being treated with bio absorbance and phytoremediation with WH. The second stage is the main research, which is the stage of applying WH as a biological agent in carrying out bio-absorption and phytoremediation in order to eliminate accumulated waste which causes a decrease in lake water quality and low biological carrying capacity to support the growth and development of Lake Biota, including fish.

The WH plant specifications used consist of several criteria as follows: number of leaves 3-6, leaf length 3-6 cm, plant height around 10-14 cm, have fresh leaves and not yellowing, weighs around 15-20 grams, stem diameter 10-15 cm and crown diameter 20-25 cm so it has a covering about 0.025 m^2 for every stem. Prior to use, WH plants were acclimatized for 1 week in a pond with clean water conditions (Abou-Shanab et al., 2007). The percentage of pond surface closure by WH was calculated based on the ratio between the accumulated cover areas of a number of WH stems divided by the surface area of the pond. A pond with a surface area of 10 m^2 requires 100 stems of WH for 25% closure, 200 stems for 50% closure, and 300 stems for 75% closure.

The iron (Fe) content was analysed using the SM3030B-2017 and SM3120B-2017 methods. Mercury (Hg) content was measured using the IK No. 19-67/IK (ICP-OES). Phosphate, nitrate and ammonia contents were measured using a convenient rapid test kit. Turbidity was measured using the spectrophotometric method with a HACH 2100N turbidity meter. Measurements were made by inserting 100 ml of sample into the sample tube in the turbidity meter. The number obtained is the value of water turbidity in nephelometric turbidity units (NTU).

The data obtained were analysed graphically to determine the kinetics of changes in each parameter in response to the treatment of WH growth at several variations surface cover percentage. The most appropriate kinetic model for changes in pond water quality was determined based on the largest correlation coefficient value. The flow diagram of research implementation could be seen in Figure 1.

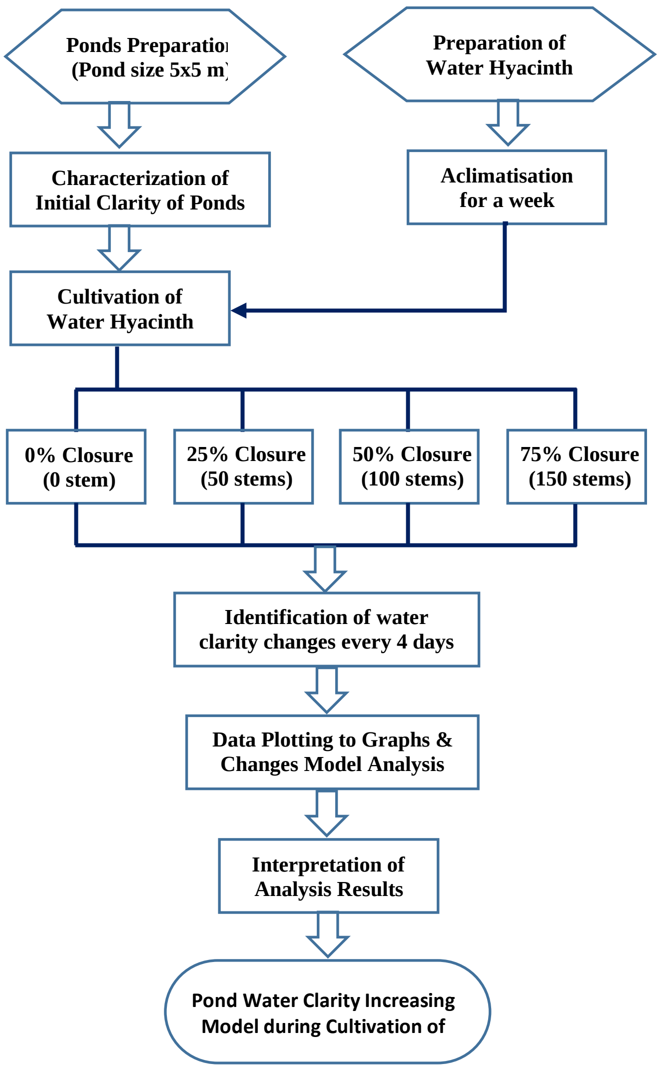

Figure 1. The flow diagram of research implementation

Result and Discussion

Chemical Quality of Brick Lake Water

Brick Lake water contains very low heavy metals Fe and Hg (respectively 0.0018 and 0.0002 mg/L), does not contain phosphate and nitrate, only contains 0.0750 mg/L of ammonia; still meets the requirements for sanitation hygiene purposes according to the Republic of Indonesia Minister of Health Regulation No. 32-2017. This is in line with report by Amin et al. (2022) which is the water quality of Brick Lake has good potential to be used as a source of household water. The high turbidity of the water (40.75 NTU) might cause by the large amount of material such as dust suspended in the water (Noor, 2020; Khayan et al., 2023; Ganesha et al., 2023).

Models of Changes in Brick Lake Water Turbidity

Lakes that was not cultivated with WH has a turbidity of 40.15 ± 0.59 NTU on the surface and 41.38 ± 1.25 NTU in the middle of the lake. At 25% of the surface area covered by WH, after 40 days the water turbidity was 24.50 ± 1.28 NTU on the surface and 24.00 ± 0.82 NTU in the middle, respectively. At 50% of the surface area covered by WH, after 40 days the water turbidity was 22.83 ± 3.12 NTU on the surface and 22.00 ± 3.16 NTU in the middle, respectively. At 75% of the surface area covered by Water hyacinth, after 40 days the water turbidity was 21.25 ± 2.22 NTU on the surface and 20.75 ± 1.71 NTU in the middle (Figure 2).

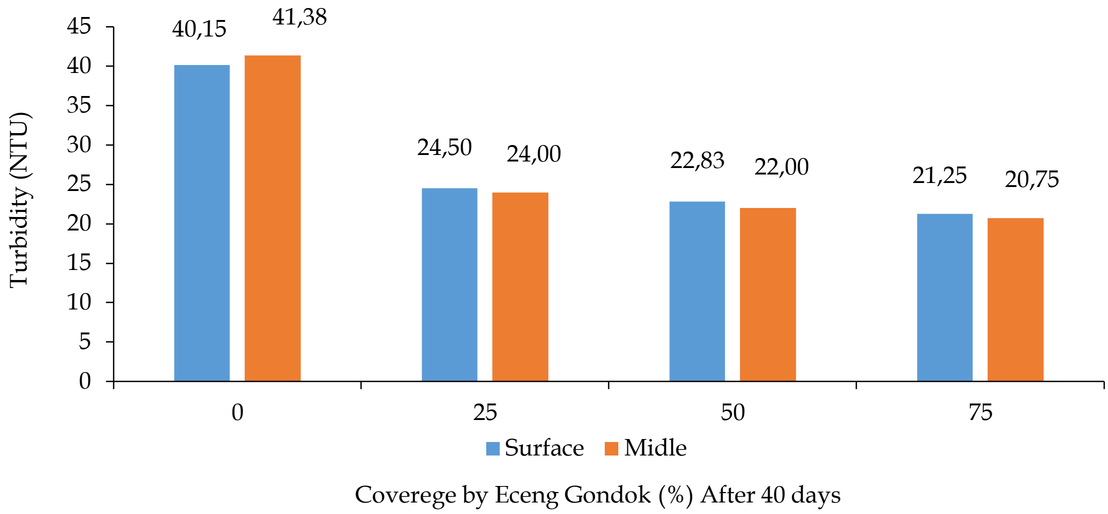

Figure 2. Lake water turbidity after 40th day at various WH closures

Before WH was cultivated, pond water had a turbidity of 40.75 ± 0.32 NTU. During the first 4 days of cultivating WH, the turbidity of the pond water changed to 29.38 ± 2.42 NTU (a decrease of 11.39 ± 2.01 NTU or equivalent to a decrease of 2.846 NTU per day). In the next 4-40 days, the lake water turbidity decreased by only 6.82 ± 0.45 NTU, equivalent to 0.182 NTU per day (Figure 3). This means that there are 2 stages of the pattern of decreasing lake water turbidity as a result of the growth of WH. The first stage is the fast decline rate which takes place in the first 4 days at a rate of 2.845 NTU/day and the second stage is the slow decline rate which takes place in the next 4-40 days with a rate of 0.182 NTU/day. A similar phenomenon was also reported by several researchers, including (Ahmad et al., 2017; Nigel et al., 2024; Ratnani et al., 2011).

The phenomenon that occurs in Figure 2 is supported by the results of observations on the solid particles that accumulated and piled in the WH roots after 4 days of cultivation, where the pile did not increase too much after 4 days (data from observations was not presented in the article).

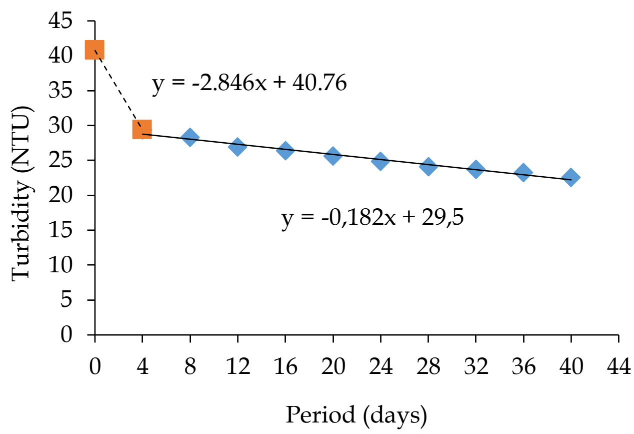

Figure 3. Two-stage pattern of decreasing water turbidity overgrown with water Hyacinth; fast decline rate (0-4 days) of 2,845 NTU/day and slow decline rate (>4 days) of 0.182 NTU/day

Similar to what was reported by Zahro & Nisa (2021), Atma (2022), and Suryati et al. (2023), the effect of WH growth on decreasing lake water turbidity was different at the surface and in the middle of the lake. The rate of decrease in lake water turbidity is higher at the surface than in the middle. At an interval of 4-40 days for the growth of WH, the water at the surface of the lake will decrease in turbidity following the equation y = -0.193x + 30.11 while in the middle it follows the equation y = -0.170x + 28.88 (Figure 4), where y is the water turbidity (NTU) and x is the growth time of WH (days). With this equation, it is known that WH cultivation in brick lakes at a closure level of 25-75% will reduce water turbidity by 0.193 NTU per day on the surface of the lake and 0.170 NTU per day in the middle of the lake. The decrease in turbidity at the surface is faster than in the middle of the lake 0.193 versus 0.170 NTU per day, this result was in line with studi of Abou-Shanab et al. (2007) and Jones et al. (2018).

It is believed that the mechanism for reducing water turbidity by WH occurs by trapping solid and sediment particles contained in the water into its root network. This can be understood because WH has long, hairy roots that stick out into the water. These protruding roots function as a natural filter and can catch solid particles and sediment in the water.

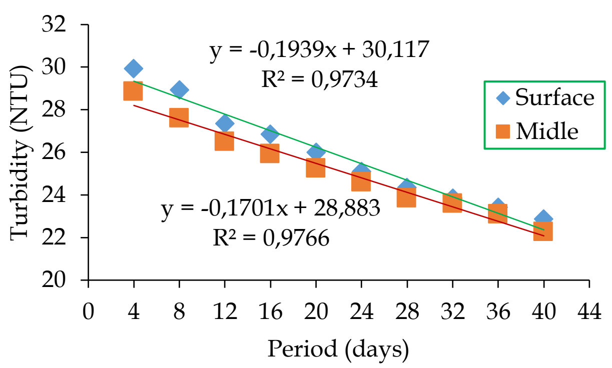

Figure 4. The rate of decrease in lake water turbidity at the surface and in the middle of the lake

The rate of decrease in lake water turbidity is different for each variation of WH cover. The rate of decrease in turbidity for lake cover levels of 25, 50, and 75% respectively follows the equation Y25% = -0.114x + 28.52; Y50% = -0.195x + 29.83 and Y75% = -0.235x + 30.14 (Figure 5). Based on Figure 5, it is known that by cultivating WH at each level of lake surface cover (25, 50 and 75%), the turbidity of lake water will decrease by: 0.114 NTU per day for a 25% closure level; 0.195 NTU per day for a closing rate of 50%; and 0.235 NTU per day for a closing rate of 75%. The more WH cultivated, the faster the water turbidity decreases. This is in line with what was reported by several previous researchers, that the effectiveness of water hyacinth in reducing the levels of suspended substances in domestic liquid waste increases in line with the number of clumps of the plant applied (Dewi, 2016; Nursari et al., 2019; Ni'am et al., 2021).

These results are supported by the report of Nwe et al. (2020), that WH can reduce wastewater turbidity significantly through the mechanism of floc removal and reduction of organic matter in water. It was reported that in 10 days, WH could reduce the cadmium (79.83%), copper (92.005) and lead (95.78%) content of industrial wastewater. In this studi, the decrease in turbidity of lake water was caused by the capacity of WH's roots in absorbing the pollutan material in its and holding it accumulately.

According to the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017, water that is safe to use must have turbidity below 25 NTU (Depkes RI, 2017). Based on these requirements as well as the information presented by Figure 5, it is known that for WH cover percentages of 25, 50, and 75%, the time needed to make lake water receivable for use is 32, 28, and 24 days, respectively.

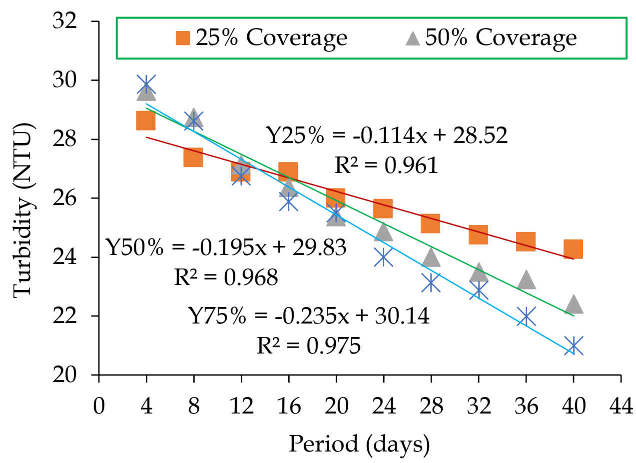

Figure 5. Turbidity reduction rate for lake cover levels of 25, 50, and 75%

After phytoremediation was carried out, Brick Lake now has sufficient biological carrying capacity to be used as a place for fish cultivation, especially tilapia, catfish and gourami. This is also stated according to research by Binawati & Puspita (2023), using the WH as a fish feed ingredient had been proven to have a positive influence on the growth of catfish, goldfish, gourami and tilapia.

Conclusion

In conclusion, We conclude that the mechanism for reducing lake water turbidity by cultivating WH is through the absorption of suspended particles by the roots and accumulating them. Therefore, clarity at the surface (closer to the roots) is faster than in the middle of the lake, namely 0.193 NTU compared to 0.170 NTU per day. The more WH is cultivated, the faster the rate of decrease in turbidity. Reducing lake water turbidity is much more effective if the WH grown is rejuvenated every 4 days. These findings support the validity of the system for determining the amount of WH in improving surface water quality. These findings highlight the importance of regulating the amount of WH cultivated and how long it could be stopped, let the water quality could be improved without worrying that it will grow massively and cause new problems.

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Authors Contribution

M.: Develop main ideas and research objectives, setting up methodology, conducting the research, perform statistical analysis and data interpretation, create graphs, tables and illustrations, writing original manuscript; A.H.: Develop concept and research question, setting up methodology, collect and organize research data, carrying out experiments or research; N.: Develop or implement software used in research, ensure the validity and reliability of data, review and edit draft articles; A.S.: Providing materials or equipment needed for research, manage the administration and logistics of research projects, oversee the research process.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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