Application of *Salvinia molesta* for water pollution treatment using phytoremediation batch system

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**Abstract.** The contamination of the river water with wastewater is a severe problem due to the utilization of the river water for drinking water mainly. Phytotechnologies can minimize the negative impact of this problem using plants in the river water rehabilitation. This study aimed to evaluate the potential of *Salvinia molesta* to phytoremediation of the polluted river by organic pollutants. There were two treatments on this research: polluted river without *Salvinia molesta* and polluted river with *Salvinia molesta* phytoremediation on the batch system. We took a water sample from the moderate polluted river for phytoremediation by *Salvinia molesta*. The period of the research was two weeks. The measured water quality parameters in this study were dissolved oxygen (DO), total solids (TS), total dissolved solids (TDS), biological oxygen demand (BOD) and chemical oxygen demand (COD). This study revealed that *Salvinia molesta* plants could improve the river water quality with enhancing DO by 58.26%, decreasing the parameters include TS by 31%, TDS by 97%, BOD by 26%, and COD by 74% compared to control without *Salvinia molesta*. Thus, the data suggest that *Salvinia molesta* may have a potential for phytoremediation (as water pollution treatment) of aquatic environments contaminated with organic pollutants from wastewater.

1. **Introduction**

Water is a natural resource that is a crucial requirement for humans. Therefore, clean water needs to be maintained. River pollution is an essential factor in environmental problems. The river is the source of water in a settlement, sometimes polluted by factory waste, household waste, and other hazardous substances. Wang et al. (2012) stated that the larger quantities of domestic or from industrial wastewater flowed into the river will lead to the water system and become severely polluted [1]. Freshwater pollution in Indonesia, more than 80% is caused by domestic waste in liquid and solid form. Nearly two-thirds of the Citarum River in Bandung City, the biological oxygen demand (BOD) comes from household pollution, as compared to one-third from all industrial and agricultural activities combined, for instance [2]. The increase of wastewater volume is quite high, and it is about 5 million m3/year [3] seeing these problems, some efforts of wastewater treatment are needed.

Wastewater treatment methods can be physical, chemical, and biological treatment methods. From the three methods, it was considered to be the most efficient way to reduce organic matter in wastewater at relatively low cost is the biological treatment method, namely bioremediation...
technology. There are many advantages to bioremediation technology. It was low cost, low environmental influence, no secondary pollution, or pollutant movement. It may reduce pollutant concentration by the maximum extent and available for the sites where regular pollution treatment technology is difficult to be applied. Bioremediation technology can be the most promising remediation [1].

Wastewater treatment can be done using simple and environmentally friendly technology. The advantage of using this technology is that it is more economical and practical in its maintenance. Phytoremediation is one of the eco-friendly methods for wastewater treatment. Phytoremediation is one of the methods of wastewater treatment by utilizing plants to reduce waste concentrations that exceed quality standards. Irhamni (2018) stated that phytoremediation is a technology that uses certain plants that work together with microorganisms in the media (soil, coral, and water) to change, eliminate, stabilize, or destroy/remove contaminants or pollutant [4].

Humans have long recognized the concept of wastewater treatment using plant media. Even it is also used to treat hazardous waste or for radioactive waste. Phytoremediation has allowed increasing attention because it can safely remove the soil pollutant via plant uptake, accumulations, and plant harvesting for another treatment or function. Leaves of the fescue plant (Festuca arundinacea) can remove 14.4% of soil Cadmium (Cd) [5]. However, the efficiency of the proper plant to phytoremediation has become a great concern. This study aimed to evaluate the potential of Salvinia molesta to phytoremediation of a polluted river by organic pollutants. Our objective was to analyze the phytoremediation capacity of Salvinia molesta to treat polluted river in Surabaya City.

The selection of kiambang (Salvinia molesta) as a phytoremediator plant in this study is based on the consideration that this plant can grow in waters with low nutrient content. Besides, morphologically, kiambang (Salvinia molesta) has a relatively small leaf diameter (an average of 2-4 cm) but has a thick and long rooting. Based on this, it is hypothesized that kiambang (Salvinia molesta) can actively absorb pollutants, but does not prevent the penetration of light into the waters.

2. Methods
This study aimed to evaluate the potential of Salvinia molesta to phytoremediation of the polluted river by organic pollutants. There were two treatments on this research: polluted river without Salvinia molesta and polluted river with Salvinia molesta phytoremediation on the batch system. The river water was taken from the Jagir river, Surabaya.

Batch Process is a biological operating system by inserting the media and phytoremediator together into the bioreactor, and the product collection is carried out at the end of the process. In a batch system, media and phytoremediators are simultaneously inserted into the bioreactor. During the process, there will be a change in conditions in the bioreactor (nutrient will decrease). The batch system was made of glass with the dimension of height x length x wide = 22.4 cm x 31.5 cm x 17 cm or equal to 12 L.

150 g of Salvinia molesta and 6 L of river water of Jagir were taken into batch system to treat water pollution. The period of the research was two weeks. The measured water quality parameters in this study were dissolved oxygen (DO), total solids (TS), total dissolved solids (TDS), biological or biochemical oxygen demand (BOD) and chemical oxygen demand (COD). DO was measured by DO meter, TS, and TDS by gravimetric method, meanwhile BOD and COD by biological and chemical reaction. This research was conducted in the Integrated Laboratory of Islamic State University of Sunan Ampel Surabaya.

3. Result
The research began with river water sampling in Jagir River, Wonokromo, Surabaya with the coordinate of -7.300335°S, 112.741150°E on Jagir floodgate, Wonokromo Surabaya. The characteristics of the Jagir river water are liquid, slightly turbid, and smelly.

Application of Salvinia molesta for Jagir River Pollution treatment using the phytoremediation batch system was made on two weeks on control and treatment. We measured parameter on day first,
which is the first day of phytoremediation, namely initial concentration. This initial concentration then compared to final concentration at the end of phytoremediation on day 14th.

![Figure 1. Phytoremediation batch system. (a) control without Salvinia molesta, (b) treatment with Salvinia molesta](image)

Here are the results of parameters measurement:

| Parameters | Day 1\textsuperscript{st} | Day 14\textsuperscript{th} | Quality Standard PP 82/2001 |
|------------|-----------------|--------------------|-----------------------------|
|            | Results | Control | Treatment | (mg/L) |                |
| DO (mg/L)  | 2.6     | 2.7     | 6.23      | 4 |                |
| TS (mg/L)  | 4032    | 5324    | 2756      | - | 1000           |
| TDS (mg/L) | 1732    | 992     | 44        | 4 |                |
| BOD (mg/L) | 5.27    | 5.07    | 3.85      | 3 |                |
| COD (mg/L) | 31.6    | 25.6    | 8.16      | 25|                |

Dissolved Oxygen (DO) concentration on day first was 2.6 mg/L, after two weeks period of phytoremediation, DO increase in control by 2.7 mg/L while treatment increased to 6.23 mg/L or 58.26%. Total Solid (TS) concentration on day first was 4032 mg/L, after two weeks period, increased on control to 5324 mg / L, while decreasing on treatment to 2756 mg/L or 31.64%. Total Dissolved Solids (TDS) concentration on day first was 1732 mg/L, and then decreasing both on control and treatment to 992 mg/L or 42.72% and 44 mg/L or 97.45% respectively after two weeks period of phytoremediation. Biological Oxygen Demand (BOD) on day first was 5.27 mg/L and then decreasing both on control and treatment to 5.07 mg/L or 3.79% and 3.85 mg/L or 26.94% respectively after two weeks period of phytoremediation. The same with BOD, Chemical Oxygen Demand (COD) has the same pattern, where on day 1\textsuperscript{st}, the COD concentration was 31.6 mg/L, and then decreasing both on control and treatment to 25.6 mg/L or 18.98% and 8.16 mg/L or 74.17% respectively after two weeks period of phytoremediation.

Dissolved oxygen is an essential parameter in determining river water quality because dissolved oxygen may play a role in the oxidation and reduction of organic and inorganic materials in the aquatic environment. The final DO concentration in the control and treatment has increased from the initial DO and much more increased on treatment. The final DO concentration for the treatment was 6.23 mg/L. This value has met the class 2 water quality standard based on Government Regulation No. 82 of 2001, while final DO on control below the water quality standard. It is assumed that Salvinia molesta plants as phytoremediators may increase dissolved oxygen levels by producing oxygen from
photosynthesis [6]. *Salvinia molesta* is a floating macrophyte that has chlorophyll for photosynthesis; thus, the plants yielded oxygen. Oxygen releasing by *Salvinia molesta* may result in higher final DO concentration.

Total Solid (TS) is the total of dissolved solids and suspended solids, both organic and inorganic. They are decreasing of TS in the second week as the result of phytoremediation. Meanwhile, Dissolved solids are the number of minerals, salts, metals, cations, and anions dissolved in water expressed in mg/L. TS and TDS was an indicator of turbidity. The final TDS concentration both on control and treatment batch system has met the quality standards for water quality class 2 but a significant decrease in treatment with phytoremediation. BOD and COD have the same pattern, which is decreasing in the second week. However, final BOD concentration both on control and treatment did not meet the water quality standard class II based on Government Regulation No. 82 of 2001, but a significant decrease in treatment with phytoremediation.

Meanwhile, COD both on control and treatment has met the water quality standard class II based on Government Regulation No. 82 of 2001 and a significant decrease in treatment with phytoremediation. The data suggest that *Salvinia molesta* may have a potential for phytoremediation (as water pollution treatment) of aquatic environments contaminated with organic pollutants from wastewater. The plant has a certain degree of purification for water pollution, especially aquatic plants such as *Salvinia molesta*. The plants with strong absorption for pollutants and good tolerance could be planted in the gross polluted water. In their mechanism, water pollutants were removed or fixed through adsorption, absorption, accumulation, and degradation by the plants for water purification [1].

Many researchers have found that *Salvinia molesta* is one of good phytoremediator. It has high nature of the hyperaccumulator, can grow in low nutrient water, and also has rapid growth [7]. *Salvinia molesta* can remove heavy metals Cu up to 90.02% -94.68% [8]. In wastewater that contains heavy copper metal, *Salvinia molesta* can survive 100% to 15 ppm, while *Pistisia stratiotes* can only survive 70% at ten ppm [9]. It can also remove zinc content (Zn) by 49% and TSS (Total Suspended Solid) by 70% [10]. Using the batch system, *Salvinia molesta* was able to remove BOD and COD content from batik industry’s wastewater up to 99% removal or equivalent to 1.693,1 mg BOD/L and 4.338,5 mg COD/L [11]. The greater the number of plants and roots, the greater the organic material that can be absorbed in domestic wastewater [12]. The roots of *Salvinia molesta* will involve microorganisms to decompose organic materials during the phytoremediation process. This phase is called rizho degradation [13]. Another study concluded that *Salvinia molesta* achieved 95% phosphate removal efficiency from the wastewater, and lowering concentration to 0.17 mg/l. Nitrate concentration was determined to be at 0.50 mg/l at the end of the experiment. Ammonia concentration showed a dynamic fluctuation trend with an average value of 2.62 mg/l. For water quality assessment, turbidity decreased by *Salvinia molesta* from 7.56 NTU to 0.94 NTU in just two days. MLVSS analysis was significantly low by day 2 of the experiment. Moreover, COD removal efficiency was determined at 39% [14].

In our research, we found that the batch system without *Salvinia molesta* also showed biodegradation. All the parameters on control were measured, decreasing at the end of the experiment. We assumed that there are indigenous bacteria on a batch system that allow the bioremediation process. These bacteria may vary due to water river pollution sources. For example, if there are organic compounds in water river pollution, then could be an organohalide-respiring bacteria live in there. The organohalide-respiring bacteria conserve energy by utilizing H2 or organic compounds as electron donors and organohalides as electron acceptors. These organohalide-respiring bacteria include *Dehalococcoides, Dehalobacter, Desulfitobacterium*, and *Sulfurospirillum* were identified on bioremediation applications [15].

Based on the results, our essential finding suggests that *Salvinia molesta* may have a potential for phytoremediation (as water pollution treatment) of aquatic environments on a batch system. The system could be developed into a continuous system. Furthermore, the *Salvinia molesta* may have a potential for remediation of more elements or compounds such as trace metal and an organic compound in aquatic environments.
4. Conclusions
This study highlighted the capability of *Salvinia molesta* on water pollution treatment on Jagir River, Surabaya. This study revealed that *Salvinia molesta* plants could improve the river water quality with enhancing DO by 58.26%, decreasing the parameters include TS by 31%, TDS by 97%, BOD by 26%, and COD by 74% compared to control without *Salvinia molesta*. Thus, the data suggest that *Salvinia molesta* may have a potential for phytoremediation of aquatic environments contaminated with organic pollutants from wastewater.

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