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Effectivenes of Hanjali plant (Coix lacryma-jobi) in absorpting linear alkylbenzene sulfonates (LAS) pollutants

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Abstract. Water is an essential need for living things on earth. The increasing population causes the availability of clean water to decrease. This is caused by the high level of water pollution by waste, including domestic waste such as detergent (LAS). Various methods can be used to overcome water pollution, including phytoremediation techniques. One of the aquatic plants as a phytoremediation agent is the Coix lacryma-jobi plant. This study aims to examine the effectiveness of the ability of the Coix lacryma-jobi plant to absorb LAS. The method used is an experimental method using a Completely Randomized Design (CRD) with 5 treatments and 4 replications (plant control; LAS 4 mg/L; LAS 8 mg/L; LAS 16 mg/L; LAS 32 mg/L; LAS 64 mg/L with a detention time of 15 days. The results showed that hanjali plants were effective in absorbing LAS with the highest removal capacity of 94% in water contaminated with LAS 4 mg/L. The temperature and pH values fluctuated and the TDS value increased along with the increase in LAS concentration. Therefore, this plant can be said to be effective in absorbing LAS pollutants.

1. Introduction

Water is a vital need for human survival [1]. In the life process, water is the most important element that must be fulfilled [2]. Water is used for daily needs and other environmental activities [3]. The increase in population is directly proportional to the increase in waste volume [4]. This will have an impact on environmental damage [5].

According to PERMENLH RI Number 5 of 2021, water pollution is the entry of foreign substances into water due to human activities so that the quality of water standards is far from those that have been determined. Domestic waste that dominates water areas comes from detergent waste resulting from household activities [6]. LAS detergent is the chemical compound most widely used commercially because it is considered to have good cleaning properties and high foaming potential [7]. This can reduce oxygen penetration into the water and threaten the life of organisms [8]. According to PERMENLH RI Number 22 of 2021, attachment VI concerning National Water Quality Standards states that the quality standard value for detergents in lake and river waters is 0.2 mg/L, while the LAS tolerance level according to [9] is 0.5 mg/L. In fact, research by [10] states that the concentration of LAS in river water around densely populated settlements is between 4.06 - 8.98 mg/L.

The LAS detergent content is the chemical compound most widely used commercially because it is considered to have good cleaning properties and high foaming potential [7]. The formation of foam creates an area between phases, resulting in a buildup of surfactant in the water mass [11]. This can reduce oxygen penetration into the water and threaten the life of organisms [8]. LAS is able to degrade quite well up to 50% in aerobic conditions, but cannot undergo degradation in an anaerobic environment because of the presence of aliphatic chains that cannot be reduced further. [12].

This changes could be due to the surfactant content in the detergent [13]. Surfactants are classified into anionic, cationic, non-ionic, and amphoteric ions according to the type and performance of their hydrophilic groups [14]. Anionic surfactants are most often found in household wastewater [15]. Meanwhile, non-ionic, cationic and amphoteric surfactants are used in industrialization processes [16]. Anionic surfactants that are often used are Alkyl Benzene Sulfonates [ABS] and Linear AlkylBenzene Sulfonates [LAS]. LAS is used more often than ABS because it has the ability to degrade more easily [17].

One of the efforts made to overcome pollution is by phytoremediation. This strategies, combined with plant-based bioremediation, offer a multi-faceted approach to managing pollution [18]. Plants used as phytoremediation have the ability to accumulate waste with a fast absorption rate [19]. This method has a number of advantages, such as relatively low costs, ease of plant maintenance, and fairly abundant plant availability [20)].

This problem make local aquatic plants the main choice in phytoremediation. One of them is the hanjali plant which is able to absorb Pb and Cd metals reaching concentrations of 8,197 mg/L and 194 mg/L. This type of plant was chosen because it is a native type of local plant, found growing wild and not widely cultivated [21]. Based on this background, it turns out that it does not rule out the possibility that local plants in the wild have untapped potential for utilization of environmental pollution. The aim of this research is to determine the effectiveness of the Coix lacryma-jobi plant's ability to absorb Linear Alkylbenzen Sulfonates [LAS] pollutants with different concentration variations.

2. Materials And Method

Materials

The materials used in this research were hanjali plants (Coix lacryma-Jobi), sand, water, distilled water (commertial grade), Linear Alkylbenzene Sulfonates 100% (commertial grade), NaOH (commertial grade), H_2SO_4 (merck, bymart), methylene blue solution(merck, gifala), $CHCl_3$ (merck, thermo scientific chemicals), isopropyl alcohol (merck, emsure)and HNO^3 (merck ,emsure).

Instrumentation

The tools used in this research were 2000 ml thinwall and hydroponic tub, 500 ml plastic bottle, cutter, label paper, aluminum foil, scissors, measuring cup, spatula, pH meter, Total Dissolved Solid, LI-6400 Portable photosynthesis system, analytical scales, digital scales, UV-Vis spectrophotometer and inverted microscope.

Method

This research consisted of 5 treatments and 4 repetitions with a detention time of 15 days with concentrations of 0mg/L, 4 mg/L, 8 mg/L, 16 mg/L, 32 mg/L, 64 mg/L and was carried out in January-March 2025 at the Green house of the Biology Study Program, Maulana Malik Ibrahim State Islamic University, Malang and the PDAM Surya Sembada Water Testing Laboratory, Surabaya City. The Hanjali plant (Coix lacryma-jobi) used in this research, seeds taken from the river basin of Martopuro Village, Purwosari District, Pasuruan Regency, were then planted independently.

3. Result and Discussion

3.1 Removal effeciency

Removal effeciency is a measure of the effectiveness of phytoremediation in reducing contaminant concentrations from phytoremediation treatment media [22]. Additional variables such as the number, type and age of plants also have an influence [23]., it can be seen in Table 1 The higher the concentration of LAS in the media, the amount of LAS absorbed by plants actually decreases. Conversely, at lower LAS concentrations, absorption by plants tends to increase. This

Table 1. LAS Removal Effeciency

Treatment	**LAS in the media (mg/L)**	**LAS is marginalized (mg/L)**	**Removal effeciency (%)**
Control	0.0	1.5	0%
4 mg/L	0.2	2.5	94%
8 mg/L	1.2	3.5	85%
16 mg/L	4.8	11.2	70%
32 mg/L	12.2	19.8	62%
64 mg/L	29.1	34.9	55%

shows that increasing pollutant levels is inversely proportional to the plant's ability to remove LAS. This decrease in removal efficiency is caused by the effect of LAS which disrupts plant physiological and metabolic processes [24]. In addition, not all types of plants are able to absorb large amounts of contaminants because each species has different tolerance limits for pollutants [25].

The results of the analysis in Table 1 show that there are differences in LAS levels in the media before and after phytoremediation treatment, with a reduction efficiency range of 94% to 55%.

These results show that this process is effective in reducing pollutant levels significantly. Conversely, if the pollutant reduction level is below 50%, then the method used is considered less effective [26]. LAS that is excluded or lost in the media is basically assumed to have been absorbed by the plant. This can occur due to cooperation between plant roots and microbes resulting in a decrease in LAS in the planting medium. The presence of rhizosphere microbes in plants affects the absorption of organic waste. Its function is to take organic substances from the aquatic environment and accumulate sediment into its body tissues [27].

3.2 Influence of Abiotic Factors on LAS Removal Efficiency

Abiotic factors include pH, TDS and temperature. These three parameters are also related to the

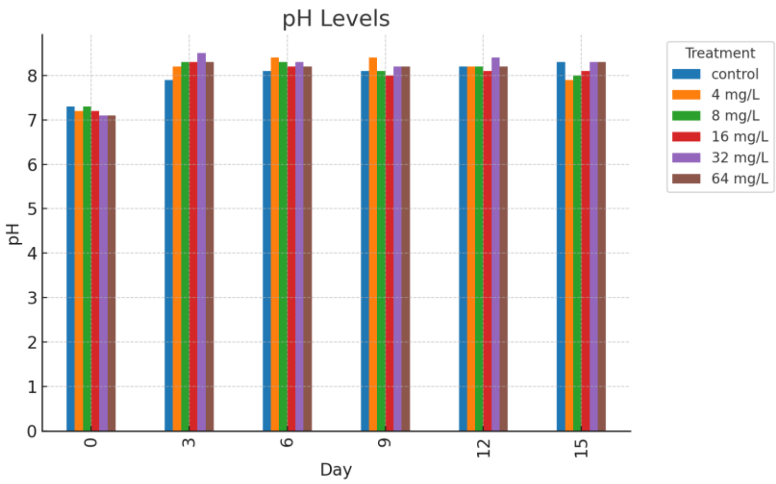

Figure 1. Abiotic factor pH on the effectiveness of LAS removal

availability of nutrients for plants, weight and metabolic rate of plants as well as important microbes in phytoremediation [28] and can be seen in **Figure 1.**

The results of measuring the pH value in **Figure 1** showed with a range of 7.1 - 8.5 show changes in values that fluctuate but are not significant. In accordance with research by Ramadhan et al. [29], this plant is able to grow in soil conditions of pH 4.5-8.7 and relatively low macro nutrient content and can grow at acid, neutral and alkaline pH. The above values are still in accordance with KLHK Regulation No. 68 of 2016 regarding the pH quality standards for domestic wastewater, which ranges from 6ppm – 9ppm. The difference in this range is due to variations in concentration in each treatment which are not much different. Other factors can also be caused by the processes of photosynthesis and respiration of plants and microorganisms in water [30]. The photosynthesis reaction will convert hydrogen, energy and CO_2 into $C_6H_{12}O_6$. Hydrogen is obtained from H+ ions from pollutants and air. In the photosynthesis process, the uptake of H^+ ions will automatically increase the pH in the water [31]. Apart from that, a shift in pH values can also occur due to the release of sulfonate groups from LAS compounds which undergo an oxidation process to become sulfate, then react with hydroxide ions (OH^-) [17].

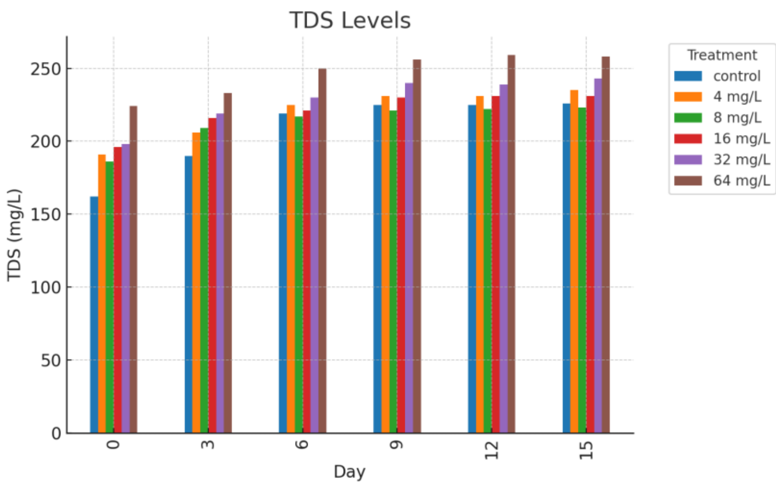

Figure 2. Abiotic factor TDS on the effectiveness of LAS removal

Measurement of the TDS value over a period of 15 days shown in **Figure 2** give a fluctuating increase in value, however, it is still in accordance with the quality standard of 2000 mg/L, so it can be said to be normal. The high TDS value is caused by the large number of organic and inorganic compounds dissolved in water, including salts and minerals [32]. Apart from that, the organic material content in the media also increases due to the accumulation of tissue remains or dead plant parts [33]. Microorganisms in plant roots can break down organic and inorganic materials into simpler compounds which make it easier for the roots to absorb pollutants [34]. Although TDS can increase water turbidity if increased above the normal threshold, its value is not dangerous. This can inhibit the penetration of light into the water, disrupt the photosynthesis process, and terminate plants [33].

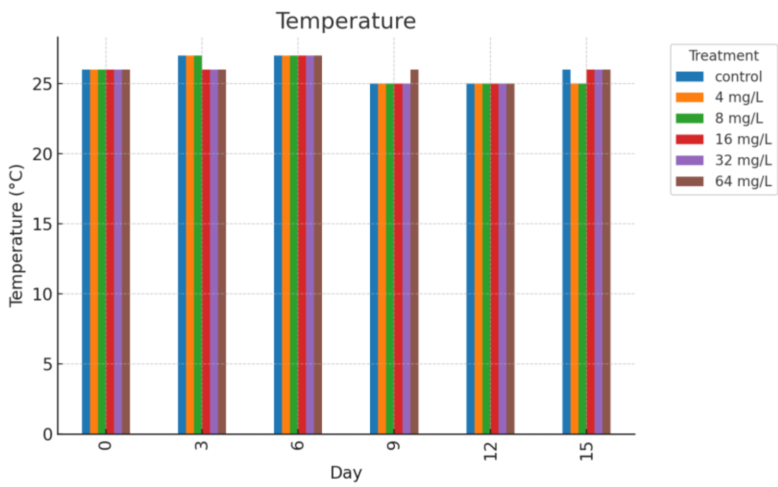

Figure 3. Abiotic factor pH on the effectiveness of LAS removal

Figure 3 showed is quite fluctuating, namely around 25-27°C. In accordance with [29] that hanjali is able to adapt well to tropical areas which tend to be dry, with a temperature range of between 25 to 35°C. This difference in temperature values can occur due to differences in exposure to sunlight intensity and the evaporation process [34]. According to Ikawati et al. [35] increasing the temperature of the planting medium will accelerate the rate of nutrient absorption by plants. However, if the temperature increases excessively, this condition can become toxic for plants, one of which is through the enzyme denaturation process which can damage the photosynthesis system [36]. Increasing temperature can also indirectly affect plant nutrient absorption because temperature is directly related to photosynthesis and plant metabolism [33]. Temperature instability can disrupt the balance of biochemical processes and microorganism activity. [37]. Apart from that, the addition of pollutants in the phytoremediation water media and the way plants regulate their metabolism also play a role in these temperature differences [38].

4. Conclusion

The conclusion from this research is that abiotic factors such as pH, TDS, and temperature influence phytoremediation. pH and TDS fluctuate but still comply with quality standards, influenced by biological and chemical processes and the hanjali plant (Coix lacryma-Jobi) has an effectiveness range of between 55%-94% for absorbing Linear Alkylbenzene Sulfonates (LAS) in water media within 15 days. The hanjali plant has potential as a phytoremediator plant for LAS because it is still above 50%.

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