

Effectiveness of Mensiang Plants (*Actinoscirpus grossus*) in Absorbing Linear Alkylbenzene Sulfonates (LAS), Copper (Cu), Nitrate and Phosphate

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Abstract. Water is essential for all living creatures, but population growth is decreasing its availability. This is due to increased pollution from human activities, including domestic waste (like detergents), industrial waste (such as copper), and agricultural runoff (nitrates and phosphates). Various ways can be done to overcome water pollution, including phytoremediation techniques. One of the aquatic plants that has the potential as a phytoremediation agent is the *Actinoscirpus grossus* plants. This study aims to assess the ability of *Actinoscirpus grossus* plants to absorb LAS, Cu metal, nitrate and phosphate with several variations in concentration and determine the response of exposure to LAS, Cu metal, nitrate and phosphate to the growth of *Actinoscirpus grossus* plants. The method used is an experimental method using a completely randomized design (RAL) with 12 treatments and 3 replications (plant control; LAS 80 mg/L without plants; Cu 5 mg/L without plants; LAS 80 mg/L; Cu 5 mg/L; LAS 80 mg/L + Cu 5 mg/L) and (plant control; nitrate 30 mg/L without plants; phosphate 30 mg/L without plants; nitrate 30 mg/L; phosphate 5 mg/L; and nitrate 30 mg/L + phosphate 5 mg/L) with a detention time of 15 days. The results showed that mensiang plants proved effective in absorbing LAS and Cu contaminants as evidenced by the value of LAS removal power decreased by 74.52% in treatment LAS 80 mg/L + Cu 5 mg/L and Cu metal decreased by 83.40% in treatment Cu 5 mg/L. The effectiveness value of absorption by mensiang plants is most optimal in treatment Cu 5 mg/L which is 62.2%. Meanwhile, the results of the plant's absorption of nitrate 50-92% and 58-84% of nitrate in the combined contamination treatment. Phosphate was able to reduce up to 71-81% and 4-41% of phosphate in the combined contamination treatment. *Actinoscirpus grossus* plant weight was not significantly affected by nitrate and phosphate contamination. However, *Actinoscirpus grossus* experienced slight changes in leaf color due to nitrate and phosphate, these changes include leaves turning dark green in phosphate contamination, yellowish green in combination contamination and brown spots in some treatments.

Keywords; *Actinoscirpus grossus*, copper, Linear Alkylbenzene Sulfonates, nitrate, phosphate, and phytoremediation.

I. INTRODUCTION

Water is one of the most important elements for all living things in the process of life on earth [Desti and Ula, 2021]. Clean water is becoming important as the population increases. However, clean water quality is currently difficult to obtain [Putriarti *et al.*, 2021]. One of the causes is the large amount of water polluted by various types of waste produced by human activities [Harmayani and Konsukartha, 2007]. Aquatic resources have an important role in life. However, the increasing intensity of human activities that utilize aquatic ecosystems such as agricultural and plantation activities contribute to a decline in water quality (Putri *et al.*, 2019). A total of 25 rivers in Indonesia have a heavily polluted status and this increased to 38 rivers with a heavily polluted status in 2019 (Firmansyah *et al.*, 2021). In addition, agricultural areas require sufficient water availability. Irrigation systems are used to ensure the availability of water for plants so that aquatic ecosystems such as reservoirs, lakes or rivers are often found as sources of irrigation water around agricultural land (Retnaningdyah & Arisoesilaningsih, 2018).

Increased detergent use has an impact on waste and the environment, including disturbed water aesthetics, decreased dissolved oxygen levels, changes in the physical and chemical properties of water, and eutrophication (Handayani, 2020). High phosphate from detergents can cause the growth of water weeds (Yuliani and Purwanti, 2015). This pollution is caused by surfactants in detergents (Suastuti *et al.*, 2015), active substances in organic chemicals which are divided into anionic, cationic, nonionic and amphoteric categories (Oppusunggu *et al.*, 2015). Anionic surfactants are generally used for households, while nonionic, cationic and amphoteric surfactants are more often used in industry (Wibisono, 2018). Apart from

detergent waste, heavy metals also often pollute the aquatic environment (Andriarna *et al.*, 2022). Heavy metals are difficult to degrade and easily accumulate (Budianta and Pambayun, 2015). They are toxic, potentially causing poisoning, metabolic disorders, and decreased physiological function in organisms (Yalcin *et al.*, 2008). Levels that exceed the maximum limit and accumulate over a long time can cause death (Putranto, 2011).

Eutrophication is water pollution due to excess nutrients, especially nitrogen (N) and phosphorus (P), which results in excessive growth of phytoplankton and aquatic plants. This can damage the balance of aquatic ecosystems, cause fish deaths, and hinder water flows (Mustika & Utomo, 2023; Darmono, 2001). Phytoremediation is an environmental cleaning method using plants to remove pollutants. This technology, which is environmentally friendly and driven by solar energy, harnesses the ability of plants to clean pollutants in-situ (Wang *et al.*, 2020; Sukono *et al.*, 2020). Plants that are effective for phytoremediation have fast growth, high water absorption capacity, and high tolerance to pollutants (Fatmawati, 2013).

The mensiang plant (*Actinoscirpus grossus*) has the potential for phytoremediation because of its ability to absorb pollutants in liquid waste thanks to its hollow stems and branched roots. Research shows that this plant, together with *Limnocharis flava*, is effective in reducing nitrate and phosphate concentrations (Sundari, 2013). Therefore, this study aims to test the effectiveness of *Actinoscirpus grossus* in reducing concentrations of Linear Alkylbenzene Sulfonates (LAS), copper (Cu), nitrate and phosphate, as well as morphological changes in plants due to these pollutants.

II. METHODS

This study uses a quantitative descriptive research type with an experimental approach. This research used a Completely Randomized Design consisting of 6 treatments and 3 replications. Observations were carried out for 15 days where these observations included measurements of physicochemical factors such as temperature, pH, TDS, LAS concentration, copper (Cu), nitrate and phosphate in the water media, as well as measuring the concentration of copper (Cu) in plants. Plant weight measurements were carried out on the 0th day before treatment and the 15th day after treatment to determine the plant's response to pollutants. The experimental design of this research is as follows (Table .1)

Concentration Variations	LAS and Cu Treatment	Nitrate and Phosphate Treatment	Detention Time
S ₀	Plant Control (Without LAS and Cu metal)	Plant control (without nitrates and phosphates)	15 Days
S ₁	LAS 80 mg/L Without plant	Nitrate 30 mg/L Without plant	
S ₂	Cu metal 5 mg/L Without plant	Phosphate 5 mg/L Without plant	
S ₃	LAS 80 mg/L + plant	Nitrate 30 mg/L + plant	
S ₄	Cu metal 5 mg/L + plant	Phosphate 5 mg/L + plant	
S ₅	LAS 80 mg/L + Cu metal 5 mg/L + plant	Nitrate 30 mg/L + phosphate 5 mg/L + plant	

The research stage begins with the process of plant acclimatization. During this process, a working solution is also made. After acclimatization is complete, with Range Finding Test (RFT) treatment.

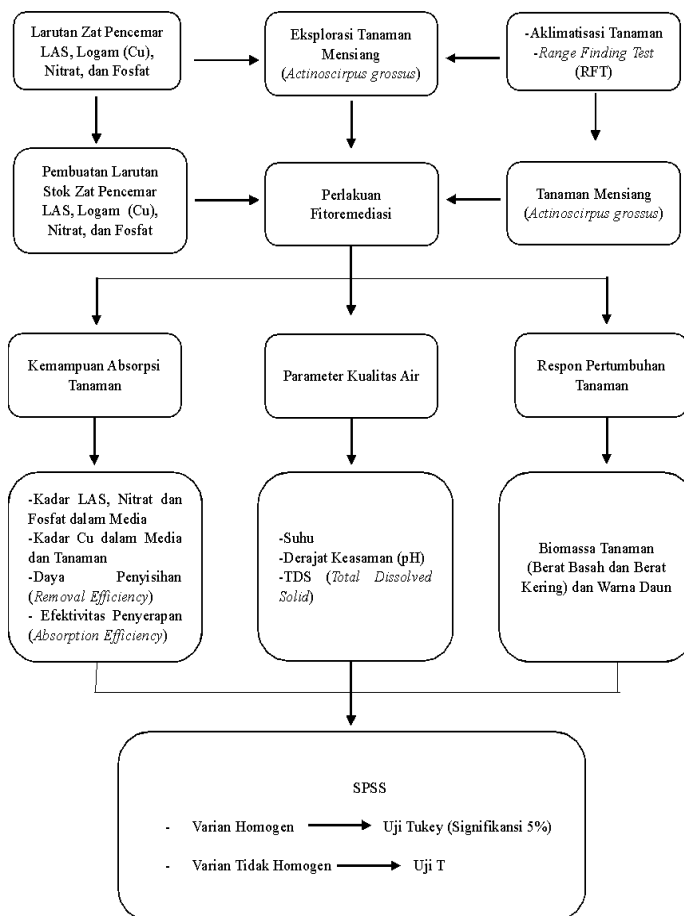


Figure 1. Research Outline

III. RESULT AND DISCUSSION

A. Removal Efficiency

Removal Efficiency LAS

The research results in Figure 1 show that the removal power of LAS varies depending on concentration. The LAS 80 mg/L + Cu 5 mg/L treatment showed optimal removal of 74.52%. *Actinoscirpus grossus* plays a role in decomposing organic compounds and increasing absorption by plants, thanks to synergy with rhizospheric microbes that absorb organic waste (Rukmi *et al.*, 2013; Ni'ma *et al.*, 2014). The combination of LAS and Cu accelerated the decrease in LAS, with LAS 80 mg/L + Cu 5 mg/L lagging behind by 20.38 mg/L on day 15, while LAS 80 mg/L lagged behind by 26.03 mg/L. The interaction of LAS and Cu metal causes structural changes in LAS, facilitating absorption by plants (Yong *et al.*, 2008; Andriarna *et al.*, 2022). The statistical test showed a significance of 0.01 ($p < 0.05$), indicating a real difference in the reduction of LAS levels with variations in treatment concentration. The most optimal value of excluded LAS levels in the LAS 80 mg/L + Cu 5 mg/L treatment was 59.62 mg/L.

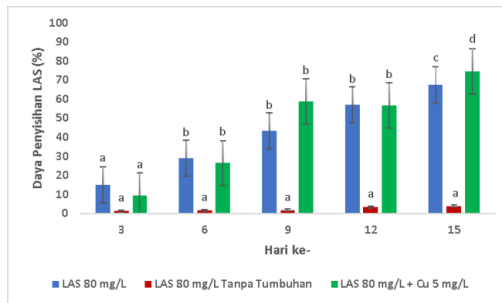


Figure 2. LAS removal efficiency value (%). The same letters above the bars indicate significant differences based on the t test $\alpha = 0.05$.

Removal Efficiency Copper Metal (Cu)

The research results in Figure 2 show variations in the removal power of copper metal (Cu) in various treatments. The optimal decrease in Cu levels occurred until day 15 in the 5 mg/L Cu treatment, with remaining Cu levels of 0.83 mg/L and removal power of 5.21%. In controls, Cu levels are considered 0 mg/L, while the normal range is 0.05–0.5 mg/L (Ed Bloodnick, 2021). The decrease in Cu levels is influenced by the absorption of *Actinoscirpus grossus* and phytochelatin compounds which reduce metal toxicity (Santosa *et al.*, 2013; Wulandari *et al.*, 2018). Absorption is also assisted by microorganisms around the roots (Widyawati and Sunu, 2021). Without plants, 5 mg/L Cu treatment showed a decrease in Cu levels of 0.45% to 4.64 mg/L, caused by evapotranspiration and metal deposition (Syranidou *et al.*, 2017; Novita *et al.*, 2012). The statistical test shows a significance value of 0.01, which

means that variations in concentration have a significant effect on reducing Cu levels. Cu treatment of 5 mg/L with plants showed the most optimal Cu content removed, namely 4.17 mg/L, with the highest average difference of 2.42400*.

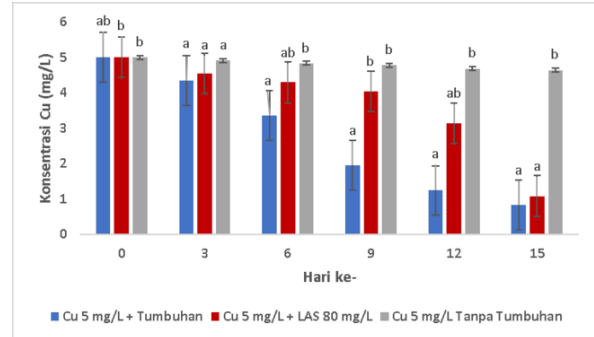


Figure 3. Copper Metal (Cu) Content in Media (mg/L). The same letters above the bars indicate significant differences based on the t test $\alpha = 0.05$.

Removal Efficiency Nitrate

The research results which can be seen in the diagram in Figure 3 show a significant reduction in nitrate concentration from 30 mg/L to 2.47 mg/L in 15 days, with a reduction of 92%. This decrease was caused by absorption by *Actinoscirpus grossus*, adsorption by the substrate (Rachmawati and Rinawati, 2020), and the activity of nitrate-reducing microorganisms (Prahardika *et al.*, 2013). In media with a combination of nitrate and phosphate, the nitrate concentration decreased from 6.47 mg/L to 4.83 mg/L on day 15, with a reduction of 84%. This decrease was lower compared to nitrate media alone, possibly due to N-P bonds which inhibit nitrogen absorption (Suasti *et al.*, 2017). In the control treatment without plants, the nitrate concentration fell from 30 mg/L to 9.90 mg/L in 15 days, with a reduction of 67%. Fluctuations in nitrate concentration are thought to be influenced by substrate adsorption and desorption processes (Vymazal, 2007), as well as nitrate-reducing microorganisms (Prahardika *et al.*, 2013).

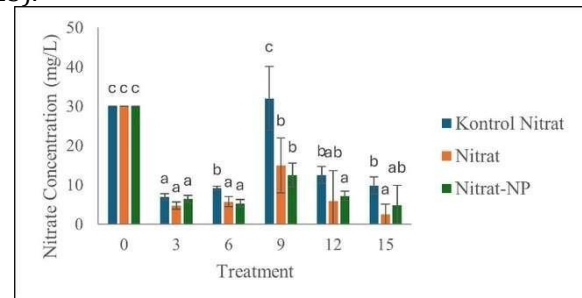


Figure 4. Comparison of Nitrate Concentrations Between Observation Times. The same letters above the blocks indicate significant differences based on the paired samples t-test $\alpha = 0.05$.

Removal Efficiency Phosphate

The research results in Figure 4 show that the initial phosphate concentration of 5 mg/L decreased significantly to 0.87 mg/L on the sixth day, with a decrease of 81%. This decrease was caused by phytoremediation by *Actinoscirpus grossus*, adsorption by the substrate (Maulini *et al.*, 2018), and possibly phosphate-reducing microorganisms (Prahardika *et al.*, 2013). Phosphate increased insignificantly on the ninth and 12th days, then fell again to 0.95 mg/L on the 15th day. In water media containing nitrate and phosphate, phosphate decreased significantly to 1.63 mg/L on the third day, then increased insignificantly to 2.00 mg/L on the sixth day and increased significantly to 4.80 mg/L on the second day. ninth. A further decrease to 2.97 mg/L on day 15 showed a 41% lower reduction compared to the single phosphate treatment, possibly due to the interaction of phosphate with nitrate.

In the control without plants, phosphate decreased significantly to 1.63 mg/L on the third day, then increased significantly to 7.10 mg/L on the ninth day before decreasing again to 5.57 mg/L on the 15th day. This fluctuation is thought to be due to substrate adsorption and desorption processes (Maslukah *et al.*, 2020; Vymazal, 2007) as well as phosphate-reducing microorganisms (Prahardika *et al.*, 2013), with the final decrease not being significant compared to the initial day, and a decrease of -11% compared to 12th day.

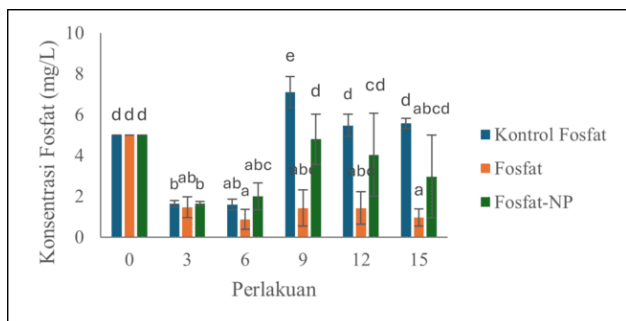


Figure 5. Comparison of Phosphate Concentrations Between Observation Times. The same letters above the blocks indicate significant differences based on the paired samples t-test= 0.05.

B. Effectiveness of Heavy Metal Cu Absorption by Plants

The results of the study in figure 5 show the effectiveness of copper metal (Cu) absorption by different plants at various concentrations. The highest Cu level was found in roots with Cu treatment of 5 mg/L, which was 3.11 mg/L, while the lowest level was in the crown with LAS treatment of 80

mg/L + Cu 5 mg/L, which was 0.84 mg/L. Hyperaccumulator plants, such as *Actinoscirpus grossus*, effectively absorb heavy metals with optimal absorption at roots (62.2% for Cu 5 mg/L) and crowns (58% for LAS 80 mg/L + Cu 5 mg/L). The absorption effectiveness is considered high if it is more than 50% (Djo *et al.*, 2017). The statistical test showed a significance of 0.04 (sig. < 0.05), indicating a significant effect of concentration on the decrease in Cu and LAS levels in plants. Treatment of Cu 5 mg/L on the roots showed the highest absorption effectiveness with an average difference of 51.26033*.

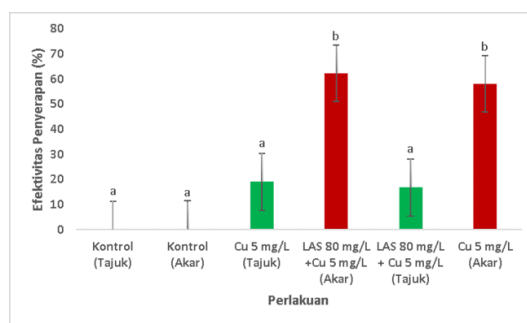


Figure 6. Effectiveness Value of Copper Metal (Cu) Absorption by *Actinoscirpus grossus* Day 15. The same letter on the block shows a noticeable difference based on the t-test $\alpha = 0.05$

C. Plant Growth Response

The observation of the observed plant growth response is the wet weight of the plant. Observations of the wet weight of the plant showed that *Actinoscirpus grossus* underwent significant changes after exposure to pollutants. On the 15th day, the highest wet weight of the plant was found in the LAS treatment of 80 mg/L + Cu 5 mg/L with an increase from 26.45 grams to 49.7 grams (Figure 6). This increase is due to the synergistic effects of LAS and Cu that stimulate growth by increasing plant metabolism and photosynthesis (Liu *et al.*, 2022). Statistical tests showed a significance of 0.03 for the wet weight of the plants, indicating a significant difference between the treatments. LAS treatment of 80 mg/L + Cu 5 mg/L showed optimal results.

Observation of the wet weight of plants in the nitrate and phosphate contamination treatment in figure 7 is known that the control treatment increased from 25 grams to 48 grams, but it was not significant due to the lack of nitrates and phosphate (153% productivity). Nitrate treatment increased wet weight from 26 grams to 54 grams, with the highest productivity value (189%). Phosphate treatment also increased from 20 grams to 46 grams significantly. The nitrate and phosphate mixture showed an increase from 13 grams to 39 grams, but it was not

significant. This result is in line with previous research which shows that nitrates and phosphates affect plant growth, playing an important role in increasing wet weight because nutrients are chemicals needed by organisms as raw materials for their survival (Soedarsono *et al.*, 2013).

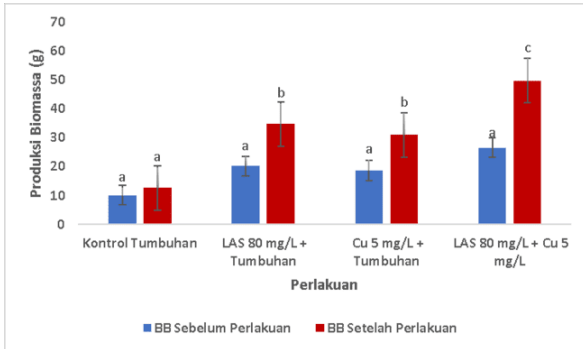


Figure 7. Wet weight of plants in LAS and Cu contamination treatment. The same letter shows no real difference based on the anova test at the level of 5%

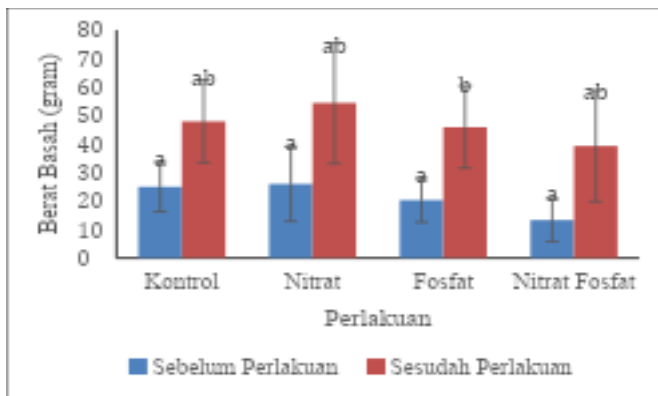


Figure 8. Wet weight of plants in nitrate and phosphate contamination treatment. The same letter shows no real difference based on the anova test at the level of 5%

D. Water Quality Parameters

The study also evaluated the effectiveness of *Actinoscirpus grossus* in addressing pollutants such as LAS, Cu metals, nitrates, and phosphates and their impact on water quality. The parameters measured were temperature, pH, and Total Dissolved Solids (TDS). The results of temperature measurements in the LAS and Cu treatments in table 1 showed fluctuations between 25-32°C. Meanwhile, in the nitrate and phosphate contamination treatment in Figure 8, the room temperature during the observation ranged from 26.5-32.1 °C, while the water temperature during the observation ranged from 25.3-27.2 °C, which was affected by the weather and sunlight intensity. This temperature range corresponds to the tolerance of *Actinoscirpus grossus*. *Actinoscirpus grossus* is

able to live in the temperature range of 32-25°C (Govaerts, 2007).

Table 2. Temperature Data on LAS and Cu Treatment (°C)

No.	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	25,1	25,4	26,6	28,5	28,7	28,8
2.	LAS 80 mg/L Without Plant	25,1	25	26,6	29,2	29,3	30,1
3.	Cu 5 mg/L Without Plant	25,1	25,1	26,6	28,8	29	29,3
4.	LAS 80 mg/L + Plant	25,4	24,9	26,6	28,4	28,7	28,9
5.	Cu 5 mg/L + Plant	25,2	25,1	26,6	28,3	28,7	28,9
6.	LAS 80 mg/L + Cu 5 mg/L	25,2	25,9	26,4	26,7	27,7	28,3



Figure 9. Temperature Data on Nitrate and Phosphate Treatment

The initial pH value of LAS and Cu treatment in table 2 ranged from 7.3-8.2, increasing to 7.7-8.6 after 15 days. Meanwhile, the pH value in nitrate and phosphate treatment at the first observation until the 15th day has a value in the range of 6.85-7.88 (Figure 9), still within the national water quality standard limit in the Minister of Environment and Forestry Number 22 of 2021 attachment VI, which is 6-9. Changes in pH are influenced by photosynthesis, respiration, and chemical reactions with pollutants (Suryadi *et al.*, 2017; Widya *et al.*, 2015).

Table 3. pH Data on LAS and Cu Treatment

No	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	7,3	7,5	7,6	7,7	7,7	7,8
2.	LAS 80 mg/L Without Plant	8,2	8,2	8,1	8,2	8,2	8,2

3.	Cu 5 mg/L	7,	7,	7,	7,	8	8,
	Without Plant	4	8	9	9	8	2
4.	LAS 80 mg/L +	8,	7,	7	7,	7,	7,
	Plant	2	4	1	1	2	
5.	Cu 5 mg/L +	7,	7,	7,	7,	7,	7,
	Plant	4	0	2	1	2	3
6.	LAS 80 mg/L +	8,	8,	8,	8,	8,	8,
	Cu 5 mg/L	2	3	4	4	5	7

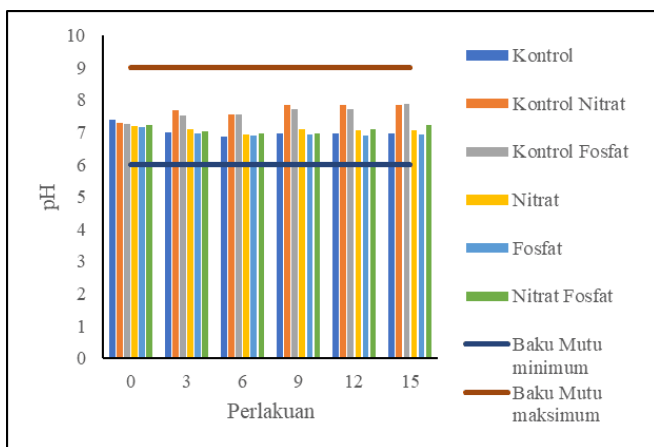


Figure 10. pH Data on Nitrate and Phosphate Treatment

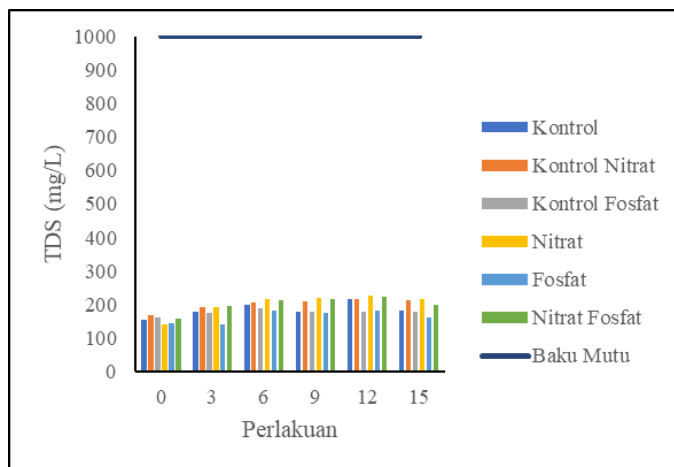


Figure 11. TDS Data on Nitrate and Phosphate Treatment

IV. CONCLUSION

Actinoscirpus grossus significantly decreases the concentration of nitrate and phosphate pollutants. In nitrate contamination, the decrease reached 92% in single treatment and 84% in combination treatment. In phosphate contamination, the decrease in phosphate was 81% in single treatment and 41% in combination treatment. In addition, LAS, Cu, nitrate, and phosphate contamination significantly affected the wet weight of *Actinoscirpus grossus*.

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Tabel 3. TDS data on LAS and Cu treatment.

No	Concentration Variations	Day					
		0	3	6	9	12	15
1.	Plant Control	150	196,3	218,7	196,7	231,7	242,3
2.	LAS 80 mg/L Without Plant	269,3	256,7	349,7	362,3	363	374,7
3.	Cu 5 mg/L Without Plant	183,3	189,7	220	202	259	268
4.	LAS 80 mg/L + Plant	252,7	257,7	346,3	396,3	398	420,7
5.	Cu 5 mg/L + Plant	173,3	208,7	219,7	225,3	248	255,7
6.	LAS 80 mg/L + Cu 5 mg/L	265,7	268,0	297,3	285,3	284,7	312,3

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