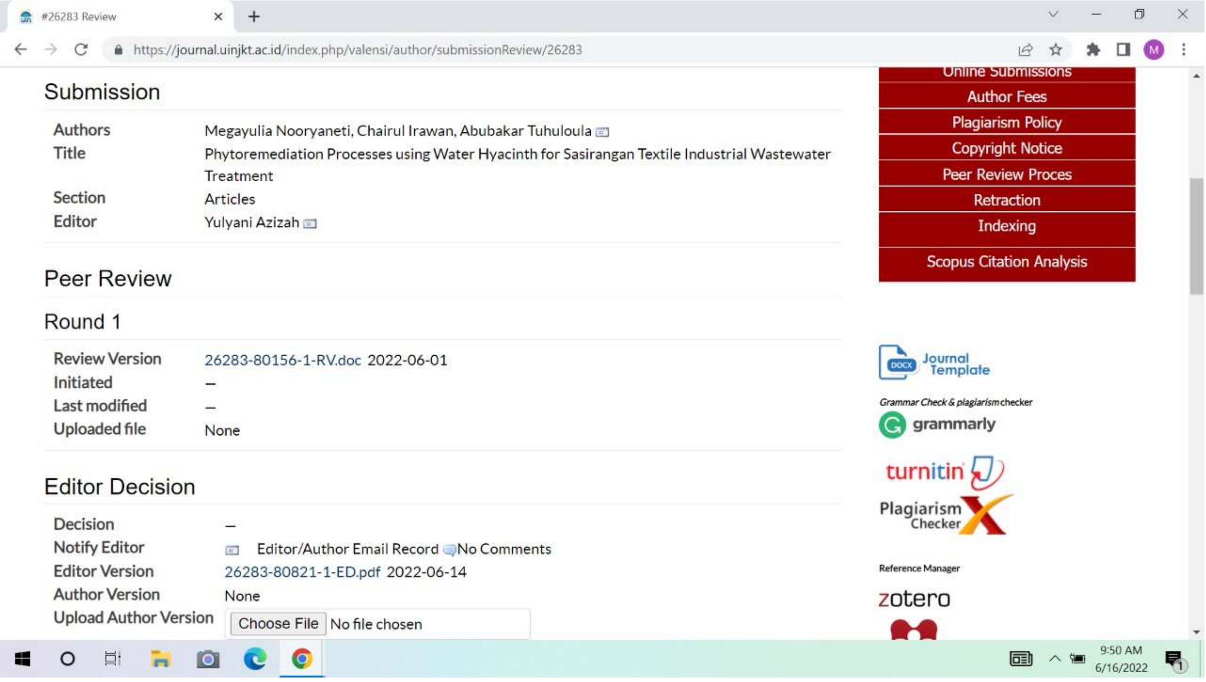
Submitted June 1, 2022



#26283 Review

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Submission

Authors	Megayulia Nooryaneti, Chairul Irawan, Abubakar Tuhuloula
Title	Phytoremediation Processes using Water Hyacinth for Sasirangan Textile Industrial Wastewater Treatment
Section	Articles
Editor	Yulyani Azizah

Peer Review

Round 1

Review Version	26283-80156-1-RV.doc 2022-06-01
Initiated	—
Last modified	—
Uploaded file	None

Editor Decision

Decision	—
Notify Editor	Editor/Author Email Record No Comments
Editor Version	26283-80821-1-ED.pdf 2022-06-14
Author Version	None
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Yulyani Nur Azizah <yulyani@uinjkt.ac.id> Sun, Jul 17

to Megayulia186, me, atuhuloula

mega Megayulia Nooryaneti:

We have reached a decision regarding your submission to Jurnal Kimia Valensi, "Phytoremediation Processes using W Textile Industrial Wastewater Treatment".

Our decision is to: Revision Required

Yulyani Nur Azizah
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EVALUATION FORM

JURNAL KIMIA VALENSI (*VALENSI JOURNAL OF CHEMISTRY*)

Title	Phytoremediation Processes using Water Hyacinth for Sasirangan Textile Industrial Wastewater Treatment
Date of Receiving	**1/07/2022**
Date of reviewing	**17/07/2022**

Please give the checklist (√) to mark your evaluation in the appropriate space

Criteria	Excellent	Good	Fair	Poor
Originality of the work				√
Scientific merit/ Importance to field		√		
Appropriateness of title. Does the title properly and clearly describe the paper? Note : ……………………………………………………………… ………………………….		√		
Is the abstract appropriate? Note : ……………………………………………………………… ………………………….			√	
Are materials and methods describe in clarity? No Ambiguity? Note : instrumen yang digunakan untuk analisis zat warna dan TSS belum ditulis dengan jelas, kondisi tanaman yang digunakan utuk fitroemediasi tidak dijelaskan, apakah menggunakan tanaman hidup atau mati?				√
Description of experimental design Note : 1. pada prosedur tidak dijelaskan bagaimana tahapan menganalisis zat warna dan TSS setelah dilakukan fitoremediasi. 2. Pada metode tidak dijelaskan mengenai pengukuran pH pada sampel, namun ada pada pembahasan. 3. pada metode tidak dijelaskan apakah analisis konsentrasi awal limbah tekstil sebelum fitoremediasi?				√
Are results presented in systematic and appropriate form? Note : hasil dan pembahasan ada yang tidak sesuai dengan experimental design, seperti pengukuran pH pada sampel.				√
Statistical treatment of data? (If necessary)				
Relevance of discussion			√	
Soundness of interpretation and conclusions				
Appropriate of literature citations		√		
Quality of figures		√		
Clarity and style of tables and graphics		√		
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Overall quality of the paper			√	

Recommendation :

1. The manuscript is recommended for publication without alteration or after minor revision by editor
2. The manuscript is recommended for publication after revision by author without reevaluation by reviewer
3. The manuscript is recommended for publication after major revision by author and reevaluation by reviewer
4. The manuscript is not suitable for publication

Additional Comments (please list)

Penelitian tentang fitoremediasi limbah tekstil dalam menurunkan zat warna menggunakan enceng gondok sudah banyak dilakukan. Pada artikel belum dijelaskan rinci apa beda penelitian yang dilakukan dengan penelitian terdahulu.

Di pendahuluan belum ditulis rinci mengenai latar belakang melakukan analisis SEM dan FTIR pada sampel.

metode:

metode yang digunakan harus lebih rinci. instrumen yang digunakan untuk analisis zat warna dan TSS belum ditulis dengan jelas, kondisi tanaman yang digunakan utuk fitroemediasi tidak dijelaskan, apakah menggunakan tanaman hidup atau mati? Tidak dijelaskan bagaimana tahapan menganalisis zat warna dan TSS sebelum dan sesudah dilakukan fitoremediasi. tidak dijelaskan juga mengenai pengukuran pH pada sampel, namun ada pada pembahasan. Untuk melihat penurunan tiap waktu, harus diketahui kadar zat warna tekstil, TSS dan pH sebelum perlakuan fitoremediasi. Bagaimana cara mendapatkan penurunan zat warna, TSS dan pH pada sample setelah perlakuan fitoremediasi?

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to Megayulia186, me, atuhuloula

mega Megayulia Nooryaneti:

We have reached a decision regarding your submission to Jurnal Kimia Valensi, "Phytoremediation Processes using W
Textile Industrial Wastewater Treatment".

Our decision is to: Resubmit for Review

Please submit before 31-10-2022

Yulyani Nur Azizah
Program Studi Kimia
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EVALUATION FORM

JURNAL KIMIA VALENSI (*VALENSI JOURNAL OF CHEMISTRY*)

Title	Phytoremediation Processes using Water Hyacinth for Sasirangan Textile Industrial Wastewater Treatment
Date of Receiving	10/7/2022
Date of reviewing	10/19/2022

Please give the checklist (√) to mark your evaluation in the appropriate space

Criteria	Excellent	Good	Fair	Poor
Originality of the work	√			
Scientific merit/ Importance to field	√			
Appropriateness of title. Does the title properly and clearly describe the paper? Note : ……………………………………………………………………………………………….		√		
Is the abstract appropriate? Note : ……………………………………………………………………………………………….		√		
Are materials and methods describe in clarity? No Ambiguity? Note : ……………………………………………………………………………………………….		√		
Description of experimental design Note : ……………………………………………………………………………………………….		√		
Are results presented in systematic and appropriate form? Note : ……………………………………………………………………………………………….		√		
Statistical treatment of data? (If necessary)		√		
Relevance of discussion			√	
Soundness of interpretation and conclusions			√	
Appropriate of literature citations			√	
Quality of figures		√		
Clarity and style of tables and graphics		√		
Article length (if too long suggest way to condense)		√		
Overall quality of the paper		√		

Recommendation :

1. The manuscript is recommended for publication without alteration or after minor revision by editor
2. The manuscript is recommended for publication after revision by author without reevaluation by reviewer

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Artikel

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Submission date: 14-Jun-2022 10:42AM (UTC+0700)
Submission ID: 1856462174
File name: 26283-80154-1-SM.doc (2.5M)
Word count: 4080
Character count: 22224

Phytoremediation Processes using Water Hyacinth for Sasirangan Textile Industrial Wastewater Treatment

Megayulia Nooryaneti[1], Abubakar Tuhuloula[2], and Chairul Irawan[3*]

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Abstract

The growth of textile industry including Sasirangan textile industry are increasing year by year, which produces large amounts of liquid waste. Generally, this liquid waste is discharged into the environment without treatment, so it becomes a source of environmental pollution. Therefore, it is very important to reduce these pollutants. Various methods, not only physical and chemical but also biological methods are available to remediate wastewater. Phytoremediation has provided an economical, environmentally friendly, and aesthetic solution to remediate wastewater. The purpose of this study was to utilize the Water Hyacinth plant as a phytoremediator and to determine its effect in reducing Total Suspended Solid and colors in the liquid waste of Sasirangan textile industry. The research phase begins with preparing Water Hyacinth plants, characterization of Water Hyacinth roots using FTIR and SEM, acclimatization of Water Hyacinth, followed by a phytoremediation processes for 15 days. Based on the results of characterization of Water Hyacinth roots with FTIR, it shows that Water Hyacinth roots contain functional groups O-H strain, C-H vibrations, C=O strain, C-H deformation, and C-O stretching. Observations with SEM showed that the roots of Water Hyacinth was very unstructured and has pores. However, it has cavities which are pores in cellulose. The biggest decrease in Total Suspended Solid was at 9 days of phytoremediation, which was 54 mg/L or 71.12% and the best color reduction at 9 days of phytoremediation was 81.5 PtCo or 92.26%. The presence of these functional groups and pores and strengthened by the results of analysis of Total Suspended Solid and colors showed that Water Hyacinth has the potential to reduce levels of Total Suspended Solid and colors in the Sasirangan wastewater.

Keywords: Sasirangan industry, wastewater, phytoremediation, Total Suspended Solid, colors

1. INTRODUCTION

The problem of water pollution in South Kalimantan has shown quite serious symptoms. The higher the population growth rate and the higher industrialization have caused a decrease in environmental quality. In addition, the low awareness of some people and industry players who directly dispose of their waste into the environment without being processed first moves the author to think about how to solve this problem so as not to burden industrial players, especially the Small and Medium Industry of Sasirangan textile industry in processing their waste. This industrial wastewater treatment includes mechanisms and processes commonly used to treat water contaminated by industrial activities before being discharged into the environment. Wastewater treatment aims to reduce or even eliminate pollutant parameters in wastewater.

The production processes of Sasirangan requires large amounts of water, resulting in a large amount of liquid waste. The liquid waste of the Sasirangan textile industry mainly comes from the dyeing and dyeing process. This liquid waste contains materials that are separated from the fiber, chemical residues added to the dyeing and coloring process. Various kinds of chemicals in the production process such as dyes, caustic soda, and other materials which are auxiliary chemicals. These materials are the main sources of pollution because only a small part is absorbed in textile products, while most of it is wasted with wastewater (liquid waste). Textile dyes are difficult to degrade because they have a complex molecular structure (Rigueto *et al*., 2020)

One way that can be done in the waste treatment method is phytoremediation using the Water Hyacinth plant (Ilo *et al*., 2020) as a biological agent in the treatment of the waste by the exposure process. Phytoremediation is becoming popular to remediate various contaminants (Saber *et al*., 2018), such as acids, bases, toxic organic and inorganic compounds, and colors (Pushpa *et al*., 2015). Phytoremediation is an environmentally friendly and cost-effective method (Holkar *et al*., 2016). Water Hyacinth is a member of monocot plants (Qin *et al*., 2016) that live floating in tropical and subtropical areas (Tabinda *et al*., 2019) containing cellulose and lignin (Gogoi *et al*., 2017). Water Hyacinth was chosen as a plant for phytoremediation because its availability in nature is quite abundant and its growth is very high (Du *et al*., 2020), able to thrive in extreme environmental conditions (Adelodun *et al*., 2021) the amount of Water Hyacinth can be doubled within one week under suitable growing conditions (Sun *et al*., 2018) and has been tested for its ability to reduce pollutants commonly found in industrial wastewater (Naaz *et al*., 2013).

Water Hyacinth is suitable for controlling various types of wastewater (Mahmood *et al*., 2018) originating from the industry. It is also proven that among aquatic plants, Water Hyacinth is also suitable for absorbing nutrients and improving water quality. Water Hyacinth as part of a wastewater treatment system has an even more important and extraordinary effect on the environment by taking CO_2 from the atmosphere, as well as collecting supplements for plants. Likewise in terms of cost, this technology is cheaper (Jiang *et al*., 2015) than other advanced technologies that require more costs to work on evacuating pollutants from wastewater (Rezania *et al*., 2015). This environmentally friendly methodology (Ekambaram *et al*., 2018) will positively assist the advancement of several new plant technologies in the use of Water Hyacinth to treat wastewater in the future.

Several researchers reported that phytoremediation for 8 days using sewage wastewater with *Lemna minor* plants, one of which was a 50.8% reduction in TSS (Abdul Aziz *et al*., 2020). Phytoremediation using *Pistia stratiotes* can reduce the color content by 86% of dyeing waste (Ahila *et al*., 2021). However, research on Water Hyacinth phytoremediation apply to Sasirangan wastewater is lacking in the scientific literature. To fill this research gap, this study aims to determine the potential of Water Hyacinth plants as phytoremediator agents in Sasirangan wastewater. The results of this study will be very useful for researchers and industry in designing alternative biotechnology to treat Sasirangan wastewater using wetland swamp plants.

2. RESEARCH METHODS

2.1 Materials

The main tools used are phytoremediation reactor, thermometer, siever, beaker, measuring cup, spatula, analytical balance. The ingredients used are distilled water, Whatman filter paper No.42, Sasirangan wastewater from one of the Sasirangan industries in Cempaka, Water Hyacinth (*Eichhornia crassipes*) plants taken from swamps in Tungkaran Village.

2.2 Preparation of Water Hyacinth for FTIR and SEM Analysis

The material used is Water Hyacinth root. Water Hyacinth roots that have been cleaned with water, dried for 3 days, at room temperature of 25˚C to 31˚C. After the ingredients are dry then the ingredients are mashed for 2 minutes. After that, the material was sieved with a size of 60 mesh and then analyzed by FTIR and SEM.

2.3 Characterization of Water Hyacinth roots by FTIR and SEM

The Fourier Transform-Infra Red test (FT-IR, Bio-rad, Digilab FTS-3500) is a functional group test of a material. FT-IR is a functional group test of Water Hyacinth root using a spectrophotometer (FT-IR, Bio-rad, Digilab FTS-3500) in the wavelength range 4000-400 cm^{-1} with a scan rate of 8.

Field Emission-Scanning Electron Microscope (FE-SEM) to determine the morphology/surface structure of Water Hyacinth roots using a Scanning Electron Microscope (JEOL, JSM-6500 LV). Scan parameters 5 kV with 2.500 and 10.000x magnification.

2.4 Water Hyacinth (Eichhornia crassipes) Acclimatization and Phytoremediation Method

At the time of acclimatization, the dilution was 1 liter of Sasirangan industrial wastewater mixed with 20 liters of distilled water and then stirred until homogeneous. Acclimatization plants done by means of disposes waste liquid into a container and settled for 4 days for plants not withered or die. After that, the plants were neutralized again with distilled water for 1 day before the experiment (Riyanti *et al*., 2019). Samples of wastewater from the Sasirangan industry were accommodated in a reactor containing 1 liter of wastewater with 20 liters of distilled water (1:20 dilution ratio). Then the diluted waste is put into a reactor. Then put into reactors containing 0.5 kg, 1 kg, and 1.5 kg of Water Hyacinth plants. After that, color and total suspended solid were analyzed for each sample on days 0, 3, 6, 9, 12, and 15.

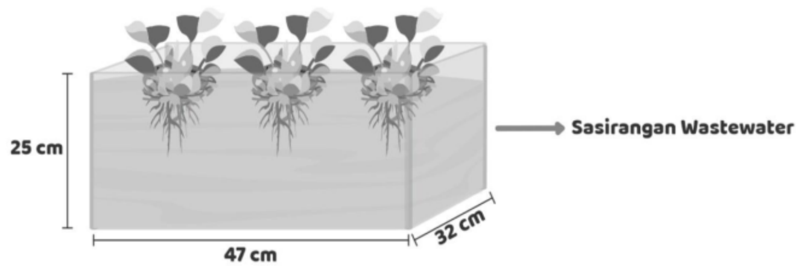


Figure 1. Set up of wastewater treatment phytoremediation processes with Water Hyacinth plant

3. RESULTS AND DISCUSSION

3.1 Characterization of Water Hyacinth roots used in the phytoremediation processes

FTIR analysis is an analysis used for the identification of compounds, especially organic compounds. The analysis is done by looking at the shape of the spectrum, namely by looking at the specific peaks that indicate the type of functional group possessed by the compound. The prepared water hyacinth roots were analyzed by FTIR to find out what functional groups were present in the roots so that they could remove the contaminant parameters in the Sasirangan wastewater.

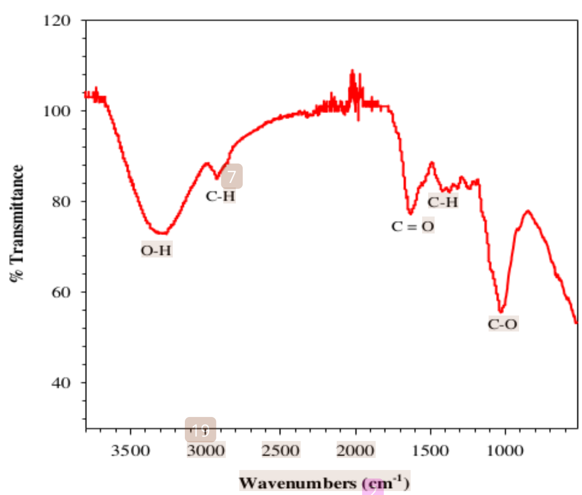


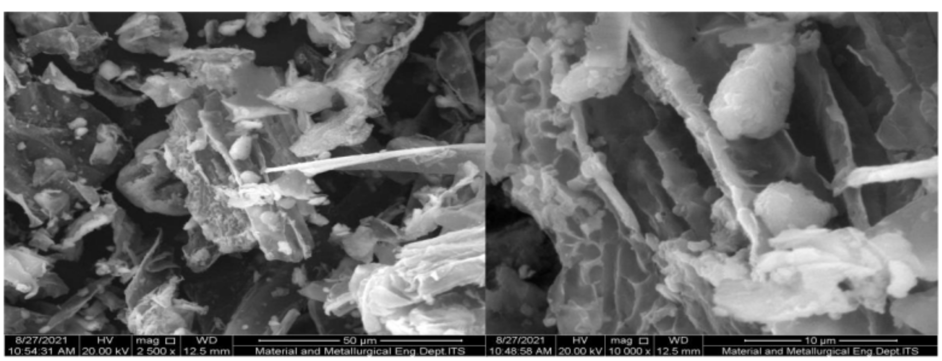
Figure 2. Graph of FTIR analysis of Water Hyacinth roots

Figure 2 shows the spectrum of Water Hyacinth roots observed on FTIR. At the wavenumber 3263.21 cm^{-1} associated with the O-H strain. The wavenumber of 2926.36 cm^{-1} is associated with C-H vibrations for alkanes. Water Hyacinth roots also showed a wave number of 1633.38 cm^{-1} associated with the C=O strain of the carboxylate. At 1370.63 cm^{-1} wave number is associated with C-H deformation. And the stretching of C-O is shown at a wave number of 1030.46 cm^{-1} which indicates the presence of an alcoholic hydroxyl group (Mukaratirwa-Muchanyereyi *et al*., 2016). Thus it can be said that the composition of Water Hyacinth root is mainly composed of lignocellulose.

These functional groups are specific functional groups of cellulose. Cellulose itself is a hydrophilic polymer with an O-H group (Mulyadi, 2019). Hydrophilic means that the compound can bond with water, because of its polar shape. Because of its ability to bind water, it can degrade contaminant parameters such as TSS, COD, color and others. In addition, the shape of the roots of Water Hyacinth is fibrous so that it is able to hold the solids present in the wastewater, so that it is able to reduce the levels of suspended solids. The presence of O – H or hydroxyl groups from the results of FTIR analysis plays a role in the adsorption of contaminants in wastewater so that it can reduce Total Suspended Solids in wastewater. The O – H group will be bound and interact with the adsorbate. Positively charged ions from the dye will bind to the O – H group which is rich in electrons, so that it will attract harmful dyes contained in the Sasirangan liquid waste. This is in accordance with what was stated by (Imron *et al*., 2021) that the functional groups that play a role in the absorption of dyes are the hydroxyl and carboxyl groups.

The appearance of the presence of cellulose can also be confirmed through analysis using SEM which shows the presence of cavities in the form of pores in the cellulose. The presence of cellulose in the roots of these plants can absorb dyes. The clusters contained in the dyestuffs of the Sasirangan wastewater react with the O – H groups of the cellulose to form compounds with covalent bonds, so that they are able to degrade the color in the Sasirangan wastewater.

SEM analysis was carried out to observe the surface morphology of the material, in this case the Water Hyacinth root which will be used for the phytoremediation processes, was characterized using SEM to determine the surface structure of the root so that it was able to absorb contaminants contained in the Sasirangan wastewater.



(a) **(b)**

Figure 3. Characterization of Water Hyacinth roots using SEM with (a) 2,500 times magnification and (b) 10,000 times magnification

Figure 3 shows that the Water Hyacinth roots surface is very unstructured. However, it has cavities which are pores in cellulose. This is in line with what was conveyed by Mukaratirwa-Muchanyereyi *et al*. (2016) that Water Hyacinth does not have a thick epicuticular wax layer and does not have a structured surface, and consists of fibers and has micropores (Muigai *et al*., 2021). Cellulose has bonds in the form of OH ions which can cause the adsorption process to occur. Cellulose has strong linear chain bonds with interactions through intermolecular and intramolecular hydrogen bonds. Intramolecular is a hydrogen bond between OH groups of adjacent glucose units in the same cellulose molecule, while intermolecular is a hydrogen bond between OH groups of adjacent glucose units in adjoining cellulose molecules (Liu *et al*., 2015).

3.2 Decrease in Total Suspended Solid and pH over a Period of Time

The decrease in pH in phytoremediation correlate with a decrease in Total Suspended Solid (TSS). For phytoremediation to be effective, suitable environmental conditions are needed to support the growth and development of Water Hyacinth. The higher the plant weight does not necessarily affect the decrease in TSS. **Figure 4** shows the decrease in pH each day. A constant decrease is seen, between TSS and pH tends to be in equilibrium. It could be that the decrease in pH is due to the greater concentration of hydrogen ions in the water. On days 0 to 3 the change in pH was not significant. It is possible that during this time, the Water Hyacinth plants are still adapting to the environment. Meanwhile, on the 3rd to 15th day there was a decrease which was almost close to neutral pH. The decrease which tends to be constant is because phytoremediation undergoes a *phytostabilization* processes mechanism, namely the attachment of certain contaminants to the roots that cannot be absorbed into the plant stem (Saleem *et al*., 2020). Roots play a role in phytostabilization (Raza *et al*., 2020). In this system, the respiration process may occur but does not exceed the photosynthesis process, so that the carbondioxide can be taken up directly by plants through the air is released back into the water and the pH will be lower but lead to normal and tend to be stable. The presence of H^+ ions caused by the decay of fallen plant parts can also cause a decrease in pH (Novi *et al*., 2019).

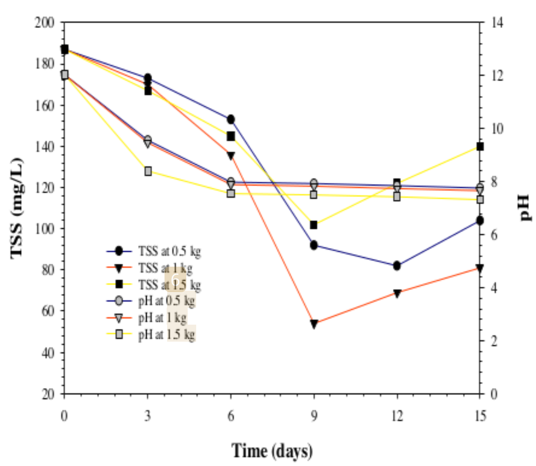


Figure 4. The Relationship between the TSS against time and pH

This decrease in pH resulted in significantly reduced TSS for 0.5 kg, 1 kg, and 1.5 kg Water Hyacinth plants. This decrease in TSS is due to phytoremediation experiencing a *rhizofiltration* processes mechanism, which is a process of adsorption or deposition of contaminants by the roots by sticking to the roots (Saleem *et al*., 2020). On days 12 to 15 there was an increase in the concentration of TSS again. This could be because the Water Hyacinth plants have experienced saturation in absorbing contaminants in the Sasirangan wastewater. The biggest decrease in *Total Suspended Solid* was at 9 days of phytoremediation, which was 54 mg/L or 71.12%. This decrease is greater than the study of Abdul Aziz *et al*. (2020) phytoremediation using *Lemna minor* plants, one of which was applied for 8 days to sewage wastewater with a Total Suspended Solid reduction of 50.8%. This difference could be due to the root system of the Water Hyacinth plant being different from that of the *Lemna minor* plant. *Lemna minor* plants have smaller roots compared to Water Hyacinth, so Water Hyacinth can filter more suspended solids. Therefore, the TSS reduction efficiency of Water Hyacinth plants was greater than that of *Lemna minor* plants.

3.3 Decrease in colors and pH over a Period of Time

The decrease in pH also correlates with a decrease in colors concentration. **Figure 5** shows the colors concentration that fluctuates from day to day. A significant decrease in colors occurred on day 3. This decrease was due to the decomposition process by microorganisms in the root zone or called *rhizodegradation*, which is a process where the substrate supplied by plants can stimulate the growth of microbial communities in the rhizosphere to break down organic pollutants. The rhizosphere provides a unique environment for microorganisms capable of breaking down harmful pollutants into harmless products through their metabolic activities. In *rhizodegradation*, the biodegradation process is produced from nutrients released by plants in the form of root exudates. The microbial population and activity in the rhizosphere can increase due to the presence of this exudate and can increase the degradation of organic pollutants (Chandra *et al*., 2017). Dyes can be reduced and the bond chain can be broken with the help of decomposing microorganisms. The first time, the process that occurs is to degrade the long-chain compounds that make up the dye into short chains which can then be used as an energy source for plants to synthesize the components that make up new cells.

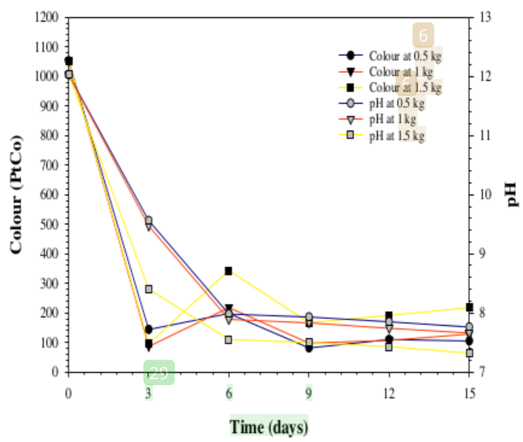


Figure 5. The Relationship between the colors against time and pH

Figure 6 shows the mechanism of degradation or absorption of dye by cellulose from Water Hyacinth roots. The increase in the concentration of dyes occurred on day 6, this was probably caused by the number of plants that had not been proportional to the pollutant load in the wastewater, coupled with the possibility of decomposition of dead plants so that their concentrations increased. Many factors influence this decrease and increase, including the unpredictable weather every day, so it really determines this phytoremediation process because the process requires sunlight. In this study, the best color reduction at 9 days of phytoremediation was 81.5 PtCo or 92.26%. This result is slightly larger than that of (Ahila *et al*., 2021) the use of *Pistia stratiotes* as a phytoremediation agent can reduce the colour content of 86% in dyeing waste. This difference could be due to the different enzyme activities produced by each plant. Enzymes released by plants can degrade dyes (Holkar *et al*., 2016). The enzymes produced by the Water Hyacinth plant may be more than that of the *Pistia stratiotes* plant so that the water hyacinth can absorb more dye than *Pistia stratiotes*.

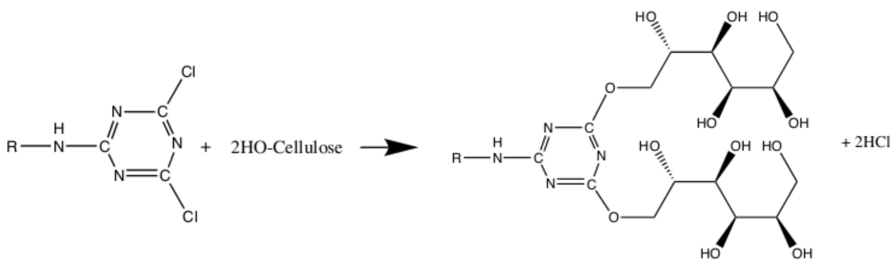


Figure 6.The reaction mechanism of Sasirangan dye degradation by Water Hyacinth roots

The dominant dyes found in the textile industry are azo. Azo dyes have one or more nitrogen double bonds (Bharathiraja et al., 2018). Water Hyacinth root contains cellulose. The presence of cellulose in plants generally can absorb dyes. The molecular structure of cellulose contains -OH or hydroxyl groups. The groups contained in the Sasirangan wastewater dye react with the -OH group of cellulose to form compounds with covalent bonds.

4. CONCLUSIONS

The Sasirangan wastewater treatment approach with the phytoremediation method showed good performance in reducing Total Suspended Solid and colors. The effect of weight variation of Water Hyacinth showed a not very significant decrease. The decrease in pH in phytoremediation correlated with a decrease in Total Suspended Solid and colors. The decrease in *Total Suspended Solid* and significant colors on day 9 was 54 mg/L and 81.5 PtCo. Based on the results of characterization of Water Hyacinth roots with FTIR, it shows that Water Hyacinth roots contain functional groups O-H strain, C-H vibrations, C=O strain, C-H deformation, and C-O stretching. Observations with SEM showed that the roots of Water Hyacinth was very unstructured and has pores.

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