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by Saprizal Hadisaputra

Submission date: 24-Feb-2021 11:19AM (UTC+0700)
Submission ID: 1516754891
File name: C32.pdf (253.13K)
Word count: 3954
Character count: 20996

ORIGINAL ARTICLE

European Journal of Advanced Chemistry Research
www.ej-chem.org

Phytoremediation of Detergent Levels in Waters Using Water Plants: *Eichornia crassipes, Ipomoea aquatica, Pistia stratoites* and Their Combinations

Syarifa Wahidah Al-Idrus, R. Rahmawati, Saprizal Hadisaputra and Hilman Qudratuddarsi

ABSTRACT

Research on phytoremidiation to reduce detergent waste in waters has been successfully carried out. The phytoremidiation process is carried out using aquatic plants: *Eichornia crassipes*, *Ipomoea aquatica*, *Pistia stratoites*, and their combinations. The treated water sample comes from the Ancar river Mataram, NTB. The research is experimental with a randomized block design, with the procedure: Water samples are planted with aquatic plants according to the research design which serves to absorb detergent waste. Detergent levels before and after the treatment of aquatic plants were observed using the MBAS (Methylen Blue Active Substance) method. The results showed that the three water plants used were able to reduce the concentration of detergents and improve the concentration of water quality parameters (pH, DO, BOD, and COD) and which had the best ability (73.60%) in absorbing detergents was a combination of *Eichornia crassipes* and *Ipomoea aquatic* the best accumulation time of absorption occurred in the period of 7 to 14.

Keywords: phytoremediation, detergent, aquatic plants.

Published Online: September 23, 2020

ISSN: 2684-4478

DOI :10.24018/ejchem.2020.1.5.12

Syarifa Wahidah Al-Idrus*
Study Program of Chemistry, Department of Education of Mathematics and Natural Sciences, Universitas Mataram, Indonesia.
(e-mail: syarifaidrus@unram.ac.id)

R. Rahmawati
Study Program of Chemistry, Department of Education of Mathematics and Natural Sciences, Universitas Mataram, Indonesia.
(e-mail: rahmawati_kimia@unram.ac.id)

Saprizal Hadisaputra
Study Program of Chemistry, Department of Education of Mathematics and Natural Sciences, Universitas Mataram, Indonesia.
(e-mail: rizal@unram.ac.id)

Hilman Qudratuddarsi
Mathematics and Science Education Department, Faculty of Education, University of Malaya, Malaysia.
(e-mail: hilmandarsi@gmail.com)

Corresponding Author

I. Introduction

A river waters are areas that are very vulnerable to pollution in the form of liquid waste caused by human activities such as cooking, bathing, and washing. Wastewater contains suspended organic matter and dissolved substances such as cohydrate, fat and protein. 80% of the causes of freshwater pollution are liquid waste [1] and 20% of the total wastewater is detergent [2]. Detergents that contain surfactants such as Sodium Dodecyl Benzen Sulfonate (NaDBS) and sodium Tripolyphosphate (STPP) are found in laundry soap, bath soap, shampoo, toothpaste, and others. Detergents are chemical compounds made from synthetic materials so that detergents have a negative effect on humans and the environment.

Surfactant in detergents is a material that is very difficult to degrade naturally so that it can cause pollution. Surfactants can cause skin irritations such as itchy and blistered skin. In the chlorination of PDAM drinking water treatment, surfactants can form chlorobenzane which is toxic and harmful to health. Detergents also contain phosphate (builders) which can reduce water hardness by binding to calcium and magnesium ions even though Phosphate itself is non-toxic and even becomes an important nutrient for living things. In large quantities, phosphate causes eutrophication of waters and causes a reduction in the amount of aquatic oxygen which can endanger the aquatic ecosystem [3], [2].

Because it is needed to control water pollution such as the process of settling and filtering using water weeds. Water plants commonly used to control water pollution are Pistia stratoites L, Eichornia crassipes and ipomoea aquatica. Plants that can be used to purify water usually have the ability to reduce the content of organic and inorganic substances in waters so that these types of plants can be used for water remediation. The process of water remediation using aquatic plants is called phytoremidiation. Phytoremediation aims to extract, reduce or clean pollutants in soil and surface water [4]. Phytoremediation technology is relevant to be applied in developing countries because it is effective, economical and sustainable [5]-[7] and environmentally friendly [7], [8]. Phytoremediation has five processes which include: rhizofilteration, phytostabilisation, phytoextraction, phytovolatilization and phytodegradation. Rhizofilteration is the use of plants to absorb, concentrate and precipitate organic and inorganic pollutants from water sources [9].

Some aquatic macrophytic species that are often used in the phytoremidiation process to remove heavy metal content in water are Eichhornia crassipes (Eichhornia sp.), Weeds (Lemna sp., Spirodella sp.), Small water ferns (Azolla sp.), And watercress (Pistia). sp.) Eichhornia crassipes (Eichhornia crassipes), ipomoea aquatica (Ipomoea aquatica) and Pistia stratoites L (Pistia stratiotes) that are able to accumulate and tolerate toxic metals (Ag, Cd, Cr, Cu, Hg, Ni, Pb and Zn) [10] are used to reduce phosphate and sulfate levels in waters [1] and Marsile aquadrifolia can reduce almost all physical, chemical, and biological parameters of the sugar industry wastewater [11].

II. Procedure

A. Preparation of water samples and plant samples

The water samples of this study were taken from waters that have been polluted by detergents namely the Ancar River. The sampling point is a fragment of the river in the densely populated downstream with detergent content greater than 0.11 mg/l, river width 9.5 m, river flow is relatively weak 0.03 m/sec, water is brown and has a fishy odor. Water samples are taken using a kammerer water sampler at a predetermined point. Then do the analysis of the parameters of the quality of water samples (pH, DO, BOD, and COD) and detergent content.

Plant samples used in this study were Eichornia crassipes (Eichhornia crassipes), ipomoea aquatica (Ipomoea aquatica), and Pistia stratoites L (Pistia stratiotes). Aquatic plants are taken under the same conditions of biomass and vegetative phases. Aquatic plants that have been taken are left for three days in distilled water, to release impurities that stick to the roots.

B. Research design

The design in this study was a randomized block design (RBD). Group A is plant species (K0, K1, K2, K3, K4, K5 and K6) and group B is time / period (H0, H7, H14, H21 and H28). The water samples that were analyzed for the initial physical physics parameters were divided into 21 observation tanks for block 1, block 2 and block 3. Each container was 20 liters and filled with 18 liters of water samples. Each tub was planted with acclimated water plants and one tub was not planted with water plants as a control (K0). The other observation basins were each planted with Eichornia crassipes (K1), Ipomoea aquatica (K2), Pistia stratoites L (K3), a combination of Eichornia crassipes and Ipomoea aquatica (K4), a combination of Eichornia crassipes and Pistia stratoites L (K3), a combination of Eichornia crassipes and ipomoea aquatica (K4), a combination of Eichornia crassipes and Pistia stratoites L (K3) ipomoea aquatica and Pistia stratoites L (K6). The mass of water plants planted in each tub is 60 g. Block 2 and block 3 are repeated treatments like block 1. Each treatment is repeated three times (blocks 1, 2 and 3), because replication in an experiment is needed to reduce errors (N> = 2). Each observation tank was observed in each period of a certain day (H0, H7, H14, H21 and H28). Measurements were taken every period of the same day, starting from H0-H28. The results of observations per period are observed and recorded.

C. Water quality analysis of Ancar river

Waste water is collected in plastic bottles from the Ancar River and physical chemical analysis such as temperature, pH, dissolved oxygen (DO), BOD, COD, detergents before and after phytoremediation is carried out.

PH analysis. Initial analysis begins by measuring the pH using a pH meter.

Analysis of DO, BOD and COD. DO analysis (dissolved oxygen) using a DO meter. BOD (biological oxygen demand) was measured using a DO meter on the 5th day. COD analysis was performed by the titration method using a potassium dichromate ($K_2Cr_2O_7$) oxidizer.

Detergent analysis. Detergent content is tested in the Laboratory. Detergent measurements were carried out using the MBAS (Methylen Blue Active Substance) method.

III. Result And Discussion

The initial water quality of the study sample is shown in Table 1. Almost all of the parameters tested were above the average grade II water quality standard according to PP no. 82 of 2001 [12].

TABLE 1: Ancar River Water Quality at The Beginning Of The Study

No	Parameter	Units	Results	Quality standard PP No. 82 of 2001 2nd Class
1	Detergen (MBAS)	mg/L	0,11	0,02
2	Dissolved Oxygen (DO)	mg/L	4,4	4
3	Biological Oxygen Demand (BOD)	mg/L	5,6	3
4	Chemical Oxygen Demand (BOD)	mg/L	41,6	25
5	pH	-	6,8	6-9
6	Temperature	ºC	28,5	-

Of all physical and chemical parameters, it shows that the water quality of the Ancar river is above the class II water level threshold and is categorized as polluted. Ancar river pollution is caused by the entry of domestic waste into the Ancar river in the form of detergents that are not degraded by microorganisms in excessive amounts so that it disrupts the life of microorganisms in water. The presence of detergent inhibits the solubility of oxygen so that the concentration of dissolved oxygen becomes low. Low dissolved oxygen (DO) causes high BOD and COD values. In addition, the content of phosphate in detergents causes the development of freshwater plants, such as algae (which uses oxygen available for the decay process) so that dissolved oxygen (DO) becomes low [13].

After different treatment of river water samples and statistical analysis results, the detergent parameter is at a significance level of 0.049. The significance level of 0.049 means that there are significantly different detergent levels measurement results. Likewise, for DO, BOD, COD has a significance of 0.034; 0.036; 0.021, means there are significantly different measurement results. PH and temperature values do not show significant differences because the significance is above 0.05.

A. Detergent

The detergent content in the control water sample (K0) did not experience a significant decrease. From day 0 (0.11 mg/L) to day 28 (0.108 mg/l). Detergent levels in water samples planted with Eichornia crassipes (K1), on the 7th day decreased well and decreased maximally on days 14 and 21. In the treatment using Ipomoea aquatica (K2), maximum absorption of detergents also occurred on day 14 and 21. The K3 treatment has the same absorption pattern as the K1 and K2 treatments but the absorption value is lower. All variations of aquatic plants are able to absorb detergents. High absorption of aquatic plant (K4) variation: variation of Eichornia crassipes and ipomoea aquatica. The pattern of decreasing detergent levels can be seen in Fig. 1.

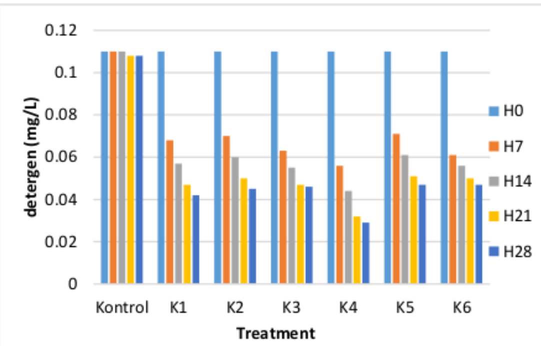

Fig. 1. Detergent levels for each treatment in 5 periods.

Absorption by Eichornia crassipes (K1) with a value (61.8%) and ipomoea aquatica (K2) with a value (59.1%). Ipomoea aquatica and Eichornia crassipes are able to absorb detergents well because they have wide leaves and hollow stems. Pistia stratoites L has a lower absorption ability because it has a short stem. The difference in detergent absorption from these three plants is also influenced by the shape of the leaves. The K4 treatment caused the water sample to have the lowest detergent level of 0.029 mg/L, close to the grade II water quality standard of 0.02 mg/L. Eichornia crassipes is more suitable to be planted in river water media with high detergent levels than Pistia stratoites L., Eichornia crassipes has been widely used in domestic wastewater treatment [14]. Aquatic plants absorb organic compounds in ionic waters. The main constituent of detergents is sodium tripolyphospate and dodecyl benzene sulfonate Phosphate is absorbed by plants in the form of $H_2PO_4^-$ and $H_2PO_4^{2-}$ ions. The absorption of pollutants in the form of organic matter is limited by the mechanism of absorption by plants and plant types. The ability to bioaccumulate, reduce and eliminate harmful contaminants in soil, water or air [8]. Inside the roots, plants form a chelating agent called phytopiderophore. After that, phytoplider binds metal or organic substances and then brought into the root cell. In order for the absorption of metals and organic compounds to increase, plants form rediktase molecules in the root membrane [15].

While in ipomoea aquatica, passive absorption depends on the water molecules that enter the membrane and the rate of plant transpiration by osmosis, and active absorption takes place because of the plant's need for photosynthesis with the help of solar energy. The absorbed liquid waste will be carried into cell walls, vacuoles and cytoplasm which bind in coordination with the sulfuhydryl (-SH) group. Inside the cell, the bond is broken down by the enzymes sitalase and oxidase in the mitochondria. The result of the breakdown is used as an energy source. The remaining liquid waste is transplanted to plant tissue at the apex, and deposited in young leaves which are still in the growth stage.

The ability to absorb waste by plants is greatly influenced by roots. Contaminants in wastewater are absorbed well by plant roots (rhizofiltration) [16]. The root is the part of the plant that first interacts with waste therefore, plant roots hold various microorganisms such as bacteria, fungi and yeast (called rhizosphere). Three plants used in this study have different root lengths. Eichornia crassipes has an average root length of 13 cm, ipomoea aquatica averaged 12.5 cm and Pistia stratoites L 5 cm. with longer roots, Eichornia crassipes and ipomoea aquatica have a higher tendency to absorb nutrients than Pistia stratoites L. The greater number of roots in Eichornia crassipes and the ability of biofilter from roots causes the absorption of waste by Eichornia crassipes better than other plants.

B. DO value (dissolved oxygen)

All treatments can increase DO (dissolved oxygen) and the best is K4. Water samples treated with Eichornia crassipes and ipomoea aquatica were able to increase DO values on day 14 to 7.65 mg/L. Laying plants can affect the solubility of oxygen in the waters. In addition, the uptake time also affects dissolved oxygen levels. Dissolved oxygen levels reach their maximums during the day and evening. The increase in DO values in all water samples is inversely proportional to the BOD and COD values. The increase in DO values can be seen in Fig. 2.

Aquatic plants in sewage reduce dissolved CO_2 during periods of high photosynthetic activity [14]. CO_2 is a major element in the photosynthesis process needed by phytoplankton and aquatic plants [17] and this photosynthetic activity increases DO values thereby supporting the activity of aerobic bacteria to reduce BOD and COD. The success of phytoremediation is highly dependent on photosynthetic activity and plant growth rates [9].

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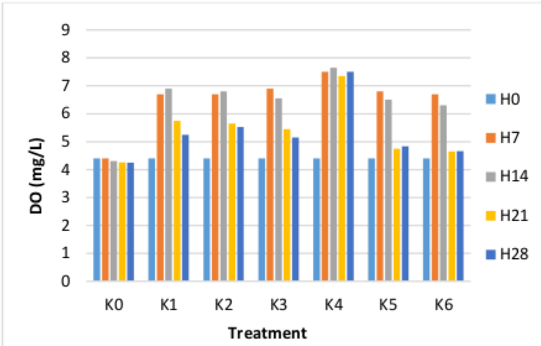

Fig. 2. DO values for each treatment in 5 periods.

Dissolved oxygen (DO) has a tendency to increase on days 7 and 14. On days 21 and 28, DO has decreased. The decrease in DO is due to plant saturation so that the roots fall out and the leaves begin to rot. So that dissolved oxygen in the water is used by decaying plants. aquatic plants can reduce contaminants, BOD and COD and increase DO in a period of 15 days [14].

C. BOD analysis

Detergent is a derivative of organic substances so that its accumulation causes an increase in COD and BOD so that the water quality decreases. After treatment with aquatic plants for 28 days the BOD and COD levels decreased, and the maximum decrease in BOD on the 21st day was 78.60%. Aquatic plants have an excellent capacity to reduce levels of toxic metals, BOD, and total wastewater solids [14]. The process of reducing BOD levels in each treatment is shown in Fig. 3.

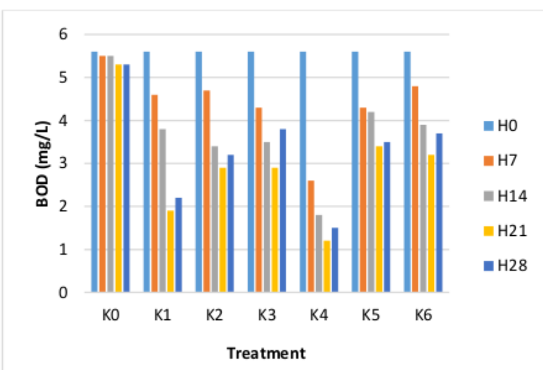

Fig. 1. BOD value for each treatment in 5 periods.

The highest reduction in BOD in K4 treatment (a combination of Eichornia crassipes and ipomoea aquatica) because both of these aquatic plants have higher photosynthetic abilities compared to Pistia stratoites L. The leaf types of both plants strongly affect their photosynthetic abilities. The highest decline period occurred on day 7. Phytoremediation increased significantly on the 7th day and then increased slowly until the 15th day [18].

D. COD analysis

Chemical oxsygen demand (COD) is an indirect measurement of the amount of organic matter in a sample [19]. COD levels decreased at K4 treatment by 60%. Eichornia crassipes can reduce textile waste COD by 40-70% [20]. The COD reduction process in this study is shown in Fig. 4.

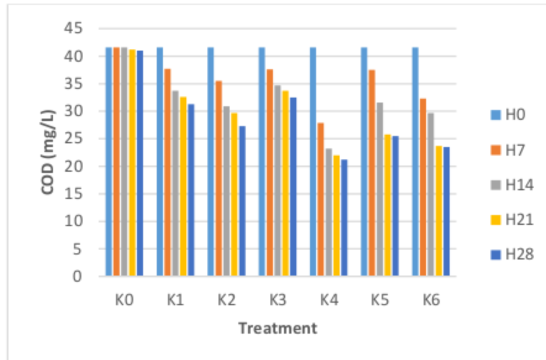

Fig. 4. COD value for each treatment in 5 periods.

The maximum COD reduction occurred in the K4 treatment (combination of Eichornia crassipes and ipomoea aquatica) and the maximum reduction period on day 7 for all treatments. From all analytical parameters, the maximum COD decrease accumulation occurred on the 7th day.

E. Acidity (pH)

The acidity (pH) did not change significantly in each treatment, the pH remained under normal conditions in the range of 6.5-7.5. In general, the pH of water is influenced by free CO_2 concentrations. The temperature parameter is also in a stable condition although it has increased but not significantly. Temperature and pH are determinants that mutually support the enzymatic activity of the alkylbenzene sulfonate reactor which works optimally at 28°c [1]. The pH conditions during the observation are shown in Fig. 5.

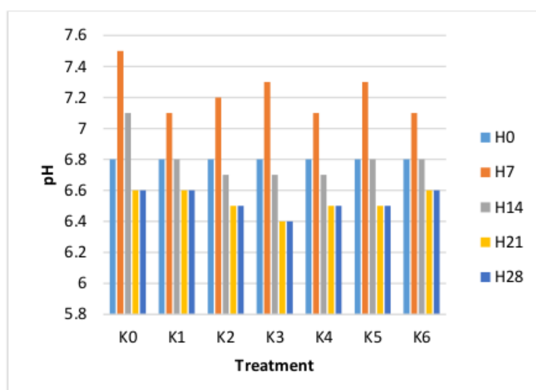

Fig. 5. The pH value of each treatment in 5 periods.

IV. Conclusion

The best ability to absorb detergents, 73.60%, is in treatment 4, which is a combination of Eichornia crassipes plants with ipomoea aquatica. The K4 treatment also gave the best results for all parameters tested (pH, DO, BOD and COD) and the best accumulation time of absorption occurred in the period of 7 to 14.

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Syarifa Wahidah Al Idrus is a lecturer in the Chemistry Education Program at University Mataram,Lombok Island, Indonesia. Syarifa Wahidah Al Idrus qualified Master of Scince, Brawijaya University, Indonesia on 2009.

She has publication national and international journals. Syarifa has 17 years of experiences in teaching and research on Mataram University. Her research interest is education and environmental chemistry.

Dr. Rahmawati is a lecturer in the Chemistry Education Program at University Mataram,Lombok Island, Indonesia. She finished PhD at Gadjah Mada University, Indonesia.

She has publication national and international journals. Rahmawati has 15 years of experiences in teaching and research on Mataram University. Her research interest is education and organic chemistry

Dr. Saprizal Hadisaputra is a lecturer in the Chemistry Education Program at the University Mataram, Lombok Island, Indonesia. He finished undergraduate in Chemistry at Gadjah Mada University at Yogyakarta, then Masters degree at Flinders University, Australia and PhD in the field computational chemistry from the Austrian-Indonesian Center for Computational Chemistry, UGM, Indonesia.

He is active in conducting research in the field of chemistry and in chemistry education and publishing articles in international journals

Hilman Qudratuddarsi is a student in Master of Science Education, Faculty of Education, University of Malaya, Kuala Lumpur, Malaysia. Previously, he was graduated from bachelor chemistry education, Mataram University, Indonesia. His research interest is education, educational instrument, chemistry accentuating on research with quantitative analysis.

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