The Ability of *Sagittaria lancifolia* as Phytoremediator on Detergent Solution

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Abstract. *Sagittaria lancifolia* is a plant that can be used as a phytoremediator. This study aimed to determine the effect of phytoremediation in various concentrations of a detergent solution, a different detention time and interaction both on levels of LAS, BOD, leaf morphology and chlorophyll content. Method using an experimental with randomized block design with three factors of each treatment with three replications. Analysis of data using ANOVA two directions and continued test of Duncan. The results showed that the average percentage reduction in the levels of LAS on the most optimal planting medium is shown at a concentration of 75 ppm detention time of 14 days at 81.53%, the average BOD is best contained at a concentration of 10 ppm to 14 days detention time of 25.55 mg/l and lowest average chlorophyll content was shown at a concentration of 75 ppm detention time of 14 days amounted to 14.433 mg/l. Chlorosis and necrosis highest concentration of 75 ppm is shown in 14-day detention time.

1. Introduction

Indonesia is a country with a population of 4th most populous in the world. Given these conditions, the more the amount of waste generated and discharged into waterways. Waste dominated one of them is domestic waste. Domestic waste is divided into two categories: first, domestic waste water from the washing water such as soaps, detergents, oils and pesticides; The second is the liquid waste from the latrines such as soap, shampoo, feces and urine. This wastewater as a potential environmental pollutant if not managed properly. The result of this waste water enters the body when water will affect the condition of the water body. The more densely populated, the more waste that must be controlled.

Soap detergent is a compound that is formed through a chemical process. In general, the main constituent of the detergent component is *Sodium Dodecyl Benzene Sulfonate* (NaDBS) and *Sodium Tripolyphosphat* (STPP), which are difficult degraded naturally. NaDBS and STPP compound can form a precipitate with alkaline earth metals and transition metals [1]. Surfactants are often used in detergents are anionic surfactants are *alkyl benzene sulfonate* (ABS) or *Linear Alkylbenzene sulfonate* (LAS) [2]. According to East Java Governor Regulation No. 72 Year 2013 regarding Standard Wastewater For Activities Laundry Levels maximum on BOD₅ (100 mg/l), COD (250 mg/l), TSS (100 mg/l), oils and fats (10 mg/l), fospat as (P₂O₅) 10 mg/l as well as MBAS (detergent) 10 mg/l, pH (6.0 to 9.0) [3].

Results of content analysis *Linear Alkylbenzene Sulfonate* (LAS) on the use of the detergent packaging weighing 46 grams were dissolved in 20 liters of water and used to wash 25 pieces of clothing that is equal to 479.58 mg/l. The results shown exceeds the threshold set by East Java Governor Decree No. 72 In 2013, at 10 mg/l.

The content is high enough detergent in water can cause a reduction in oxygen levels. At a concentration of 0.5 mg/l of detergent has been able to form a foam that inhibits the diffusion of oxygen from the air to the surface of the water body. Based on research data reported that the content of the surfactant in the range of 2-16 ppm gutter [4]. Detergents are polluting the environment,
especially the phosphorus content nourish water hyacinth, thus reducing the share of dissolved oxygen for aquatic [5]. Fitoremediasi hyacinth (Eichornia crassipes) through dilution of 25% and precipitation potential to improve the quality of effluent out according to standard quality standard [6].

Often the detergent wastes discharged into waters without prior processing. If the amount is excessive, it can lead to contamination. The effort to combat pollution caused by the waste detergent is phytoremediation. Phytoremediation is part of a natural technology that uses the role of plants to improve environmental quality. Some herbs that can be used as phytoremediator in efforts to solve water pollution one of which is the plant Sagittaria lancifolia [7].

The use of aquatic plants such as Sagittaria lancifolia in improving water quality in the still waters should continue to be developed, to look for a wastewater treatment system that is safe for the environment. This study is expected to be a source of information that the plant is able to serve as an accumulator detergent.

2. Materials and Methods

2.1. Research Design
The research was experimental using Randomized Block Design (RBD). This study was conducted in February-May 2019. Sampling Sagittaria lancifolia obtained from Plant Conservation Center Purwodadi - LIPI. Content analysis Linear Alkylbenzene Sulfonate (LAS) carried out in Research and Industry Standards Surabaya, at Jl. Jagir Wonokromo No. 360 Surabaya.

2.2. Materials
The tools used in this research is a jar (capacity of 5 liters, diameter 23 cm, height 20 cm), analytical balance, measuring glass 500 ml and 1000 ml termohigrometer, luxmeter, pH meter, thermometer, scissors cuttings, a trowel, a sickle, mortal and pestle, bright winkler bottles, 250 ml erlenmeyer, spectrophotometers. Materials used in this research is Sagittaria lancifolia, a solution of detergent which is a synthetic detergent water.

2.3. Preparation
Steps must be done to complete this study were 1) preparation of phytoremediation (acclimatization and manufacture of growing media), 2) treatment stage, 3) data collection phase, 4) content analysis Linear Alkylbenzene Sulfonate (LAS) to the growing media, 5) analysis of Biochemical Oxygen Demand (BOD) in the planting medium and 6) analysis of leaf chlorophyll content.

2.4. Parameter Observation and Data Analysis
Data obtained by the results LAS content analysis of the growing media, analysis BOD content, leaf morphology and leaf chlorophyll content analysis. Data were analyzed by descriptive quantitative and two-way ANOVA statistical test and followed by Duncan test using the Statistical Product and Service Solutions (SPSS) 21.0 for Windows for see the difference among treatments. Then compared with the East Java Governor Regulation No. 72 Year 2013 regarding Standard Wastewater For Activities Laundry.

3. Result and Discussion

3.1. The percentage decrease in levels of LAS
Based on the research that has been done at various concentrations and the detention time, the data obtained in the form of the average value of the levels of LAS on the planting medium, which is shown in (Table 1).
Table 1. Percentage Decrease Level of LAS (%) in Various Concentration of Detergent and Different Detention Time

| Phytoremediation          | The detergent concentration (ppm) | Detention Time (days) |
|---------------------------|-----------------------------------|-----------------------|
| Control (Without plants)  | 10                                | 1.14±0.01a            |
|                           | 50                                | 1.27±0.02a            |
|                           | 75                                | 1.33±0.01a            |
| Treatment (Existing plants)| 10                                | 71.65±0.21b           |
|                           | 50                                | 73.44±0.17c           |
|                           | 75                                | 77.43±0.85e           |

Note: The figures followed the same alphabet in rows and columns show the results of which were not significantly different at the 0.05 test level according to Duncan test.

Based on the statistical test using the One Sample Kolmogorov Smirnov showed that the normal distribution of data. The test results Levene's Test of Equality Error Variances shows the variation of data is equal or homogeneous. Table shows the real difference in the concentration and detention time is shown from a different alphabet notation on the row and column. This shows that the higher the concentration the higher the percentage decrease in the levels of LAS on the planting medium (notation f). The longer the detention time, the lower the levels of LAS on the planting medium (notation f). Two-way ANOVA test results showed that there was interaction between the detergent concentration and detention time to decreased levels of LAS on the planting medium. The mean percentage reduction in the levels of LAS on the best growing medium that is in the treatment of phytoremediation concentration of 75 ppm and 14-day detention time of 81.53%. LAS value is in accordance with the quality standards set are below 10 mg/l.

The results showed that treatment detention time also affect the percentage decreased levels of LAS to the growing media, the detention time of 14 days which shows the percentage decrease in LAS higher than the 7-day detention time. The percentage decrease in the levels of LAS obtained amounted to 81.53%. The high percentage LAS decreased levels caused by microbes in plant roots are still able to absorb the levels of LAS in the planting medium. The increasing levels of LAS time then decreases [8]. This shows that the detergent with a great LAS levels decomposition takes longer and detergents with high levels of small LAS will be quickly unraveled. Because the contact time between the water detergent and the longer aerobic microorganisms so as to provide longer periods of time also for bacteria to decompose detergent.

In general, the plants will absorb the nutrients dissolved in water through their roots. All plants have the ability to absorb that allow movement of ions across cell membranes, ranging from abundant elements up to a very small element needed by plants and can be accumulated by plants [9]. The roots of plants in the planting medium will absorb ions that contain not only ion essential but non-essential ions and organic compounds. In the event of pengabsorpsian ion imbalance in the plant is not able to take nutrients efficiently, either because of the direct effect of toxic ions on the metabolism or function of the roots or because it is caused by competition or interaction with nutrient ions, as well as difficult to obtain CO₂. Carbon dioxide is used as the base material of photosynthesis [10].

LAS absorption by plant roots resulted in decreased levels of LAS on the planting medium. LAS influx into the body through some process plants. The process includes the absorption by the roots detergents, detergent translocated from the root to the tip (stems and leaves) through the xylem and phloem, and the localization of detergent in the cell or plant tissue. LAS containing Na⁺, plant roots will absorb these compounds are then localized to a specific part of the cell that does not inhibit the metabolic processes of plants [11]. LAS classified anionic surfactants are surfactants which have a major element of sodium ions (Na⁺). Na ions will enter through the plant roots by simple diffusion. Ion
will be dissolved in water which will further penetrate into the cortex toward the xylem tissue [12]. Ions will diffuse into the root through apoplast is in the cell walls of the epidermis. Apoplast is the path that includes the diffusion and mass flow of water from cell to cell through the space between the cell wall polysaccharides. The endothermic kaspari ribbon will force all the ingredients into the endodermis cells across the plasma membrane. Ion is absorbed by the epidermis cells and moves towards the xylem through Symplast [13]. LAS that enters the plant will accumulate in the vacuole. Vacuole serves to keep the LAS does not inhibit the metabolism of plants. If the amount of LAS is very much in the vacuole, the vacuole can be broken so that the liquid in it will mix with the cytoplasmic result in damage to the plasma membrane. Damage to the plasma membrane will have an impact on the chloroplasts, which are indicated by damage to chloroplasts [14].

LAS absorbed by plant roots roots accumulate in organs and lead to decreased levels of LAS on the planting medium. The process of absorption of substances contained in the waste carried by the ends of the roots with meristem tissue occurs because of the attractive force by the water molecules that exist in plants. Substances that have been absorbed by the roots will fit into the trunk through the carrier vessels (xylem), which will then be forwarded to the leaves [15].

### 3.2. The BOD value Growing Media

Based on the research that has been done at various concentrations and the detention time of data obtained in the form of the average value of BOD water quality parameters. result BOD Duncan test parameters are shown in (Table 2).

| Phytoremediation | The detergent concentration (ppm) | Detention Time (days) |
|------------------|----------------------------------|-----------------------|
| Control (Without plants) | 10 | 29.37±0.382e | 29.22±0.153e |
| | 50 | 29.40±0.250e | 29.48±0.252e |
| | 75 | 29.57±0.161e | 29.60±0.436e |
| Treatment (Existing plants) | 10 | 26.90±0.687bc | 25.55±0.937a |
| | 50 | 28.08±0.419d | 26.18±0.993ab |
| | 75 | 28.10±0.794d | 27.48±0.782cd |

**Note:** The figures followed the same alphabet in rows and columns show the results of which were not significantly different at the 0.05 test level according to Duncan test.

Based on the statistical test using the One Sample Kolmogorov Smirnov showed that the normal distribution of data. The test results Levene's Test of Equality Error Variances shows the variation of data is equal or homogeneous. Table shows the real difference in the concentration and detention time is shown from a different alphabet notation on the row and column. This suggests that the lower the concentration, the lower the BOD value to the growing media (notation a). The longer the detention time, the lower the BOD (notation a). Two-way ANOVA test results showed that there was interaction between the detergent concentration and detention time of the BOD in the planting medium. Mean BOD are best used in the treatment of phytoremediation concentration of 10 ppm and 14-day detention time of 25.55 ppm.

Treatment of various concentrations of detergents give effect to the BOD reduction in the planting medium, where the BOD significant decline in line with the longer detention time and the lower the concentration of detergent. In the planting medium, the BOD value was lowest for the treatment concentration of 10 ppm and 14-day detention time of 25.55 ppm. Kangkungan plants...
(Ipomoea crassicaulis) capable of lowering the concentration of surfactant in the detergent solution sample of 97.76% for 30 days processing [21].

Detention time also affects the BOD reduction. This shows that the longer the detention time the BOD content of the growing media will decrease. Domestic waste (Detergent) greatly affects the BOD reduction in order to achieve water quality standards of waste within a period of 20 days [22]. Plants play a role in absorbing organic substances in the planting medium, so the content of BOD has decreased. Plants also working with microbes in the process of degradation of organic matter so that the higher dissolved oxygen content. The high dissolved oxygen in the growing media is also due to the supply of oxygen from the photosynthesis of plants that will lead to reduced levels of BOD in a planting medium that is below the threshold that is equal to 100 mg/l. Therefore, the smaller the BOD value, the better the water quality [23].

3.3. Leaf morphology Sagittaria lancifolia

Based on observations of leaf morphology Sagittaria lancifolia the detention time of 7 and 14 days are shown in (Table 3).

**Table 3. Leaf Morphology Detention Time Sagittaria Lancifolia 7 and 14 Days**

| Days   | Leaf Morphology |
|--------|-----------------|
| 7      | ![Image 1](image1.jpg) | ![Image 2](image2.jpg) | ![Image 3](image3.jpg) | ![Image 4](image4.jpg) |
| 1      | ![Image 5](image5.jpg) | ![Image 6](image6.jpg) | ![Image 7](image7.jpg) | - |
| 2      |                   |                   |                   |                   |


LAS toxicity in plants *Sagittaria lancifolia* causes morphological changes in plants is chlorosis and necrosis. The results of the research in plants *Sagittaria lancifolia* at a concentration of 75 ppm showed that the change of color in the leaves the symptoms of chlorosis (leaf lose chlorophyll characterized by yellowing of the leaves) and at higher concentrations of leaves showing symptoms of necrosis (symptoms of cell death of plants characterized by leaves that curl and leaves wrinkles / scarred). Chlorosis on leaves due to changes in lipid composition in thylakoid membrane, causing a decrease in the production of chlorophyll, plastoquinon, carotenoids, and the activity of NADP⁺. This drop will cause a reduction in electron transport to the chloroplast and disruption of calvin cycle. So that the leaves undergo chlorosis as more content accumulated LAS decreased the growth of plants [16].

The more dense and extensive rooting it needs absorbed water will be more and more [18]. On *Sagittaria montevidensis* on installation constructed wetland can breed well. This is demonstrated by the growth of new shoots and flowers of these plants during the wastewater treatment process carried out up to the last observation [19]. The growth of new roots and shoots of plants as a way to survive. The reason is the presence of nutrients in wastewater diminishing [20].

3.4. Chlorophyll levels Leaves
Based on the research that has been done at various concentrations and the detention time of data obtained in the form of the average value of leaf chlorophyll content. Result Duncan test parameters are shown in chlorophyll content (Table 4).

**Table 4.** Leaf Chlorophyll Content (mg/l) Detergent and Concentration in Various Different Detention Time

| Phytoremediation | The detergent concentration (ppm) | Detention Time (days) | 7 | 14 |
|------------------|----------------------------------|-----------------------|---|----|
| Treatment (Existing plants) | 10 | 18.449±0.404e | 17.559±0.476d |
| | 50 | 17.798±0.182de | 15.384±0.417b |
| | 75 | 16.679±0.777c | 14.433±0.127a |

**Note:** The figures followed the same alphabet in rows and columns show the results of which were not significantly different at the 0.05 test level according to Duncan test.
Based on the statistical test using the One Sample Kolmogorov Smirnov showed that the normal distribution of data. The test results Levene’s Test of Equality Error Variances shows the variation of data is equal or homogeneous. Table shows the real difference in the concentration and detention time is shown from a different alphabet notation on the row and column. This shows that the higher the concentration, the lower leaf chlorophyll content (notation a). The longer the detention time, the lower the leaf chlorophyll content (notation a). Two-way ANOVA test results showed that there was interaction between the detergent concentration and detention time to leaf chlorophyll content. Average low chlorophyll content is at a concentration of 75 ppm and 14-day detention time of 14.433 mg/l.

LAS translocation results in the accumulation of LAS on the leaves. LAS accumulated in leaves causing damage that occurred in the structure of the chloroplast, where the mineral nutrients such as Fe and Mg may affect the formation of chloroplasts structure. Excessive accumulation can reduce the amount of Fe and Mg is needed in the process of the formation of chlorophyll, so that the chlorophyll content of plants decreased [17]

3.5. Physical and Chemical Environmental Factors
Based on the physical and chemical environmental factors consisting of temperature, humidity, light intensity and pH and water temperature were measured for 7 and 14 days of treatment. The average results of measurements that have been done are presented in (Table 5).

**Table 5.** Average Temperature, Humidity, Light Intensity, pH and Water Temperature on Detention Time 7 and 14 Days

| Detention Time (days) | Parameter               | Unit     | Average   | Quality standards* |
|-----------------------|-------------------------|----------|-----------|--------------------|
| 7                     | Temperature (°C)        | 27.71    | deviation 3 |
| 7                     | Humidity (%)            | 73.57    | -         |
| 7                     | Light intensity (lux)   | 15915.71 | -         |
| 7                     | pH                      | 7.93     | 6-9       |
| 7                     | The water temperature   | 22.13    | 28-30     |
| 14                    | Temperature (°C)        | 27       | deviation 3 |
| 14                    | Humidity (%)            | 73.21    | -         |
| 14                    | Light intensity (lux)   | 20089    | -         |
| 14                    | pH                      | 7.99     | 6-9       |
| 14                    | The water temperature   | 21.65    | 28-30     |

*Description: The quality standard is based on East Java Governor Regulation No. 72 Year 2013

Based on observations obtained a state of physical and chemical environmental factors which fluctuate daily. The growing media is seen that the average detention time water temperature higher than the 7 days to 14 days. Whereas at pH higher than 7 days to 14 days. However, it is still within the range specified quality standards.

The results of measurements on the physical and chemical environmental factors indicate that the temperature has fluctuated, on the morning of relatively low temperatures in accordance with the intensity of sunlight is low. At noon there was an increase in temperature, because the intensity of sunlight at high noon and in the afternoon decrease with decreasing intensity of sunlight. Temperature is an important determinant of mutual support of the enzymatic activity of enzymes perombak alkylbenzenesulfonate. Alkylbenzenesulfonate perombak enzyme works optimally at 28°C. Temperatures that are too high and too low can cause the enzyme is protein will undergo denaturation
[24]. Although the range of temperature and humidity fluctuate but the average is still suitable as a nursery or propagation of plants. So if conducted acclimatization and treatment of the environmental factors sufficient support in adapting plants.

In the planting medium, the temperature of the water at 7-day detention time is higher than 14 days, with a value of 22.13°C and 21.65°C. It is inversely proportional to pH, which the detention time of 14 days is higher than 7 days. Generally the pH of water is affected by the concentration of free CO$_2$. Phytoplankton and other aquatic plants will take CO$_2$ out of the water during the process of photosynthesis, resulting in increased water pH decreases during the day and at night. The activity of microorganisms in the waste decompose organic matter is also related to the photosynthetic activity that takes CO$_2$ dissolved in the form H$_2$CO$_3$ which causes an increase in pH [25]. Impairment pH detergent waste allegedly due to the release of the detergent sulfonate group then oxidized to sulfate [26].

4. Conclusion

1. Phytoremediation different effects at different concentrations of detergent solution and detention time on levels of LAS, BOD and leaf chlorophyll content.

2. There is an interaction between concentration and detention time on levels of LAS, BOD and leaf chlorophyll content. Interaction best shown in phytoremediation treatment with a concentration of 75 ppm and 14-day detention time (LAS and chlorophyll), while against the best interaction BOD on phytoremediation treatment with a concentration of 10 ppm and 14-day detention time.

3. Chlorosis and necrosis highest concentration of 75 ppm is shown in 14-day detention time.

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References

[1] P. Herlambang and O. Hendriyanto. 2015. Fitoremediasi Limbah Detergen Menggunakan Kayu Apu (Pistia stratiotes L.) dan Genjer (Limnocharis flava L.). BioSMART: Journal of Biological Science, vol. 7, pp. 115-124.

[2] A. Rachmawati. 2018. Uji Efektivitas Duckweed (Lemma sp.) Sebagai Agen Fitoremediasi Larutan Mengandung Surfactan. Skripsi, UNI Sunan Kalijaga, Yogyakarta.

[3] Peraturan Gubernur Jawa Timur Nomor 72 Tahun 2013 Tentang Baku Mutu Air Limbah Untuk Kegiatan Laundry.

[4] D. Hrsak and Begonja. 2000. Possible Interaction Within a Methanotrophic-Heterotrophic Groundwater Community Transform Linear Alkylbenzenesulfonates. Applied and Environmental Microbiology, vol. 66, pp. 44333-4439.

[5] A.M. Siswandiari, I. Hindu dan S. Sukarsono. 2017. Phytoremediation of Phosphate content in liquid laundry waste by using Echinodorus paleafolius and Equisetum hyemale used as biology learning resource. Jurnal Pendidikan Biologi Indonesia, vol. 2, pp. 222-230.

[6] D.S. Vidyawati dan H. Fitrihidajati. 2018. Pengaruh Fitoremediasi dengan Eceng Gondok (Eichornia crassipes) Melalui Pengenceran dan Pengendapan Terhadap Kualitas Limbah Cair Industri Tahu. LenteraBio, vol. 8.

[7] R. Irawanto. 2016. Fitoremediasi Menggunakan Tumbuhan Akuatik Koleksi Kebun Raya Purwodadi.

[8] H. Adhitiastuti dan P. Hastuti Oktafia Bisono. 2009. Pengolahan Limbah Deterjen Sintetik Dengan Trickling Filter. Eprints Journal, Universitas Diponegoro, 1-6.

[9] E. Erawati. 2017. Pengaruh Konsentrasi Terhadap Fitoremediasi Limbah Zn Menggunakan Eceng Gondok (Eichornia crassipes). Jurnal Teknologi Bahan Alam, vol. 1, pp. 24-28.
[10] A.H. Fitter dan R.K. Hay. 2001. Fisiologi Lingkungan Tumbuhan. Yogyakarta: UGM Press.
[11] M.I. Permadi. 2019. Pemanfaatan Bambu Air (Equisetum sp.) Untuk Menurunkan Kadar Timbal (Pb) Menggunakan Fitoremediasi Sistem Batch. Disertasi. UIN Sunan Ampel Surabaya.
[12] L. Advinda. 2018. Dasar-Dasar Fisiologi Tumbuhan. Deepublish.
[13] F.B. Salisbury and C.W. Ross. 1995. Fisiologi Tumbuhan Jilid I, II, dan III. Diterjemahkan oleh Dian RL dan Sumaryono. ITB: Bandung, 343.
[14] H.Y. Liu, B.H. Liao, P.H. Zhou and P.Z. Yu. 2004. Toxicity of linear alkylbenzene sulfonate and alkylethoxylate to aquatic plants. Bulletin of environmental contamination and toxicology, vol. 72, pp. 866-872.
[15] N. Hardyanti dan S.S. Rahayu. 2007. Fitoremediasi Phospat dengan Pemanfaatan Enceng Gondok (Eichhornia crassipes) (Studi Kasus Pada Limbah Cair Industri Kecil Laundry). Jurnal Presipitasi, vol. 2, pp. 28-33.
[16] P. Sharma and R.S. Dubey. 2005. Lead toxicity in plants. Brazilian journal of plant physiology, vol. 17, pp. 35-52.
[17] M. Ulfah, F. Rachmadiarti dan Y.S. Rahayu. 2017. Pengaruh Timbal (Pb) Terhadap Kandungan Klorofil Kiambang (Salvinia molesta). Jurnal LenteraBio, vol. 6.
[18] R. Irawanto. 2016. Revitalisasi Koleksi Tumbuhan Akuatik Kebun Raya Purwodadi sebagai Taman Kolam Fitoremediasi. Researchgate Journal.
[19] A.R. Oktaviansyah. 2016. Studi Pemodelan Constructed Wetland Menggunakan Vegetasi Sagittaria montevidensis dengan Kombinasi Arang Aktif dalam Menurunkan Kadar Polutan pada Air Limbah Deterjen. SISTEM Jurnal Ilmu Ilmu Teknik, vol. 12, pp. 25-38.
[20] S.M. Haslam. 1997. River Pollution, an Ecological Perspective. Belhaven Press, London.
[21] N.G.A.M.D.A. Suastuti, I.W. Suarsa dan D.K. Putra. 2015. Pengolahan Larutan Deterjen dengan Biofilter Tumbuhan Kangkungan (Ipomoea Crassicaulis) dalam Sistem Batch (Curah) Teraerasi. Jurnal Kimia, vol. 9, pp. 98-104.
[22] C.A. Stefhany. 2013. Fitoremediasi Phospat dengan Menggunakan Tumbuhan Eceng Gondok (Eichornia crassipes) pada Limbah Cair Industri Kecil Pencucian Pakaian. Jurnal Institut Teknologi Nasional, vol. 1, pp. 2-10.
[23] D.D.R. Turista. 2017. Biodegradation of Organic Liquid Waste by Using Consortium Bacteria as Material Preparation of Environmental Pollution Course Textbook. Jurnal Pendidikan Biologi Indonesia, vol. 3, pp. 95-102.
[24] U. Lusiana. 2011. Wastewater Treatment Efficiency Using Up Flow Anaerobic Filter and Activated Sludge Aclimatization. Jurnal Biopropal Industri, vol. 2.
[25] E. Novita, A.A.G. Hermawan dan S. Wahyuningsih. 2019. Komparasi Proses Fitoremediasi Limbah Cair Pembuatan Tempe Menggunakan Tiga Jenis Tanaman Air. Jurnal Agroteknologi, vol. 13, pp. 16-24.
[26] A. Hidayatullah. 2018. Pengaruh Persentase Pengenceran Dan Waktu Kontak Dalam Pengolahan Limbah Laundry Menggunakan Tanaman Kayu Apu (Pistia stratiotes L.) Dengan Metode Floating Treatment Wetland. Skripsi, Universitas Airlangga.