The use of water spinach plants (Ipomoea aquatica Forsk.) for phytoremediation of hospital waste

Suherman¹, S Rahmawati¹*, I Said¹, Nurbaya¹, S Armiyanti¹, and N Thamrin²

¹Chemistry Education, Department of Mathematics and Natural Science Education, Faculty of Teacher Training and Education, Tadulako University, Palu 94118 – Indonesia
²English education study program, Faculty of Teacher Training and Education, Tadulako University, Palu 94118 – Indonesia

*Corresponding author: suherman@untad.ac.id

Abstract. Water spinach (Ipomoea aquatica Forsk.) has the ability to accumulate pollutants so that it can be useful for wastewater treatment processes. The purpose of this study was to determine the phytoremediation technique in hospital wastewater using kale in improving the quality of hospital wastewater and to determine the level of accumulation of Pb and Cr metals in plants. The study used a completely randomized design with four treatments, namely treatment 0 days (without treatment), 2 days, 4 days and 6 days. Parameters include the physical and chemical quality of the waste as well as the content of Pb and Cr in the waste and plants. To determine the effect of phytoremediation on the quality of household waste and metal content, ANOVA analysis and further testing with the BNT test level of 5% were used. Phytoremediation with kale was able to reduce the temperature of the waste on the 4th day of treatment and dissolved oxygen on the 4th treatment and increase the pH. The accumulation of Pb and Cr on each day is different. The highest accumulation of Pb and Cr occurred on day 6, namely 0.1587 mg/L for Pb metal and 0.2167 mg/L for Cr metal. Kale plants are very possible to be used in the phytoremediation process.

1. Introduction

Environmental pollution problems related to water pollution are experienced by many developing countries such as Indonesia. This pollution needs to be anticipated to overcome the level of pollution. Please note that the source of water pollution comes from urban waste and industrial waste. One of the urban wastes comes from hospital wastewater [1].

The hospital is one of the efforts to improve health which consists of a medical center and a doctor’s practice which is also supported by other units, such as operating rooms, laboratories, pharmacy, administration, kitchens, laundry, waste and waste management, as well as providing education and training [2].

Hospital is a complex health facility. One of them is the Anutapura Palu General Hospital which has Type B, which has a fairly solid activity in carrying out complex services to patients [3].

Hospital waste can be divided into two, namely liquid waste and solid waste. Liquid waste can contain organic and inorganic materials which are generally measured and parameters BOD, COD.
and TSS, while solid waste consists of easily decomposed waste, infectious waste, and others. These wastes are likely to contain pathogenic microorganisms or hazardous and radioactive toxic chemicals that can cause infectious diseases which can then be spread to the hospital environment [4].

Treatment of waste generated from hospitals is necessary to minimize its impact when released into the environment. Waste treatment aims to reduce the toxic materials contained in the waste to a minimum or even zero (0)% before the waste is disposed of. One of the efforts that can be made for the hospital waste treatment process is the use of natural resources, namely utilizing the types of aquatic plants that grow in the sewers around the settlements [5].

The use of aquatic plants in the wastewater treatment process causes the process of ion exchange and absorption [6]. One of the treatment methods for tackling water pollution by using these aquatic plants as a medium for absorbing waste is the phytoremediation method [7]. One of the aquatic plants that can be used as phytoremediation agents is water spinach. This plant has the ability to absorb pollutants and heavy metals dissolved in the growing media so that its content decreases or the quality of wastewater increases [8].

The use of kale for phytoremediation has been carried out on various wastes, including: tapioca liquid waste, batik waste and tofu industrial waste [8]. Therefore, in this study, phytoremediation was carried out on Anutapura hospital waste. The purpose of this study was to determine the phytoremediation technique in hospital wastewater using water spinach (Ipomoea aquatica Forsk) in improving the quality of hospital wastewater and to determine the level of accumulation of Pb and Cr metal levels in water spinach plants (Ipomoea aquatica Forsk).

2. Methods

2.1 Pre-research (Preparation Stage)

2.1.1 Preparation stage for water spinach plants (Ipomoea aquatica Forsk.)
The water spinach plant (Ipomoea aquatica Forsk.) which were used in this study was taken from rice fields in the biromaru area and then carried out the acclimatization process on water growing media. Acclimatization is a stage of adaptation of plant tissue culture results to the new environment. Acclimatization can be referred to as the stage of adjustment, before the plant is finally able to live in the field [9]. This acclimatization process aims for plants to adapt or adapt to new environments or unusual conditions, such as changes in temperature, humidity and light intensity. The procedure for acclimatization of kale is to prepare ingredients in the form of fresh water spinach and water, and prepare tools in the form of a bucket, steroform as a support for kale, and a measuring cup. Fill the bucket with 2 liters of water. Choose kale with the same size and arrange in a bucket using steroform as a support. Allowing water spinach plants to grow for 7 days or 1 week [10].

2.1.2 Hospital liquid waste preparation phase the hospital
Liquid waste used in this study was taken at one of the hospitals in Palu City, namely Anutapura General Hospital. Liquid waste is taken from several sources of hospital disposal using containers in the form of jerry cans and then taken to the research location, namely the chemistry laboratory, faculty of teacher training and education, then mixed thoroughly and analyzed for its physical and chemical properties. The next step is the liquid waste is filled into 12 glass containers according to the treatment, as much as 1 liter for each container.

2.2 Research Procedures
2.2.1 Phytoremediation process
Water spinach plants that have been acclimatized and then grown are transferred into a glass container that already contains 1 L of hospital liquid waste. Where plant maintenance in liquid waste media is carried out according to a completely randomized design with the treatment that the plants are maintained in liquid media for 2x24 hours for three repetitions, for 4x24 hours for three
repetitions, for 6x24 hours for three repetitions and control treatment. After that, the liquid waste samples were re-analyzed to determine the physical and chemical quality. The physical quality measured include temperature, conductivity and turbidity, while the chemical quality include pH and O₂ dissolved (DO).

2.2.2. Analysis of Pb and Cr content in plant samples was carried out by atomic absorption spectrophotometry method.

Preparation of plant samples to be analyzed was carried out by crushing 1 g of plant parts (roots, stems and leaves). Added 10 mL of HNO₃. Heated at 90 ℃ for 20 minutes. The temperature is raised to 150 ℃ for 1 hour. Added distilled water until the volume reaches 25 mL. The levels of lead (Pb) and chromium (Cr) were tested using an atomic absorption spectrophotometric (AAS) instrument. The data obtained were analyzed statistically using Anova and further tested [6].

3. Result and Discussion

This research is to carry out a phytoremediation technique in Anutapura Palu hospital wastewater by utilizing a plant, namely water spinach (Ipomoea aquatica Forsk) to improve the quality of hospital wastewater and accumulate Pb and Cr metal levels in the waste. Phytoremediation is the treatment of waste by using plants and their parts which function to reduce pollutants in the environment contaminated with waste. This phytoremediation process is one way to reduce the concentration of pollutants in the waters. The phytoremediation method can reduce and neutralize Pb heavy metal content in soil and water [11].

Water spinach that has been taken from the initial location is then acclimatized which aims to adapt the plant to the surrounding environmental conditions, namely temperature, climate, temperature and others before the plant is finally able to live in the actual environment at the phytoremediation test research stage. This acclimatization was carried out for ± 7 days by moving water spinach from the initial location to the study site, then the plants were cleaned first of dirt attached to the roots, stems and leaves. After that, the plants are put in a container that has been filled with water [12].

Water spinach plants that have been acclimatized are then grown by being transferred into a glass container that already contains 1 L of hospital liquid waste. Where plant maintenance in liquid waste media is carried out according to a completely randomized design with the treatment that the plants are maintained in liquid media for 2x24 hours for three repetitions, for 4x24 hours for three repetitions, for 6x24 hours for three repetitions and control treatment. After that, the liquid waste samples were analyzed to determine the physical and chemical quality. The physical quality measured include temperature, conductivity and turbidity, while the chemical quality include pH and O₂ dissolved (DO).

| Table 1. Results of measuring the physical and chemical quality of hospital effluent |
|-----------------------------------------------|----------------|----------------|-----------|-----------|-----------|
| Treatment | Physical Quality | Quality Chemical |
|           | (°C) | (NTU) | (µS) | Color | Smell | pH | DO (mg/L) |
| Day 0     | 30   | 2.19  | 2.32 | White | Smell | 7.91 | 2.07 |
| Day 2     | 31   | 3.91  | 2.94 | White | Smell | 7.84 | 2.00 |
| Day 4     | 25   | 4.38  | 4.51 | White | Less Smelly | 8.33 | 1.29 |
| Day 6     | 30   | 5.63  | 6.31 | White | Less Smelly | 8.21 | 3.66 |

In general, utilization of water spinach plants can alter the physical and chemical wastewater hospitals (Table 1). Based on the data in the table, the temperature measurement varies from 25°C
to 31°C. The increase in temperature can increase the rate of ion diffusion to the roots of kale plants including Hg ions and Cr ions [13]. From the data in Table 1 it can also be seen that the turbidity value increased from the first day to the sixth day (2.19 – 5.63 NTU). This shows that the water spinach plant has not been able to reduce the level of water turbidity but this condition is still in good water stability and far below the threshold range of a waters where the maximum threshold for turbidity of aquatic biota is 30 NTU so that in this condition it is still optimum for life [14].

The results also showed an increase in the conductivity value, which ranged from 2.32 to 6.31 S/cm (Table 1). This value is still very good and meets the standard requirements of <700 that have been set by FAO (Food and Agriculture Organization) for agriculture. The data in Table 1 shows that the pH of the liquid waste also increased at the end of the observation. It can be concluded that kale has the potential to increase the pH of hospital wastewater. The pH value ranges from 7.91 to 8.34. The pH value obtained is still in the normal pH range for biota life in a waters, which is 6-9 [15,16]. The pH parameter needs to be studied during phytoremediation because it can affect the solubility of nutrients that cause plant growth. The increase in pH may be due to the oxidation of organic matter during the phytoremediation process.

Dissolved oxygen is a basic requirement for plant life in water. The ability of water to maintain the concentration of O₂ minimum needed in life greatly affect plant life in the water. The concentration of O₂ dissolved will be at least microbial life can not be less than 6 ppm. Temperature and atmospheric pressure are factors that can affect various concentration O₂ in the state of saturation. The maximum of dissolved at 1 atm to a temperature of 24-28°C range between 8.5 to 9.9 ppm. To the O₂ concentration dissolved is too low and too high can interfere in aquatic biota.

Based on research data, it shows that kale has a high adaptability to physical and chemical waste factors, with the fact that in the field it is able to grow in a very low dissolved oxygen range (1.29-3.66 ppm) below normal (8.5-9.0 ppm).

First of all, before testing the phytoremediation of waste by plants, a preliminary test was carried out to determine the content of pollutants such as dangerous heavy metals contained in the waste using the atomic absorption spectrophotometry (AAS) method at Chemistry Laboratories, Faculty of Mathematics and Natural Sciences. The test results obtained that there is a level of waste Pb of 5.829 ppm and waste Cr of 5,000 ppm.

Changes in the physical condition of water spinach plants during the phytoremediation process were clearly visible in each treatment. Starting from the condition of the leaves that are increasingly yellowing in color and withering over time of contact, accompanied by a decrease in the volume of wastewater. In general, the leaves begin to turn yellow due to exposure to heavy metals, this indicates the inhibition of chlorophyll formation in plants. The presence of metals (particularly Pb and Cr) contributes to the disruption of the photosynthetic process in this case disrupting the function of enzymes that act as chlorophyll biosynthesis.

Phytoremediation test research on the absorption of heavy metals lead (Pb) and chromium (Cr) in water spinach plants (*Ipomoea aquatica* Forsk.) was conducted to determine the accumulation ability of these plants. The study was conducted for 6 days. The test for the absorption of lead (Pb) and chromium (Cr) in plants was carried out four times, namely on the 0, 2, 4 and 6 days. The absorption rate of heavy metals lead (Pb) and chromium (Cr) is known from the time of contact or exposure of plants to heavy metals during the study.

The ability of absorption of heavy metals Pb and Cr by water spinach plants which were harvested on days 2, 4 and 6 were different. The longer the time to harvest the kale, the greater the levels of heavy metals Pb and Cr absorbed by the plant. On the second day of phytoremediation of Pb metal, the absorbed metal content decreased by 0.0476 mg/L, on the 4th day it decreased by 0.111 mg/L, and on the 6th day it decreased by 0.1587 mg/L (Fig 1). Microorganisms that help reduce concentration are around the roots of water spinach. Pb that is absorbed by the roots accumulates in it, the rest is carried to the stomata. In the water spinach body there is a metabolic process of decomposition of Pb mixed with oxygen to produce PbO₂ which, if released into the air, does not experience environmental pollution.
Phytoremediation of Cr metal, found a decrease in levels on day 2 of 0.0500 mg/L, day 4 decreased by 0.1500 mg/L and on day 6 decreased by 0.2167 mg/L (Fig 2). The process of decreasing by rhizofiltration and phytoextraction. Cr which is absorbed by water spinach through the roots is carried to the leaves to be released into the air through the stomata. The decrease in the concentration of Pb and Cr is influenced by the activity of microorganisms that play a role in helping to reduce the concentration in large quantities. Water spinach is a plant that can accumulate Pb and Cr in high concentrations so that it can be used as a phytoremediation plant for polluted substances. Effect of the residence time is directly proportional to decreasing the concentration of Pb and Cr (see Figure 1 and Figure 2) and the large number of water spinach greatly affect the absorption of the concentration of Pb and Cr.

![Figure 1. Graph of contact time relationship with metal concentration Pb](image1)

![Figure 2. Graph of the relationship contact time with concentration of Cr](image2)

Several factors that affect water spinach in heavy metal absorption are metal accumulation in plants not only depending on the heavy metal content in water and soil, but also soil chemical elements, metal types, soil pH, and plant species. In relation to harvesting time, the longer it is harvested, the more heavy metals will accumulate in the body of the water spinach plant [17].

|                   | Sum of Squares | df | Mean Square | F      | Sig   |
|-------------------|----------------|----|-------------|--------|-------|
| Pb (ppm) Between Groups | 0.019          | 2  | 0.009       | 18.494 | 0.003 |
| Within Groups     | 0.003          | 6  | 0.001       |        |       |
| Total             | 0.022          | 8  |             |        |       |
| Cr(ppm) Between Groups | 0.042          | 2  | 0.021       | 76.000 | 0.000 |
| Within Groups     | 0.002          | 6  | 0.000       |        |       |
| Total             | 0.044          | 8  |             |        |       |

Based on Table 2 shows the results of data calculations using Analysis of Variance (ANOVA)
are the Fcount = 18,494 and 76,000 when compared to the distribution list table F. The Fcount value is greater than Ftable with a significant level of = 0.05 (5%) in degrees independent (df) 2 and 6 so that Ftable = 5.14. Thus Fcount > Ftable or p (0.000) < 0.05 in the treatment, meaning that H0 is rejected. This shows that there is an effect of water spinach plants (Ipomoea aquatica F.) on the reduction of Pb and Cr metal levels in hospital waste, or various weights of water spinach (Ipomoea aquatica F.) have a significant effect on reducing Pb and Cr metal levels. From the coefficient of diversity (KK) obtained a value of 15.00822%. The resulting KK value is less than 20%, then it is continued by using the BNT test (Least Significant Difference). The results of the calculation using the test BNT (Least Significant Difference) is 0.035901. This value will be compared with the average that exists in the measurement results of reducing the levels of Pb and Cr metals. If the average result is close to the BNT value, there is no significant difference, but if the average has a large difference with the BNT value, there is a significant difference in the test.

The LSM/BNT test table shows that based on the Least Significant Difference (BNT) test, there are nine treatments that are in different subsets, meaning that the value is less than 0.03. The effect of the phytoremediation method using water spinach (Ipomoea aquatica F.) with P1, P2, P3 and the control there was a significant difference in the effect of reducing Pb and Cr metal levels in hospital wastewater.

4. Conclusion
Water spinach (Ipomoea aquatica Forsk.) is a plant that has the ability to accumulate Pb and Cr metals in high concentrations in hospital waste samples so that it can be used as a phytoremediation plant for polluted substances. The metal content of Pb and Cr was different in each treatment. The highest metal content was found at the longest harvest time, namely day 6 of 0.1587 mg/L for Pb metal and 0.2167 mg/L for Cr metal. Cr accumulation was higher than Pb in all treatments.

Acknowledgement
The author would like to thank the Head of the Chemistry Laboratory of FKIP Universitas Tadulako and the Chemistry Laboratory of FMIPA Untad who have facilitated this research.

References
[1] Ferronato N and Torretta V 2019 Waste mismanagement in developing countries: A review of global issues Int. J. Environ. Res. Public Health 16
[2] Ramadhani C, Gafur A and Idris F P 2019 Efficiency of wastewater treatment at pelamonia hospital in Makassar and syekh yusuf hospital in Gowa Celeb. Environ. Sci. J. 1 27–35
[3]ousefli Z, Nasiri F and Moselhi O 2017 Healthcare facilities maintenance management: a literature review J. Facil. Manag. 15
[4] Said N I and Wahjono H D 1999 Hospital Wastewater Treatment Technology with “Aerobic-Aerobic Biofilter” System (Jakarta, Indonesia)
[5] Adisasmito W 2014 Hospital environmental management system (Jakarta, Indonesia)
[6] Lestari W 2013 Use of Ipomoea aquatica Forsk for phytoremediation of household waste (Riau University)
[7] Dewi F, Faisal M and Mariana 2015 The efficiency of phosphate absorption in laundry waste using water spinach (Ipomoea aquatic forsk) and jeringau (Acorus calamus) USU J. Chem. Eng. 4 7–10
[8] Sinulingga N N K and K A E B 2015 Phytoremediation of metallic mercury (Hg) in aqueous media by water spinach (Ipomoea aquatica Forsk.) Environ. Biol. 2 75–81
[9] Nurmalinda, Yuliansyah A T and Prasetya A 2018 Aklimatisasi Tanaman Lemna Minor Dan Azolla Microphyllya Terhadap Lindi Tpa Piyungan Pada Tahap Awal Fitoremediasi Pros. Pertem. dan Present. Ilm. Peneliti. Dasar Ilmu Pengetah. dan Teknol. Nukl. ISSN 0216-
[10] Handayani A D, Herman T, Fatimah S, Setyowidodo I and Katminingsih Y 2018 Inquiry based learning: A student centered learning to develop mathematical habits of mind Journal of Physics: Conference Series vol 1013
[11] Tarigan-Sibero N H B, Wijayanti N P P and Perwira I Y 2019 Phytoremediation of heavy metal lead (Pb) by kiapu plant (Pistia stratiotes) based on mass balance analysis Current Trends Aquat. Sci. 2 89–95
[12] Ghiohani D and Tangahu B O 2017 Phytoremediation of water contaminated by laundry waste using apu wood (Pistia stratiotes) ITS Eng. J 6 2301–9271
[13] Patra M and Sharma A 2000 Mercury toxicity in plants Bot. Rev. 66
[14] Pescod M B 1973 Investigation of Rational Effluent and Stream Standard for Tropical Countries. Enviromental Eng. Div. Asian Inst. Technol. Bangkok. Bangkok.
[15] Barakwan R A, Trihadiningrum Y and Bagastyo A Y 2019 Characterization of alum sludge from Surabaya Water Treatment Plant, Indonesia J. Ecol. Eng. 20
[16] Harahap A, Barus T A, Mulya M B and Ilyas S 2018 Macrozoobenthos diversity as bioindicator of water quality in the Bilah river, Rantauprapat Journal of Physics: Conference Series vol 1116
[17] Juhri D A 2017 Effect of heavy metals (cadmium, chromium, and lead) on wet weight reduction of water spinach (Ipomoea aquatica forsk) as extension material for vegetable farmers Lantern Educ. Res. Cent. LPPM UM Metro. 2 219–29