Phytoremediation of domestic wastewater (detergent) with arrowhead and burhead plants in Purwodadi Botanic Garden

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Abstract. The aquatic plants is use for reduce the organic materials levels contained in the domestic wastewater. Some aquatic plants can be used as a phytoremediator in an effort to overcome water pollution, one of them is Arrowhead (*Sagittaria lancifolia*) and Burhead (*Echinodorus radicans*). The aim of this research is to know how Arrowhead and Burhead plants as phytoremediation of domestic wastewater (detergent) in Purwodadi Botanic Garden. The design of this study was Randomized Block Design (RAK) with 2 factors: crop treatment on medium and locus of domestic wastewater concentration (detergent) 0 g/L (as control); 0,05 g/L; 0,1 g/L; 0,15 g/L. The data observation are plant morphology, plant water level, plant biomass at the beginning and end of environment and environmental parameters such as temperature and humidity. The results obtained were no significant morphology of *Echinodorus radicans* plants observed in green and fresh colours, for water levels of 0,05 g/L, decreased by 0,5 cm, concentrations of 0,1 g/L down 0,6 cm, concentration 0,15 g/L down 1 cm. At the observation of biomass difference of 0,05 g/L concentration of 3,6 g; 0,1 g/L concentration of 5,6 g; 0,15 g/L concentration of 8,6 g. On observation the average temperature is 22-25°C and the moisture average 52-64%. The results obtained were for morphology *Sagittaria lancifolia* mortality rate, for water level with concentration 0,05 g/L, amount 0,4 cm; concentration 0,1 g/L or decreased 0,3 cm; concentration 0,15 g/L decreased 0,4 cm. At the observation of biomass difference of 0,05 g/L concentration of 5,5 g; 0,1 g/L concentration of 3,5 g; 0,15 g/L concentration of 39,7 g. On observation the average temperature is 22-25°C and the average moisture averages 60-64%.

1. Introduction

Water contamination is a change of state in a water reservoir such as lakes, rivers, oceans and groundwater due to human activities [1]. One of the main causes of water pollution is domestic waste. Pollution of fresh water in Indonesia, 80% is caused by domestic waste in both liquid and solid form. Of liquid waste domestic, 35% comes from household waste disposal containing detergent material [2]. Detergents are soap compounds that are formed through chemical processes. In general, the main components of detergent are *Sodium Dodecyl Benzen Sulfonate* (NaDBS) and *Sodium Tripolyphosphat* (STPP) which are very difficult to degrade naturally. The NaDBS and STPP compounds can form precipitates with alkaline earth metals and transition metals [3]. One way to overcome the water pollution is to use phytoremediation techniques.

Phytoremediation is defined as the leaching of pollutants into harmless forms [4]. Phytoremediation is a cheap, efficient, and environmentally friendly method. Phytoremediation method is very rapidly

developed because this method has several advantages such as relatively cheap compared with conventional methods so that the cost can be saved by 75-85% [5].
In its application phytoremediation using aquatic plants. Aquatic plants that can be used are burhead (*Echinodorus radicans*) and Arrowhead (*Sagittaria lancifolia*).

Echinodorus radicans is aquatic plants or aquatic plants that spread from Brazil, Peru, Mexico, and Uruguay. *Echinodorus radicans* flowers are pure white, petals look thin, and the center of the flower is yellow stamens. *Echinodorus radicans* is often blooming not know the seasons and does not need special handling because it is easy to live [6].

Sagittaria lancifolia come from tropical America especially the Florida region up to Puerto Rico North America. The character of this plant is growing upright and stiff, reaching a height of 1 m. Leaves are shaped like spears, oval somewhat narrowed or shaped almost like elongated ribbons. The color of leaves is shiny green, with the bones of leaves slightly prominent. Flowers arranged in a vortex. In one bunch, every average vortex consists of 3 flower buds whose crown is white and rounded. The petals are made up of 3 small, greenish strands [7].

(a) **(b)**

Figure 1. (a) *Echinodorus radicans;* (b) *Sagittaria lancifolia*

In this study using Range Finding Test (RFT). RFT technique is done by doing research with various variations of concentration to find out how much the ability of plants to absorb pollutants at a certain concentration.

2. Method

Time and place of study was conducted on 15 January to 15 February 2018 held at Balai Konservasi Botanical Garden Purwodadi - LIPI. Research using experimental method implemented in the laboratory scale followed by literature study to strengthen the results of his research.

The tools used include reactor, plastic container capacity 5 liters, diameter 23 cm, and height 20 cm, scales, measuring 500 ml glass, thermohigrometer, meter, cutter, cutting scissors, cetok and sickle. While the materials used are aquatic plants such as *Echinodorus radicans* and *Saggitaria lancifolia* obtained from aquatic plant ponds in the garden, detergent waste which is a domestic waste, controlled water samples taken from a source of clean water in the Garden Raya Purwodadi.

Prior to the experimental stage, first measured the temperature and humidity of the environment around the greenhouse. Collection of collectible plant samples located in the Aquatic Pond, and placed on each reactor. Provision of NPK fertilizer in each reactor with a concentration of 7.5 grams. The acclimatization of aquatic plants conducted on the medium grows water for 14 days. *Echinodorus radicans* and *Saggitaria lancifolia* inserted into the reactor already containing waste detergent are in each reactor after acclimatization phase completed. The experimental scheme can be seen in Figure 2.

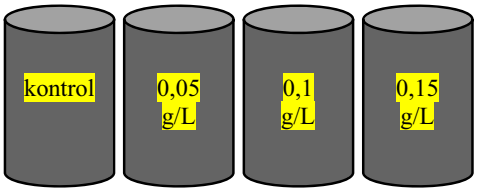

Figure 2. Schematic of research experiment

Sampling of sample data in the form of water level data, environmental parameters and morphological data is carried out with following details: first take (1), second take (2), third take (3), fourth take (4). Measured wet weight beginning and end of jasmine water plants and spear leaves using scales.

The data were analyzed descriptively based on data obtained through phytoremediation experiments including physical measurements (temperature and humidity), as well as changes in plants (water level, wet weight and morphology).

3. Results and discussion

On observation morphology *Echinodorus radicans* did not change significantly. the plants still look fresh and green. On the 3rd and 4th observations the concentrations of 0 g/L and 0.05 g/L of leaves were green, whereas 0.1 g/L and 0.15 g/L leaves were green with brown leaf curved edges. It can be said that the observed plants are still green and fresh until the observation of the fourth day. In all three concentrations the plant is still alive and green in color so it can be used as a phytoremediation plant.

Based on observations made on *Sagittaria lancifolia* can be seen morphological changes are visible. In plants with concentration 0 g/L (control), did not show morphological changes from observation to 0 to 4. Plants with concentration of 0.05 g/L on observation to 3 and 4 leaves have necrosis. Plants with concentrations of 0.1 g/L on observations of 3 and 4 leaves had chlorosis and necrosis. Plants with concentrations of 0.15 g/L on observation of the 2 leaves had chlorosis and necrosis; at the 3rd and 4th observations the leaves were dying. Chlorosis can be caused by contaminants of organic matter and the absorption of toxic substances by plants. If chlorophyll formation is impaired, the photosynthesis process is also disrupted, eventually interfering with the growth and decrease of pollutant levels [8].

Measurement of water level in plants aims to determine the level of water absorption absorbed by plants. The longer the observation the water level measured the lower. This is because plants need water.

Table 1. Plant water level *Echinodorus radicans.*

Observation to-	Concentration g/L			
	0	0.05	0.1	0.15
0	6.8	6.6	6.6	6.7
1	6.8	6.5	6.5	6.5
2	6.7	6.5	6.3	6.3
3	6.6	6.3	6.2	5.9
4	6.5	6.1	6	5.7

Table 2. Plant water level *Sagittaria lancifolia.*

Observation to-	Concentration g/L			
	0	0,05	0,1	0,15
0	6,6	6,8	6,8	7,1
1	6,5	6,6	6,7	6,9
2	6,5	6,6	6,6	6,8
3	6,3	6,5	6,5	6,7
4	6,2	6,4	6,5	6,7

Based on Table 1. on observation of water level of *Echinodorus radicans* with concentration 0 g/L decreased by 0.3 cm, at a concentration of 0.05 g/L decreased the water level by 0.5 cm, at 0.1 g/L concentration decreased 0.6 cm, while at concentration 0.15 g/L decreased by 0.10 cm. At observation of water level *Sagittaria lancifolia* the biggest decrease occurred at concentration 0 (control); 0.05 g/L and 0.15 g/L by 0.4 cm while the smallest decrease occurred at a concentration of 0.1 g/L of 0.3 cm. There was a decrease in the water level that occurred in the observation. It is also because the decline in water level is directly proportional to the length of time the study, given the absorption of plants and evaporation. The longer observation causes the water level to become lower. This is because plants need water. The plant is absorbed by plants and used for plant growth and transpiration. When the plant growth, the plant uses the nutrients contained in the planting medium (water) so that the water level in each treatment has decreased. This is because the organic compound that can improve the process of photosynthesis, modification, nitrification, and fixation of N that has an important role in plant growth [9].

Measurement of biomass aims to determine the initial weight and final weight on plants that have been given domestic waste (detergent).

Table 3. Plant wet weight *Echinodorus radicans.*

Observation	Concentrations g/L			
	0	0.05	0.1	0.15
Beginning	29.5	35.3	28.2	41.3
Final	26.2	31.7	22.6	32.7
Difference	3.3	3, 6	5.6	8.6

Table 4. Plant Wet Weight *Sagittaria lancifolia.*

Observation	Concentration g/L			
	0	0.05	0.1	0.15
Beginning	90.2	89.5	43	166.7
End	91.6	84	39.5	127
Difference	1.4	5.5	3.5	39, 7

On the wet weight measurement *Echinodorus radicans* obtained the result of the wet weight difference at a concentration of 0 g/L ie 3.3 grams, at a concentration of 0.05 g/L wet weight difference obtained is 3.6 grams, wet weight difference obtained from 0.1 g/L concentration of 5.6 grams and at a concentration of 0.15 g/L ie having a wet weight difference of 8.6 grams. In the wet weight measurement of *Sagittaria lancifolia*, the greatest weight loss occurred at 0.15 g/L concentration of 39.7 grams and the smallest weight loss occurred at a concentration of 0 (control) of 1.4 grams.

Plants can accumulate large amounts of metals but very slow growth or low plant biomass [10]. The decline of plant biomass is influenced by the toxicity that causes: (1) difficult to obtain water due to the osmotic effect arising from excessive amounts of the solution, where the plant osmotic problem is due to certain ions reaching high levels of the solution. If the plant is placed in a solution with a lower water potential than the root xylem, then the water retention will stop, because the osmotic potential of the solution is greater than that of the plant, so there is no osmotic adjustment. This will result in insufficient water retention, (2) difficulty in obtaining nutrients due to competition between ions, where plant roots absorb ions from complex media containing not only one or more essential nutrients but also non-ionic ions essential and organic compounds. (3) Difficult to obtain CO_2, where CO_2 is used as the base material of the process of photosynthesis, where plants difficult to obtain CO_2 then the process of photosynthesis will not run perfectly, and (4) the reception intensity of the light. As a result the growth of plants will experience obstacles or stalled. It can also be one of the causes of the wet weight loss of plants because the water plants do not get the optimum temperature to grow. Likewise, there is a significant change in the value of greenhouse [11].

The wet weight of the plant shows the metabolic activity of plants. The value of wet weight is influenced by water content of tissue, nutrients and plant metabolism. At the end of the treatment there is a decrease in the wet weight of the plant. This means that detergent waste can affect the growth of plants that is lowering the weight of wet plants. Therefore it can be said that detergent waste is toxic in plants if in large quantities, it can decrease the wet weight of plants and even cause the death of plants [12].

The environmental parameters measured in the experiment were the temperature and humidity of the greenhouses, the average temperature during the experiments ranged from 22-25° C while the moisture contained in the greenhouse was 50-64%.

Table 5. Physical measurements (temperature and humidity).

Observation to	Temperature (°C)	Humidity (%)
1	23	64
2	25	50
3	22	64
4	22	60

Climatic characteristics measured in this study are temperature and humidity. The average value of temperature and humidity of the observations is 22-25°C. While on the research results say that the average water temperature for optimum water plants are in the range 26.69-28.34°C [13]. In general, aquatic plants prefer atmospheric carbon dioxide as a carbon source compared to bicarbonate and carbonate [14]. Based on the research results the relationship between air humidity to carbon in the atmosphere is inversely proportional. This is because the evaporation of water vapor transferred into the air is due to rising air temperatures so that CO_2 concentrations decrease [15].

4. Conclusions

In the research that has been done, it can be concluded as follows:

1. In phytoremediation by using *Echinodorus radicans* plant and spear leaf (*Sagittaria lancifolia*) can be observed based on plant morphology, water level, initial and final wet weight and can use parameter environment i.e. temperature and humidity.
2. The morphology of *Echinodorus radicans* plants (*Echinodorus radicans*) shows symptoms such as wilting, chlorosis, necrosis until death in plants. However, in the experimental results showed that water plants *Echinodorus radicans* at concentrations of 0.5 g/L, 0.1 g/L, and 0.15 g/L did not change significantly. Observed plants are still green and fresh until the fourth day of observation. Therefore forplants *Echinodorus radicans* can be used as phytoremediation plants.
3. Spear Leaf Plants (*Sagittaria lancifolia*) can be said to be effective in remediation of domestic waste (detergent). The experimental results show thatwater plant is *sagittaria lancifolia* still able to live well until the concentration of 0.1. Plants are able to grow well and show no signs of wilting and yellowing at that concentration.

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