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Effectiveness of Lotus and Duckweed in Ferum Removal to Improve Greywater Quality

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ABSTRACT

The broad environmental issue for surface water is the water pollution and always due to various industrial and domestic activities that produce liquid waste. The untreated wastewater that contain high concentration of ferum can lead to the damage healthy skin cells, causes of residue inside the pipes. Besides that, the The untreated greywater that contain high concentration of ferum can cause the growth rate of the plants reduced and affect the growth of aquatic organisms. The goal of this study is to test the greywater quality after planting lotus in the sample greywater. The parameters tests include the pH, biological oxygen demand (BOD) and chemical oxygen demand (COD), turbidity, concentration of ferum, dissolve oxygen (DO), ammoniacal nitrogen (AN) and total suspended solids (TSS) of the sample greywater, before and after planted with lotus. The sample greywater tested for 3 days and 7 days after planted with the lotus to identify whether the duration of treatment can improve the water quality. This study also includes compare the effectiveness of lotus and duckweed in improving the quality of sample greywater. Results from the experiment showed that the lotus had the ability to reduce ferum and improve quality in the greywater to standard A. Besides that, the quality of sample greywater keeps on improving with the longer time planted with lotus. The sample greywater had the better quality after 7 days planted with lotus compare to the greywater that had planted by lotus for 3 days. For example, the concentration of ferum in greywater sample recorded as 0.28mg/L and reduced to 0.80mg/L after 7 days planted with lotus. The duckweed had the better ability to remove ferum and turbidity in the greywater whereas lotus had the better ability in increasing the DO and reducing the BOD and COD of the sample greywater. The percentage of duckweed in ferum removal recorded as 77.06% which is 50.45% higher than lotus.

Key words: Duckweed, ferum concentration, greywater, lotus, water quality

1. INTRODUCTION

Greywater is the wastewater from sinks, dishwashers, showers, hand basins, baths and water from washing machine in which it may contain fats, oils, harmful chemicals, bleaches and germs that can cause human health threatened. In fact, the greywater produced considered as high volume, low strength wastewater which poses high potential for reuse and application. The composition of greywater may be varied due to the lifestyle, fixtures and climatic conditions. The heavy metal and particulate matter found in the greywater can reduce if the correct treatment applied. In fact, the treated greywater can discharge the lesser heavy metal and particulate matter into the river or discharge into the environment.

Every year, there is total of 2200 metric tons of the mercury had emitted into our environment [1]. When the untreated wastewater spread widely, that will increase water borne diseases and rapid degradation of environment [2]. The lotus a type of aquatic plant is applicable to the greywater treatment system to help in the heavy metal absorption and improve the water quality.

Lotus (Nelumbo Nucifera) chosen for greywater treatment is due to the lotus can obtain easily and can live in the water easily. Lotus can be found every place in Malaysia and it is a well-known plant and hence it is suitable for greywater treatment used. The lotus plant did not need the fertilized sparingly and this is important where the collected greywater will not further be contaminated by the fertilizers. Lotus able to oxygenate bottom sediments and preventing the toxic gasses released and preventing release of nutrients through anaerobic decomposition processes. Duckweed (Lemnoideae) also choose to complete this study due to compare the effectiveness of the ability of variety aquatic plants in to choose the suitable aquatic plants for improving the water quality of a specific area.

The greywater treatment enables to provides reusable water to the community. This treatment taking excess or used industrial water, filtering out harmful contaminants and leaving a water source clean and safe for everyone. In addition, a treated greywater to rivers and streams helps maintain natural areas, encouraging tourism. Hence, the life of aquatic

organisms will be protected without contaminated by the wastewater effluent.

2. MATERIALS AND METHODS

The greywater sample collected from Universiti Tun Hussein Onn hostel that mainly collected from clothes washing, flood irrigation and showers activities. The materials used in the study are lotus, duckweed and greywater. After collected the greywater, the greywater poured into two basins with the presence of a filter to avoid affect the growth of the lotus and duckweed. After filtering the larger particles, the sample greywater planted for lotus and duckweed. Three basins are filled with greywater only, greywater planted with lotus and greywater planted with duckweed respectively. The three basins are placed under hot sun to make sure the survival of the lotus and duckweed.

The total of 12 litres of the sample greywater is collected and each basin is full with 4 litres to make sure that was enough water for plant growth and able to take the water sample to do the experiment. The lotus used in the treatment of the greywater sample approximately have 10 leaves and will not less than 5 leaves to make sure the accuracy of the obtained result. On the other hand, the quantity of the duckweed keeps on increase due to duckweed is a fast-reproductive aquatic plant. The initial quantity of the duckweed was about 300.

After three days, the greywater in the basins are stirred and collected in small amount for the water quality testing. The turbidity, pH, BOD, COD, ferum, total suspended solid and dissolved oxygen is measured and recorded. Subsequently, the quality of the greywater was measured again after seven days. The testing of collected greywater quality is carried out at Environment Lab in UTHM Pagoh Educational Hub with the permission and consent of the lab authorities.

The value of turbidity, pH, dissolve oxygen, BOD, COD, ferum and total suspended solid is measured before planting any plant for phytoremediation. After that, quality of the greywater is checking again after the plant is being planted for wastewater treatment usage. After collecting the data, compare the initial value of turbidity, pH, dissolve oxygen, BOD, COD, ferum and total suspended solid of greywater before treatment with the value after treatment. Besides that, this experiment also measures the effectiveness of the lotus and duckweed by measuring the quality of greywater. Moreover, the effectiveness of lotus and duckweed also being measured according to the duration of the treatment which is 3 days and 7 days respectively. The effectiveness of the lotus and duckweed is calculated by using the following Equation 1:

$$\% \text{ Removal Efficiency} = \left(\frac{C_{inf} - C_{eff}}{C_{inf}}\right) x\ 100 \quad (1)$$

Where C_{inf} is initial concentration and C_{eff} is final concentration. To increase the accuracy of the result collected, the greywater data were analysed using a repeated measures analysis of standard deviation (JMP, 1994) and the mean value is calculated. The formula of standard deviation can be expressed by the following Equation 2:

$$s = \sqrt{\frac{\sum_{i=1}^{N} x_i^2 - \frac{(\sum_{i=1}^{N} x_i)^2}{N}}{N - 1}} \quad (2)$$

Where x is the value of data and N is the sum of the sample.

Figure 1: Duckweed

Figure 2: Lotus

3. RESULTS AND DISCUSSIONS

3.1 Greywater Quality after plating lotus and duckweed

3.1.1 pH

pH is the indicative of the acidic or basic condition of a sample water. From the experiment that had done, the pH of the sample greywater being reduced from initially 9.38 reduced to 7.47 then 7.14. The pH of the sample greywater is considered as alkaline before planting lotus but the pH of the sample greywater reduced to optimum range which is 6.5-7.5 after planted the lotus. The sample greywater reduce in pH can interpreted that the absorption of pollutants by the lotus. Besides that, the reduction in pH of the greywater can be said that the absorption of nutrients and other salts by the lotus and release of hydrogen ions with the uptake of metal ions [3]. pH level reduction is due to microbial activities and increase in CO_2 level in photosynthesis. A slight change in pH of sample

greywater is important for the removal of phosphorus and other nutrients. Duckweed had the ability to resist the alkalinity of the greywater in which duckweed can change the condition of water to slightly alkali condition.

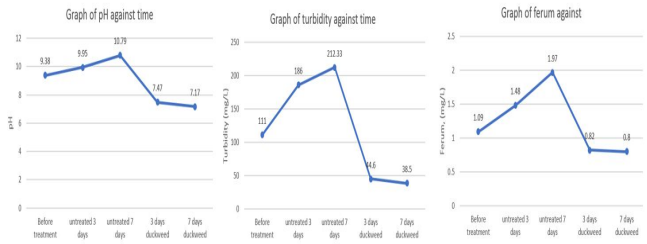

Figure 3: The pH, turbidity and concentration of ferum in greywater with lotus

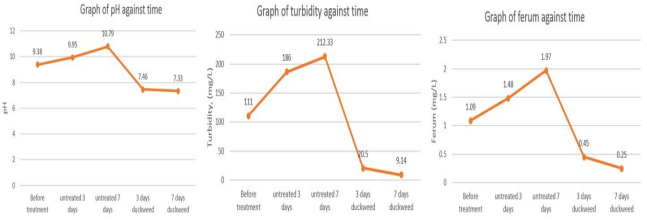

Figure 4: The pH, turbidity, and concentration of ferum in greywater with duckweed

3.1.2 Turbidity

Turbidity is a reduction on water clarity because of the presence of suspended matter that will absorb or scatter light and water is considered turbid when the presence of suspended particles becomes conspicuous. The lotus could improve the clarity of the greywater. Reduction of the greywater turbidity is due to salt removal from the greywater by lotus uptake or root adsorption. By using the lotus, it is possible to increase the clarity of greywater in short time and maintain the low turbidity due to the phytoremediation system. Lotus has firmly root and hairy extensive roots which able to help the dark brownish particulates attached to the roots and make them easier to be adsorbed to roots. The root of lotus consumed the organic suspended solid for growth and used up for converted to carbon dioxide and nutrient. Furthermore, lotus have extensive root system which able to trap all the colloidal particles and other dust particles near the roots. On the other hand, the plenty of root found in the duckweed can act as a tool to purify the sample greywater. From Figure 4 show that the turbidity of the sample greywater decreased from 111 mg/L to 38.5 mg/L in seven days.

3.1.3 Concentration of Ferum

Ferum easily can be found in any wastewater and must be removed as much as possible to prevent the environment being polluted. Lotus is a species of plants that are capable for the extraction and accumulation of ferum without severely affecting their growth in the sample greywater. The lotus and duckweed able to accumulate ferum for growth and development. Lotus require a balance between the uptake of essential metal ions to maintain growth and development and the ability to protect sensitive cellular activity and structures from excessive levels of essential and non-essential metals. Hence, the concentration of heavy matter present in the sample greywater will be decreased with planted of lotus and duckweed. The quantity of ferum reduced is due to the metabolic activities of lotus. The lotus can be used to absorb the ferum present in the greywater because lotus have a rapid growth rate and able to tolerant to high levels of the metal. From Figure 3 and 4, the figures show that the concentration of ferum being reduced when started to plant the lotus and duckweed on the selected greywater.

3.1.4 Chemical Oxygen Demand (COD)

COD is a method of estimating the oxygen would be depleted from a sample water to oxidise chemically organic materials of both biodegradable and biologically degradable to CO_2 and H_2O. The data from graph in Figure 4 shows that the reduction of COD in the greywater by planting the lotus. The COD of greywater before treatment recorded as 228 mg/L, but the COD of greywater reduced to 114 mg/L and 48.5 mg/L after 3 days and 7 days respectively. The value of COD decrease is caused by microorganisms found in the root of the lotus. The lotus plays an important role in absorption of organic pollutant contents. If the root of the lotus continues to grow then the lotus could absorb contamination from the greywater. Organic suspended solids found in the greywater were metabolised by the cell and converted to energy, carbon dioxide and water hence caused the COD value reduced [4]. The reduction of COD increased during the growth of the lotus because the root system developed well. The root of lotus is overgrown with many microorganisms and hence the microorganisms lowering the COD value of the greywater. The more effective the COD value being decreased as the microorganism in increasing and the microorganism can adapt well to the environment. The quantity of the root of duckweed is more due to the larger quantity of the duckweed and hence it able to reduce the value of COD. Besides that, the COD value in the sample greywater declined is due to the reduction in pH of the sample greywater.

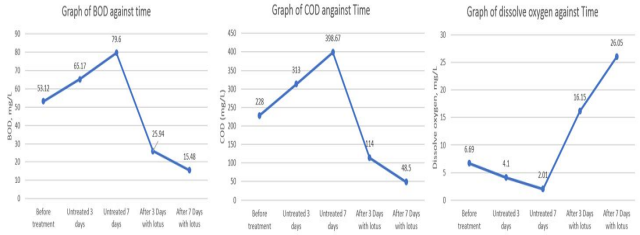

Figure 5: The pH, turbidity and concentration of ferum in greywater with lotus

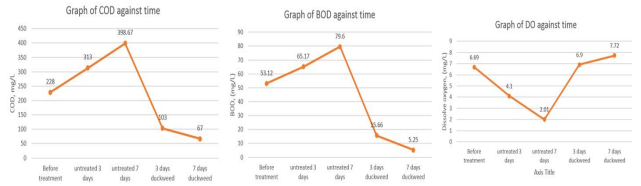

Figure 6: The pH, turbidity and concentration of ferum in greywater with duckweed

3.1.5 Biochemical Oxygen Demand (BOD)

BOD is a method to determine the amount of oxygen needed by microorganism to decompose the organic material in the greywater. The BOD value will be higher if the greywater presents of more organic matter in the greywater. When the BOD increased and the dissolve oxygen will be decreased. Through planting of the lotus and duckweed, the average value of BOD at the greywater has decreased. This is due to the decrease of the oxygen required by microorganism to decomposed the organic matter biologically. The BOD value reduced also due to the increased oxygen dissolve in water due to photosynthetic activity. The photosynthetic activity increases the dissolve oxygen of sample greywater and creating an aerobic condition in the greywater which are suitable for the aerobic bacterial activity. From Figure 5 and 6 above, it can see that the BOD of greywater decreased from 53.12 mg/L to 15.48 mg/L in seven days planted with lotus, whereas the value of BOD reduced from 53.12 mg/L to 5.25 mg/L in seven days planted with duckweed.

3.1.6 Dissolve Oxygen (DO)

DO is an important parameter used to determine the water quality. The value of dissolve oxygen usually measured the concentration of oxygen available in a sample water. The greater of the value of dissolve oxygen on water sample, the better the quality of the water sample. Based on the experiment that had done, the dissolve oxygen on the untreated greywater is lower compare to the greywater that is planted with lotus. This means that the water quality being improved after planted the lotus on the greywater. The presence of lotus and duckweed in greywater decrease dissolve carbon dioxide gas during the period of high photosynthetic activity. As the product of photosynthesis, the quantity of oxygen will be increased and the dissolve oxygen will be increased. After planted the lotus in the sample greywater, there was increase in the DO after treatment as indicated by reduction of BOD and COD in the greywater. Besides that, the measurement of dissolve oxygen on a sample body also to check whether the sample water have the enough oxygen for the biota such as fish and microorganisms to live. From the graph in Figure 5 and 6 above, the dissolve oxygen of the greywater is increased because of planting the lotus and duckweed on the greywater. Moreover, the dissolved oxygen increased when the COD decreased. Hence, from the above graph can be seen that planting of lotus able to raise the dissolve oxygen of greywater.

3.1.7 Total Suspended Solid (TSS)

TSS is the portion of fine particulate matter that remains is suspension in a sample water. Usually, the total suspended solid contains particles that are larger 2 microns. The lotus and duckweed able to reduce the total suspended solid present in a sample greywater. The lotus and duckweed absorb the nutrients needed from the greywater and hence in return the suspended solid in the greywater will decreased. The suspended solid absorb by the lotus is essential for the lotus and to carry out the photosynthesis. The reduction in total suspended solid is due to the root system of lotus retaining of coarse and fine particulate organic materials presents in the greywater for their continuous growth. The TSS of greywater reduced because the lotus is fully growth and the filtration capacity of the roots also increased. Hence the biofilms or filamentous algae able to grow on the root of lotus and the algae can consume the organic suspended solids and eventually causing the TSS to reduce. From Figure 7 and 8, we can see that the TSS of the sample greywater decreased to 226.7 mg/L and 243.3 mg/L in seven days with planted of lotus and duckweed respectively.

3.1.8 Ammoniacal Nitrogen (AN)

Ammoniacal nitrogen is the measure the amount of ammonia, a toxic pollutant often found in waste products, sewage, and landfill leachate. Greywater derived from greywater potentially contains nitrogen and it is a contributor to decline the quality of a water body. Nitrogen in excess found in the environment can lead to the changes in the natural nitrogen cycle between living being, soil, water, and atmosphere. Besides that, the excessive of the nitrogen found in the water bodies can cause the eutrophication occur. Nitrogen is an essential for the growth of the plants in the formation of proteins. In fact, the nitrogen molecular cannot used by most aquatic, therefore the nitrogen must change to nitrate ions and ammonium ions. Based on Figure 8 the ammoniacal nitrogen of the sample greywater reduced after planting the lotus and duckweed in the greywater in which from 0.89 mg/L to 0.29 mg/L and 0.89 mg/L 0.30 mg/L respectively. The lotus and duckweed utilise of the nitrogen involves few steps which including the uptake, assimilation, and translocation. Moreover, the ammonia also absorbs by the lotus and duckweed then incorporated into proteins and other organic combinations. The value of ammoniacal nitrogen in the sample greywater reduced due to the ammonium ions and nitrate ions are absorb by the lotus for plant growth and are necessary in larger amount than other mineral nutrients.

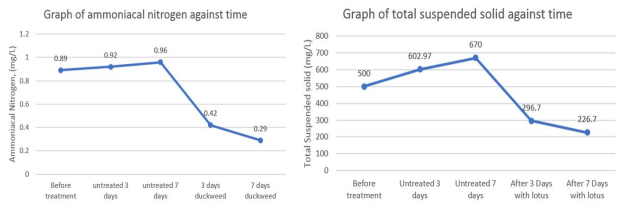

Figure 7: The ammoniacal nitrogen and suspended solid in greywater with lotus

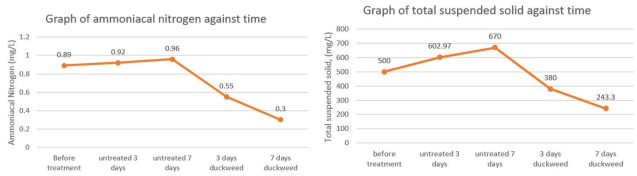

Figure 8: The ammoniacal nitrogen and total suspended solid in greywater with duckweed

3.2 Greywater quality after 3 days and 7 days with lotus

From Figure 9 and 10, the greywater sample has better quality after 7 days planted with lotus compare greywater that has been planted lotus for 3 days. From the experiment, can conclude that the longer the time of lotus planted in the greywater, the lotus had the better ability to uptake the ferum and other organic matter from the greywater and hence the water quality will be improved. The lotus are effectively reliable indices as water status indicator. Lotus' ability in taking up metal and toxic pollutants has shown their level of strength as well as tolerance in any types of water sample in many concentration levels. The accumulation of ferum was found maximum in shoots followed by the roots and hence lotus needed the longer time for better removed of the ferum that had been adsorbed by the roots.

According to the result, the COD of the greywater before planting lotus recorded as 228 mg/L and the COD decreased to 114 mg/L after planting the lotus on the greywater for 3 days then the COD of the greywater further reduced to 48.5 mg/L after planting the lotus on the greywater for 7 days. Through the experiment, we can say that the greywater quality can be continue improved if the lotus is planted for a longer time until reach the capacity. The ability of lotus to reduce the concentration increased with time due to the ferum was very useful for plant growth.

From the research, the result show that the lotus had the ability to purify sample greywater and lotus show a decreasing trend of value of BOD, COD, turbidity, TSS and concentration of ferum. The BOD, COD, turbidity, TSS and concentration of ferum in greywater decreased for the 6 subsequent months. On the other word, the quality of greywater keeps on improved for the next six months, when starting planted the lotus on the greywater. From Figure 6, we can clearly see that the BOD, COD and turbidity decreased with time. Whereas the dissolved oxygen of the greywater increased with time. From Figure 7, the value of pH, ferum and total suspended solid decreases with time. This result is same with the research in India, in which the research stated that the water quality able to be become better with the sample wastewater is being planted by lotus for a long period of time [5].

Based on the National Water Quality Standards for Malaysia, the ammoniacal nitrogen of the untreated greywater regarded as CLASS III with value of 0.96 mg/L. But the value of ammoniacal of nitrogen decreased from 0.42mg/L to 0.29 mg/L with 3 days and 7 days planted with lotus and it regarded as CLASS II. For the biochemical oxygen demand, the untreated greywater considered as CLASS V with 79.60 mg/L and reduced to 15.48 mg/L when planted the lotus in the greywater for 7 days. Besides that, the chemical oxygen demand also included in the water quality index (WQI). From the reading of chemical oxygen demand of the untreated greywater is recorded as CLASS IV with value of 79.60 mg/L and successfully decrease to 25.94mg/L (CLASS III) with three days of lotus and eventually the greywater recorded as CLASS II when the greywater is treated with the lotus for 7 days. Moreover, based on the dissolve oxygen of the untreated greywater regarded as CLASS IV and change become CLASS I after treated by lotus with 3 days times. The pH of the sample greywater after the planted with the lotus also recorded as CLASS I from CLASS V. From the six parameters that determine the WQI of the sample greywater, it show that the greywater successfully reached the CLASS III from initially CLASS V.

Based on the standard set by the Environmental Quality Act 1974, the effluent that is discharge upstream of a water supply intake should meet Standard A, while the effluent that discharged downstream meet the Standard B. From the result gained from the experiment, we can see that the initial value of chemical oxygen demand and biochemical oxygen demand of the sample untreated greywater regarded as Standard B and eventually change to Standard A with planted lotus in the sample greywater for 7 days. The pH of the treated sample greywater recorded as Standard A. Moreover, the greywater effluent also reduced from standard B to standard A with treatment of lotus and duckweed. The effluent of the greywater before treatment contained of 1.09 mg/L of ferum and reduced to 0.80 mg/L which regarded as standard A. Briefly, the wastewater planted with lotus and duckweed is effectively to convert the greywater effluent from standard B to standard A.

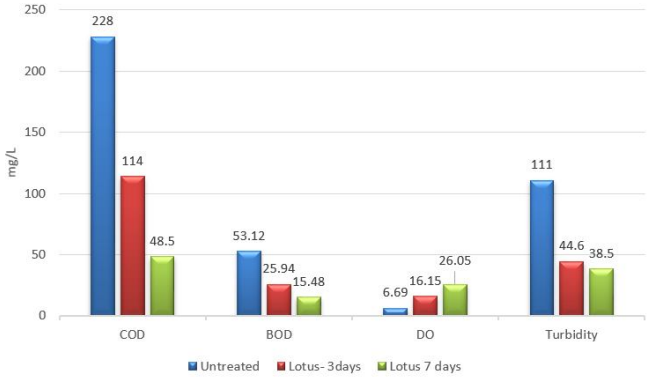

Figure 9: The changes of COD, BOD, dissolve oxygen and turbidity with time

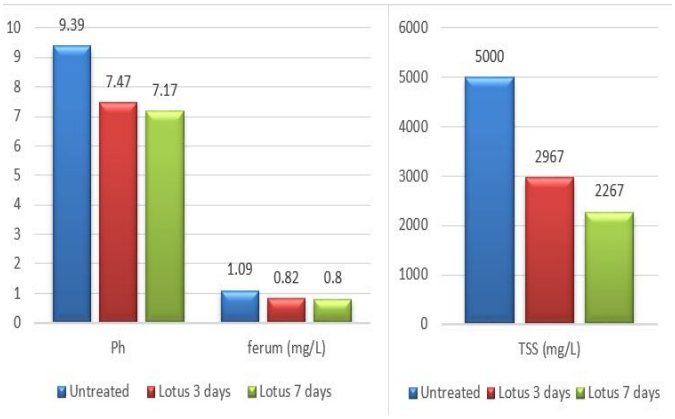

Figure 10: The changes of pH, ferum and TSS with time

3.3 Compare the effectiveness of lotus and duckweed in greywater treatment

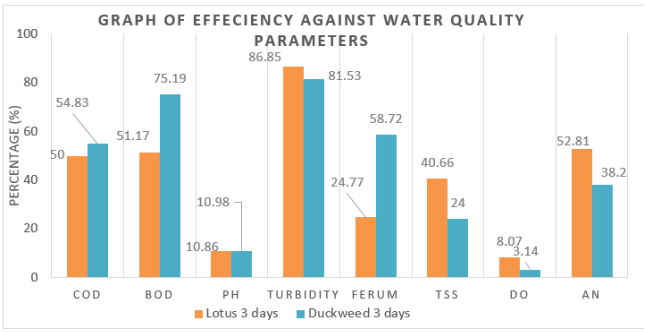

Figure 11: The efficiency of lotus and duckweed in greywater treatment (3 days)

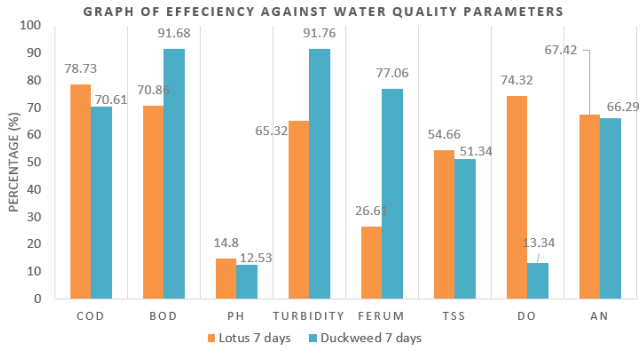

Figure 12: The efficiency of lotus and duckweed in greywater treatment (7 days)

From Figure 11 and 12 above, it is clearly seen that the lotus plays an importance role in reducing the greywater turbidity, total suspended solid and increased the value of dissolve oxygen. Whereas, duckweed had the better effectiveness in the reduction of BOD, COD, PH, and ferum concentration compare to lotus with a 3 days' treatment. After 7 days of treatment, the lotus had the better efficiency on decrease the value of COD, pH, and total suspended solid compare to duckweed. The lotus also possesses of better efficiency to increase the dissolve oxygen in the sample greywater. On the other hand, the duckweed had the better efficiency on reduce the value of BOD, turbidity and concentration of ferum. From the data obtained from the experiment, we can conclude that different types of plant had the different ability to reduce the water quality parameter.

3.3.1 Effectiveness on Chemical Oxygen Demand (COD)

Based on the result, the duckweed had the higher efficiency to reduce the COD of the sample greywater with 3 days of treatment. After 7 days, the lotus had the better efficiency to reduce the COD of sample greywater. This is because the lotus is bigger in size compare to the duckweed. The ability of duckweed lowers that lotus because the duckweed died off in the sample water that in turn increase organic load. The lower efficiency of duckweed to treated the sample greywater after 7 days this is because the production of oxygen by duckweed is lower than the duckweed [6]. Undeniably, the rate of duckweed to degrade the organic matter present in the sample greywater is slower; so that the duckweed can have better efficiency on reduce the COD of greywater. Besides that, the lifespan of the duckweed considered as 30 days to 35 days but the life span of the duckweed considered as perennial, in which the lotus able to grow for many years. This is the reason the duckweed had the better efficiency to reduce the value of COD of the sample greywater. Some of the duckweed may die during the greywater treatment and hence the efficiency of the duckweed decreased. Based on the past research, the COD can have the greater removal efficiency on the sample greywater after 14 days planted with lotus and duckweed [7].

3.3.2 Effectiveness on Biochemical Oxygen Demand (BOD)

In comparing the effectiveness of lotus and duckweed, duckweed possess the higher ability to reduce the BOD in the sample greywater. The BOD removal is higher in the duckweed this is because the presence of microbial activities is minimal as the greywater planted with duckweed is alkali in which the decomposition of the organic matter is prefer in an acidic condition. Hence the greywater planted with the duckweed is less suitable for microbial activities and the BOD value will be lower. Besides that, the lower efficiency of duckweed in reducing the BOD of the sample greywater is due to the duckweed are still adjusting to remediate greywater and hence it is not too effective in absorbing waste [8]. The higher efficiency of the duckweed can occur with the cooperation between aerobic microorganisms and the lotus plants. The process of metabolism of the microorganisms produced the carbon dioxide gas which then used by plants to carry out the photosynthesis. Through the process of photosynthesis, the glucose produced and become the nutrients for lotus and the oxygen produced and reused by aerobic microorganisms to decompose the organic content in the greywater. The large

number of roots found in duckweed compare to the lotus and hence the BOD removal efficient is higher by using lotus compare to duckweed. Based on the past research, the BOD can have the greater efficiency with 64.33%, 94.74% on reducing the BOD of the sample greywater after 14 days planted with lotus and duckweed respectively [7].

3.3.3 Effectiveness on pH

From the experimental data, both duckweed and lotus are effective in regulate the pH to the optimum range which is the 6.5 to 8.5. The effectiveness of lotus to reduce the pH of greywater is higher than duckweed this is due to high pollutants absorption ability found in the lotus. Effectiveness of pH level reduction is due to microbial activities and increase in CO_2 level in photosynthesis. The lotus had the better photosynthesis rate and hence it is more effective in the reduction of pH. With the growth of the lotus, the pH of the greywater slowly declined and means that the lotus can better grow in the sample greywater compare to the duckweed [9]. Even though lotus had the better efficiency on regulate the pH of the greywater, but the duckweed also plays in the pH regulate. Based on the past research, the longer duration of lotus and duckweed planted in greywater can have better efficiency on reducing the pH of the sample greywater after 14 days planted with lotus and duckweed [10].

3.3.4 Effectiveness on turbidity

Based on the result, the lotus had the higher efficiency that lotus to remove turbidity in 3 days' treatment but at the 7 days' treatment, duckweed had the better efficiency. The efficiency of turbidity removal in lotus and duckweed varied with duration is this is due to the growth rate of the duckweed. Duckweed counted as the most vigorously growing plants on the earth [11]. In fact, the quantity of the duckweed increased at the seven days' treatment and hence had the higher efficiency to remove turbidity by up-taking nutrients through the root of duckweed. The higher efficiency of lotus also due to the roots of lotus, lotus can retain both coarse and fine particulate organic materials present in sample greywater to support their growth [12]. The lotus had the lower effectiveness in removal the turbidity of greywater because the surface area of the root is smaller than the duckweed. The duckweed plenty in the sample greywater and hence the surface area of the root is greater than lotus so that the root can better capture the turbidity. Based on the past research, the efficiency of the turbidity removal increased when greywater exposed to duckweed and lotus for a longer time.

3.3.5 Effectiveness on ferum concentration

From the experimental data, duckweed had a better efficiency on ferum removal in the greywater compare to the duckweed with 77.06% efficiency. The duckweed had higher efficiency is due to the duckweed had the ability to assimilate ferum for their growth and provide a good habitat for bacteria to enhance nitrification and denitrification which can result in higher ferum removal efficiency than lotus. According to the research by Kanoun [13], the research stated that duckweed has a greater tolerance to higher concentration of ferum [13]. The high tolerance of the ferum cause the duckweed had the better ability to remove the ferum. The high tolerance of duckweed against ferum is due to the release of organic anions. On the other hand, the decay of lotus leaves could reduce the ferum removal efficiency [14]. Duckweed extensively studied in greywater treatment in which high efficiency of the ferum removal mainly due to its fast growth. Duckweed just consist of simple root and active having chloroplast and help in ferum uptake from the greywater and stabilizes the duckweed. Based on the past research, the ferum can have the greater removal efficiency on the sample greywater after 14 days planted with lotus and duckweed [15].

3.3.6 Effectiveness on total suspended solid

In comparing the effectiveness of lotus and duckweed on ability of reducing total suspended, the lotus had the higher efficiency with 16.66 % higher than the efficiency of the duckweed. Since the suspended solid concentration in a sample water are normally from algae, the leaves of floating-leaf plants in lotus above the greywater can prevent wind action and suppress sunlight. As a result, this condition is unfavourable for the growth of algae and reduce the sedimentation. In duckweed, there was more light enter the greywater and the light can stimulate the growth of algae which caused the higher concentration of total suspended solid. The significant decrease of total suspended solid in the sample greywater by using lotus is due to the calm water conditions in which particles or colloids from the sample greywater are easily to settle down to the bottom and hence easily to attach to the root of the lotus and hence the higher efficiency. The duckweed had the relatively low efficiency is because the duckweed is float on the water surface and roots is not long enough to attach to the sediments or colloids that are settle down of the bottom of the sample greywater. Based on the past research, the total suspended solid can have the greater removal efficiency on the sample greywater after 14 days planted with lotus and duckweed.

3.3.7 Effectiveness on total dissolve oxygen

By referring to the graph in Figure 7 and 8, the lotus had higher efficiency to increase the dissolve oxygen in the sample greywater. Lotus had a higher of 60.88% efficiency than the duckweed in increasing the dissolve oxygen of the sample greywater. The high efficiency of lotus in increasing the dissolve oxygen is due to photosynthesis that adds oxygen to the sample. The leaves of lotus are bigger in size that duckweed and hence the leaves of lotus can capture more sunlight than the duckweed. When the more light is being capture by the lotus, and the photosynthesis rate of lotus is more effective and more oxygen can be produced than duckweed. The ability of duckweed to produce oxygen during

the photosynthesis activity is slower than duckweed due to the lowered chlorophyll leaves that made the photosynthesis rate slower [16]. The lotus can cause the higher dissolve oxygen level because of the fibrous root of the lotus which usually have higher radical oxygen loss in which allow the excess oxygen diffuses into the greywater surface [17]. Based on the past research, the DO of the greywater increased gradually from 3 days to 14 days treatment.

3.3.8 Effectiveness on ammoniacal nitrogen

By referring to Figure 11 and 12, lotus had the higher efficiency in removal of the ammoniacal nitrogen present is the sample greywater. This is because the lotus able to absorb nitrate and ammonium more quickly than the duckweed due to the larger size of the roots found in the lotus. The roots of the duckweed are slender and duckweed take time to absorb the nitrogen from the sample greywater. Moreover, the lotus required lower energy than duckweed for uptake and assimilation of ammonium ions in relation to the nitrate ions. Ammonium ions can directly absorb by the roots of lotus and duckweed and cause the reduction of the nitrate ion. The lotus had the better efficiency in removing the nitrogen is due to the demand of nitrogen require for lotus to growth is higher compare to the duckweed. Besides that, the lotus had the higher efficiency of nitrogen absorption due to the higher rate of photosynthesis compare to duckweed. The high rate of photosynthesis will cause the more microorganisms to grow around the roots of lotus and hence remove the nitrogen more effective than duckweed. Based on the past research, the total suspended solid can have the greater removal efficiency on the sample greywater after 14 days planted with lotus and duckweed [18].

4. CONCLUSION

Based on the result obtained from the experiment and the previous research done, it had showed that the planting of the lotus and duckweed in the greywater can improve the water quality and reduced of the ferum concentration. Besides that, it also finds that the greywater will have the better water quality and higher ferum removal efficiency with the longer time greywater planted with lotus. Furthermore, lotus and duckweed had their own ability to improve the specific water quality. For example, lotus had the better efficiency to reduce the ferum concentration found in the greywater. The planting of lotus at a selected urban area able to cope the severe challenge such as water pollution prevention and treatment [14]. The efficiency of the lotus and duckweed in ferum removal can reach to 26.61% and 77.06% respectively and hence it can be concluded that duckweed had the better efficiency in ferum removal.

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