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Treatment of Industrial Wastewater At Gebeng Area Using *Eichornia Crassipes Sp.* (Water Hyacinth), *Pistia Stratiotes Sp.*(Water Lettuce) and *Salvinia Molesta Sp.*(Giant Salvinia)

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ABSTRACT

This paper shows a study to investigate the effectiveness of *Eichornia Crassipes sp., Pistia Stratiotes sp.* and *Giant Salvinia sp.* to be used in the phytoremediation technology and their potential as the heavy metals removal in root zone. This study is being applied to the industrial wastewater that contains heavy metals. Heavy metals content can cause many effect to human health. It is important to treat the wastewater before it is discharge into the water system. Thus, a new technology based on environmental friendly and economic are required. Phytoremediation concept is the best technology to be used in order to solve the water pollutant. Phytoremediation takes advantages of plants nutrient utilization processes to in water and nutrients through roots. This study focused on the use of the root zone in order to clean up the pollutants. The length of the root being measured and the water quality is being analyzed every week for 2 months durations according to 9 parameters referred to Standard Examination of Water and Wastewater by American Public Health Associate (APHA, 2002) .There are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), pH, Turbidity, Oil and Grease (O&G), Iron (Fe), Nitrate (NO_2) and Nitrite (NO_3). Analysis of data was performed by using a 1-way analysis of variance (1-way ANOVA). *Eichornia Crassipes sp.* is the most effective among them with Fe percentage removal of 139.4% and followed by Water Lettuce at 137% and Giant Salvinia 102%. Its root zone also growth faster and continuously compare to others and proved that the contaminant is successfully absorbed by the root in order to stabilize the industrial wastewater.

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INTRODUCTION

Water is one of the important needs in human living. The sources are consisting of surface water and groundwater. As Malaysia is fast becoming an industrial country, many of the rivers have become polluted due to the many wastes that have been poured out into the rivers. This study focused on the technology that being applied in order to treat the water pollution problem which is caused by the industrial wastewater. Industrial wastewater can be determined as the water effluents from industrial sources that may contain hundreds to thousands of chemicals, but only a few are responsible for aquatic toxicity [3]. There are many methods in order to treat the industrial wastewater depending on the suitability, one of them is phytoremediation. The phytoremediation of metals is a cost-effective green technology based on the use of metal-accumulating plants to remove toxic metals, including radionuclide, from soil and water. Phytoremediation takes advantage of the fact that a living plant can be considered a solar-driven pump, which can extract and concentrate particular elements from the environment [2]. This phytoremediation technology is suitable to be applied in treating the industrial wastewater since it is the emerging cleanup technology for contaminated soils, groundwater and

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wastewater that is both low-tech and low cost [1]. The objectives for this study are to identify the performance of effectiveness of *Eichornia Crassipes sp.*, *Pistia Stratiotes sp.* and *Giant Salvinia sp.* to be used in the phytoremediation technology and their potential as the heavy metals removal in root zone. The experiment or test will be held in the Environmental Laboratory and the planting area. The wastewater is taken from the industrial area at Gebeng, Kuantan, Pahang. Heavy metals pollution has leads to serious ecological and health problems, thus removal and recovery of heavy metals are very important with respect to environmental and economical considerations.

MATERIALS AND METHODS

2.1 In situ method:

This method explained as the treatment of the wastewater at the plantation area. In the plantation area, all the tanks that been used for this phytoremediation study were located near the Environmental Laboratory of Faculty Civil Engineering and Earth Resources besides the Block Z in University Malaysia Pahang. Figure 1 shows the design layout for the tank. The selected aquatic plant had located in the tank at the planting area. The wastewater for this study took from the industrial activity effluent at industrial area in Gebeng, Kuantan, Pahang which were Kaneka (M) Sdn Bhd and Polyplastics Asia Pacific Sdn Bhd. The industrial wastewater that had been collected was poured into the 4 collector tanks. The 3 of the collector tank will be treat with the three species of the selected aquatic plant while the other one untreated by the plant which known as the control sample. The entire sample will be circulate in the tank by using the water pump and provide with oxygen. The water sample placed there for about 2 months which is along the study activity duration. The growth rate of the plant also been observed. The average for 8 measurement of each root plant will be recorded from the beginning of this project. The first amount reading will be compared to the last readings in order to get the different value and this will be evaluated as the growth rate of the plants.

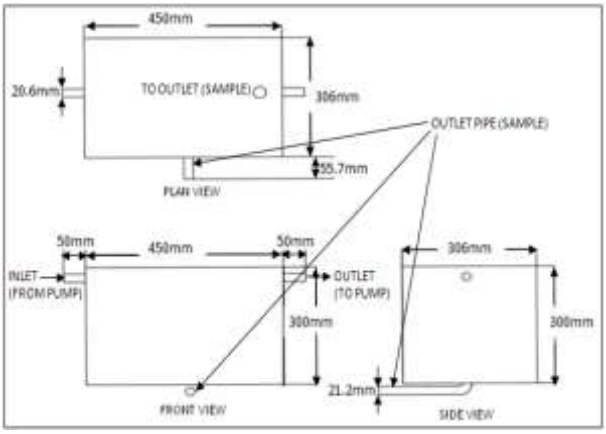

Fig. 1: Design layout for the tank.

1.2 Ex situ method:

Ex situ is the experiment done in the laboratory. This method was been done once a week to analyze the physical and chemical characteristics of the industrial wastewater based on all the 9 parameters All of them will be analyze according the standard method that has been establish by the American Public Health Association (APHA), American Water Works Association and Water Environment Federation. There are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), pH, Turbidity, Oil and Grease, Iron (Fe), Nitrate (NO_2) and Nitrite (NO_3). In order to analyzed and collecting data, 4 samples were taken from the plantation area. 3 sample from the tank that being fill with the industrial wastewater and the aquatic plant and 1 sample from the controlling tank where there is no aquatic plant used in this tank. The experiment will be done in the Environmental Laboratory of Faculty Civil Engineering and Earth Resources. But some of the parameters must be analyzed immediately at site. There are pH, turbidity and dissolved oxygen (DO). Some of the experiment that involved is taken much long time than expected. To make sure that the quality data in the study will be getting for a time being, the preservation of the sample in the proper way had been done according to Environmental Protection Agency Guidelines. All the experiment result must be fulfill the parameters limits of effluent that has been fixed by the Environmental Quality (Sewage and Industrial Effluents) Regulations 1978 in the Environmental Act 1974.

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1.3 Result Data Analyze:

After the experiment, all the result data that has been achieve will be gathered and analyze using the Statistical Package for the Social Sciences (SPSS) Statistics 17.0 software through One-way Analysis of variance (ANOVA). This software shown that either the hypothesis null, H_0 which is the earlier hypothesis that approving there is no significant different (P) for the analyzed when the significant value more than 0.05 ($P>0.05$), can be accepted or not. If not ($P<0.05$), the alternative hypothesis, H_1 that approving that there is a significant different happen will be used in conclude all the data statistically.

RESULTS AND DISCUSSION

3.1 Parameter experiment:

3.1.1 BOD:

The result from the BOD experiment can be summarized as the BOD content will be decreased from day by day by using the 3 differences types of plants. There is no significant different statistically in BOD value when the treatment is being done in different date once a week since the significant value, $P>0.05$ but there is significant different statistically in BOD value when comparing it between all the 4 treatments sample ($P<0.05$) and this can be seen in the percentage removal that discussed in the conclusion. BOD value is decreasing week by week. The control sample does not change too much since there is no plant used in treat the industrial wastewater. The decreasing value is from 23.9mg/L to 22mg/L. For *Salvinia Molesta sp.* in the wastewater, the BOD level is changing from 10mg/L to 8.6mg/L. The *Pistia Stratiotes sp.* remove the BOD value from 17mg/L to 8.3mg/L while the *Eichornia Crassipes sp.* decreasing the value from 16.4mg/L to 8.1mg/L. It shown that *Eichornia Crassipes sp.* is the most effective plants among them to be used in removing the BOD content in 5 days duration.

3.1.2 COD:

For the COD, the results in the experiment is there is a significant different statistically in COD value when the treatment is being done in different date once a week ($P<0.05$). It is also can be conclude that there is a significant different statistically in COD value when the treatment is being done by using all of the 3 types of plants and the industrial wastewater without plant (control sample); $P<0.05$. All treatment is effective in order to decrease the COD level, but the *Eichornia Crassipes sp.* is the most effective plant in removed the COD from 122mg/L to 33mg/L. By the presence of *Salvinia Molesta sp.* in the wastewater treatment, the COD level changed from 126mg/L to 52mg/L while wastewater contain the *Pistia Stratiotes sp.* decreased from 135mg/L to 40mg/L. The control sample reading decreased from 150mg/L to 99mg/L.

3.1.3 pH:

From all the result that had been analyze, there is a significant different statistically in pH value when the treatment is being done in different date once a week by using all of the 3 types of plant and compare it with the control sample ($P<0.05$). It also can be said that there is a significant different statistically in pH value when the treatment is being done ($P<0.05$). The result explain that the wastewater condition where it is reducing towards neutral condition from alkalinity and *Eichornia Crassipes sp.* make the water nearer to the neutral pH level where it is reducing from 7.78 to 7.35. The range of the control sample pH reading is between 8.62 and 7.65. The *Salvinia Molesta sp.* pH level for the water is reducing from alkali which is 8.56 to almost neutral 7.38. Meanwhile, the pH range for *Pistia Stratiotes sp.* contains wastewater is between 7.81 and 7.37.

3.1.4 DO:

The DO content in the water will be decreasing from day by day since the plants need the oxygen in order to make sure them continuously live. Higher the DO content, more good the water quality. From the result there is a significant different statistically in DO value week by week when the treatment is being done ($P<0.05$). The DO level in the control sample is highest among all the treatment since there is no plant using that will absorb the DO content where reduced from 7.76 mg/L to 5.74 mg/L. *Eichornia Crassipes sp.* used less of DO (makes the DO in the water to become 5.59 mg/L from 7.69 mg/L) while the *Salvinia Molesta sp.* absorbed greater amount of the DO (7.07 mg/L to 4.7 mg/L) and *Pistia Stratiotes sp.* DO value decrease from 7.54 mg/L to 5.33 mg/L. When the $P>0.05$, there is no significant different statistically in pH value when the treatment is being done because the different between the treatment is too little to be determine.

3.1.5Turbidity:

From the experiment, it can be determine that the turbidity condition during this treatment is increasing week by week. It affects the clearness of the water. There is a significant different statistically in turbidity value when the treatment is being done in different date once a week ($P<0.05$) but there is no significant different statistically in turbidity value when the treatment is being done by using all of the 3 types of plants and control

sample (P>0.05). This explain that the differences in turbidity value among all the treatment is too little but the most effective plant that used in this technology is *Salvinia Molesta sp.* where it produced less turbidity compare to the others plants, increasing from 8.5 NTU to 27.7 NTU. The industrial wastewater contains *Eichornia Crassipes sp.* gives the reading range of 10.5 NTU to 39.5 NTU while the *Pistia Stratiotes sp.* increase from 11 NTU to 56.7 NTU.

3.1.6 O&G:

From the result that had been determine, it can be summarize that there is a significant different statistically in O&G value when the treatment is being done in different date once a week by using all of the 3 types of plant and compare it with the unplanted industrial wastewater (control sample) with P<0.05. When the O&G content is being compare between all the treatment it also shown P<0.05. This approve that the O&G level is increasing week by week and this can be seen by the result where *Eichornia Crassipes sp.* is the lesser increasing the O&G content from 0.8mg/L to 1.43mg/L in the water. This is because the rates of plant growth make contaminant grease increase. The control sample O&G reading increasing from 0.76 mg/L to 1.2 mg/L. For the water with the *Salvinia Molesta sp.*, the reading change from 0.98mg/L to 1.58mg/L. while the industrial wastewater with the *Pistia Stratiotes sp.* increase from 0.91mg/L to 1.54mg/L.

3.1.7 Fe:

The result from the experiment as shown in Figure 2 can be summarized as the Fe content will be decreased from day by day by using the 3 differences types of plants. From the analysis, there is a significant different statistically in Fe value when the treatment is being done in different date once a week by using the treatment, P<0.05 but there is no significant different statistically in Fe value when comparing it between all the 4 treatments sample (P>0.05) From the data, it shown that *Eichornia Crassipes sp.* is the most effective plants among them to be used in absorbing the Fe content with reading reduces from 0.282mg/L to -0.129mg/L. The control sample reading reduces from 0.328mg/L to 0.101mg/L. The *Salvinia Molesta sp.* changes the reading from 0.328mg/L to 0.101mg/L while *Pistia Stratiotes sp.* decreasing from 0.32mg/L to -0.121mg/L Fe content.

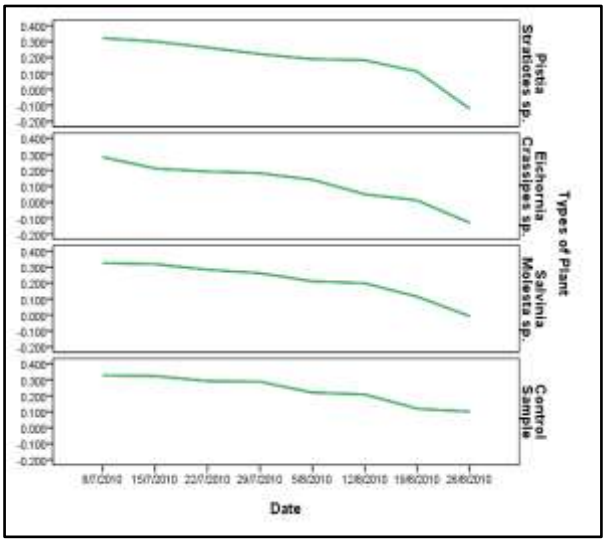

Fig. 2: Fe results.

3.1.8 NO_2^-

The summary for this NO_2 experiment can be summarizing as it will decreased from week by week as shown in the Figure 3. This can be approved by the ANOVA analyze where P<0.05, there is a significant different statistically in NO_2 value when the treatment is being done in different date once a week by using all of the 3 types of plant and compare it with the control sample. The *Eichornia Crassipes sp.* shows the best performance in NO_2 removing even the analyze shown significant different, P>0.05 where there is no significant different statistically in NO_2 value. The percentage of NO_2 removal, 183.4% shows that the Water Hyacinth effectively absorbs the NO_2 content from the industrial wastewater. NO_2 value in the control sample is decreasing from 0.6mg/L to 0.1mg/L. The effluent that treated with the *Salvinia Molesta sp.* contain the NO_2 that decrease from 0.6mg/L to -0.1mg/L while the *Pistia Stratiotes sp.* decreasing the reading from 0.7mg/L to -0.2mg/L.

3.1.9 NO_3:

From all the result, it can be summarize that there is a significant different statistically in NO_3 value when the treatment is being done in different date once a week by using all of the 3 types of plant and compare it with control sample ($P<0.05$). This is because the NO_3 value is decreasing along the experiment period where it can be seen from the graph in Figure 4. In differentiate the NO_3 removing efficiency among the plants, it can be known that $P>0.05$; there is no significant different statistically in NO_3 value. By the way, from the analyze it can be determine that *Eichornia Crassipes sp.* is the most effective plant in absorbing the NO_3 when it changed the industrial wastewater value from 0.009mg/L to -0.003mg/L. The control sample decreasing the NO_3 value from 0.01mg/L to 0.005mg/L. *Salvinia Molesta sp.* shows the changed of the value from 0.009mg/L to 0.003mg/L while *Pistia Stratiotes sp.* effluent become 0.002mg/L from the value of 0.008mg/L.

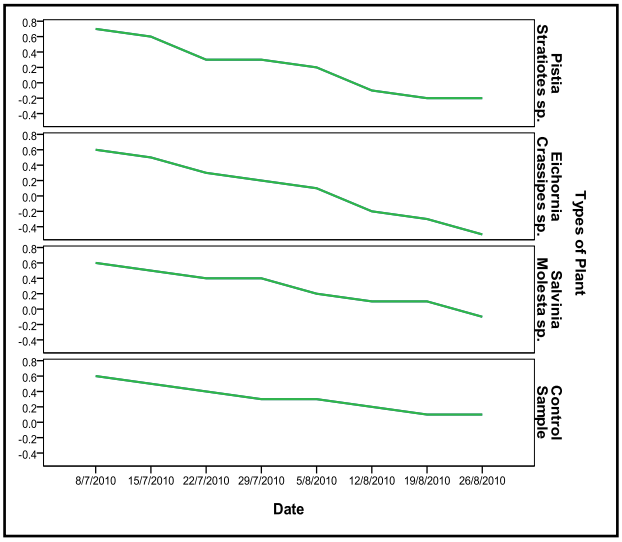

Fig. 3: NO_2 results.

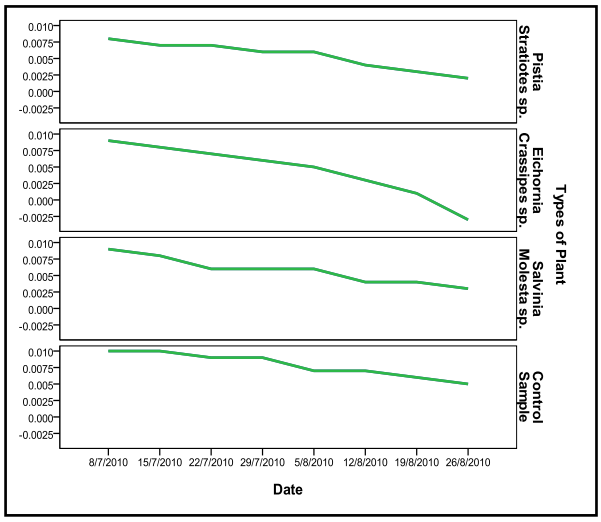

Fig. 4: NO_3 results.

1.4 Growth Rate of Plant:

In this phytoremediation process, three types of aquatic plants had been chosen. There are *Eichornia Crassipes sp.*, *Pistia Stratiotes sp.* and *Salvinia Molesta sp*. All of these 3 plants acted as the absorb medium by using their root. This is known as the rhizobium concept. All the contaminant from the industrial wastewater will be absorb through the root and become a food for the plant to grow health. The measurement of the root length is being done once a week for the whole 2 months. In order to get the average length, about 8 measurements is taken from the plant root. Root for the *Eichornia Crassipes sp.* growth faster and increase week by week. In 2 month, the root is increasing from 180 mm to 334 mm. The *Pistia Stratiotes sp.* also increasing from 254 mm to 413 mm while the *Salvinia Molesta sp* changed from 15 mm to 28 mm. From the observation,

it can be conclude that, the Water Hyacinth has the potential in order to absorb the contaminant from the industrial wastewater. It is strongly surviving in the water under the polluted condition.

2. Conclusion:

The main objective in this technology is to make sure all the plants potentially remove the contaminant from the industrial wastewater. It can be determine that all the three plants can give a good performance in order to remove the contaminant from the industrial wastewater, especially heavy metals which are Iron (Fe), Nitrate (NO_2) and Nitrite (NO_3) in high percentage of removal. From the result, it can be conclude that *Eichornia Crassipes sp.* give the most positively responded in order to removed all the contaminant compare to *Pistia Stratiotes sp.* and *Salvinia Molesta sp.* through their root zone. The effectiveness of the phytoremediation system in order to remove the heavy metal can be seen from Table 1. *Eichornia Crassipes sp.* removes the Fe at the percentage of 139.4%, NO_2 at 183.4% and NO_3 at 130%. From the percentage, it can be defined as the water had been cleaned up from all the heavy metal by the plant for the treatment about 2 months time. The root zone of the plant is the part where all the contaminant will be absorbed. It is being observed from day to day in order to determine the potential either the root zone is the most high reaction part in this treatment. The result show that the root for *Eichornia Crassipes sp.* growth fast and continuously. As a final conclusion, from the observation that had been done, *Eichornia Crassipes sp.* is the most potential and effective plant that can be used in the phytoremediation treatment in treat the industrial wastewater. All the 3 plants have their ability and shown their performance effectively as the plants in phytoremediation technology. It also had been approved that the root zone of this plant can stabilizing the industrial wastewater in purpose to cleaning up it from being polluted. The continuous growth of the root shown that, the heavy metal can be absorbed as a food for all the plant since it is neutralized along with the increase of root growth.

Table 1: Percentage removal by all plants.

	PERCENTAGE REMOVAL		
PARAMETER	WATER LETTUCE (%)	WATER HYACINTH (%)	GIANT SALVINIA (%)
BOD	65.3	66.1	64
COD	73.3	78	65.3
pH	14.5	14.7	14.4
Dissolve Oxygen (DO)	31.3	28	39.4
Turbidity	-85.4	-79	-70
Oil & Grease	-50.6	-46.9	-51.9
Ferum (Fe)	137	139.4	102
Nitrate (NO_2)	133.4	183.4	116.6
Nitrite (NO_3)	80	130	70

REFERENCES

[1] Hinchman, R.R., M.C. Negri and E.G. Gatliff, 1996. Phytoremediation: Using Green Plants to Clean Up Contaminated Soil, Groundwater and Wastewater.
[2] Raskin, I., R.D. Smith and D.E. Salt, 1997. Phytoremediation of Metals: Using Plants to Remove Pollutants from the Environment.
[3] Science Daily, 2007. *Definition of Industrial Wastewater* http://www.sciencedaily.com.
[4] Padmavathiamma, K.P. and L.Y. Li, 2007. Phytoremediation Technology: Hyper-accumulation Metals in Plants.
[5] Barcelo, J. and C. Poschenrieder, 2003. Phytoremediation: principles and perspectives.
[6] Ansola, G., C. Fernandez and E.D. Luis, 1995. Removal of Organic Matter and Nutrient from Urban Wastewater by Using an Experimental Emergent Aquatic Macrophyte System.