WASTEWATER TREATMENT USING PHYTOREMEDIATION BY *IMPERATA CYLINDRICA* AND *HELICONIA PSITTACORUM*

Khairul Anam Moktar
Faculty of Civil Engineering, Universiti Technology MARA
40000 Shah Alam, Selangor, Malaysia
Email: khairulanam9@gmail.com

Wan Suriatty Mazlan
Faculty of Civil Engineering, Universiti Technology MARA
40000 Shah Alam, Selangor, Malaysia
Email: wansuriatty@sunway.edu.my

Ramlah Mohd Tajuddin
Faculty of Civil Engineering, Universiti Technology MARA
40000 Shah Alam, Selangor, Malaysia
Email: ramlah160@salam.uitm.edu.my

ABSTRACT

Phytoremediation system is the one of the purifier technology with less cost and less technology requirements. Phytoremediation technique consist a number of different methods that can lead to contaminant degradation, removal through accumulation or dissipation, or immobilization.This plant-based method helps to degrade pollutants with the insignificant amount of site management and low cost technology options. The aim of this study is to identify the potential terrestrial plants to be used for phytoremediation. Two terrestrial plant species, Imperata Cylindrica and Heliconia Psittacorum were assessed for their ability in treating wastewater from the commercial area. The plants were selected based on their availability, fast growth and low cost. The plants were exposed to wastewater for several days. Sample solution was collected every 24 hours interval from day to day to determine the effluent quality. The results were calculated in the formula of water quality index from the Department of Environment Malaysia in order to indicate the performance of the treatment toward the national standard. Index result shows that Imperata Cylindrica gives higher index, 73.56 compared to Heliconia Psittacorum, 68.28. After the phytoremediation treatment, the positive performance shows the waste water sample index are improving from polluted to slightly pollute. Tap root by Heliconia Psittacorum achieve a higher water quality index performance compared to the fibrous root by Imperata Cylindrica. Therefore, it can be conclude that tap root has a better performance in removal the pollutants based on water quality index from the commercial area wastewater.

Keywords: *Imperata Cylindrica, Heliconia Psittacorum*, Phytoremediation, Terrestrial plant.

INTRODUCTION

Phytoremediation are capable to treat the wastewater naturally. Eliminate or reduce contaminants to the level that cause no adverse effect on human or the receiving environment is the main objective in wastewater treatment process. Phytoremediation technology is the direct uses of various types of plants by absorbed, accumulated, detoxified and for render harmless, and reduces contamination in the soils, sediments, surface water, waste water or ground water through physical, chemical and biological processes (Morrice et al., 2008). According to previous research Nuraini and Felani (2015), terrestrial plants have the advantage of large amount of biomass and longer process by giving a support platform to enable growth on water. Moreover, terrestrial plants root system growth faster than aquatic plant. For the phytoremediation process in this study, the terrestrial plants have been used as the clean agent with the two different types of roots which is fibrous root and tap root structure. The fibrous root and tap root are potential in absorbing the contaminant and metal from the wastewater. The fibrous root is the root structure which has many roots underneath. Fibrous root structures can be in the land plants or aquatic plant. Most of the aquatic macrophytes are from fibrous root structure. In fact, fibrous root structure are consist large amount fine hair like roots that will form a thick mat below the surface which contain void space that will support buoyancy of the plant (Nuraini and Felani, 2015). Tap roots structure is contain one large, primary vertical root that spawns many smaller horizontal root structures. By penetrating deep in the soil, tap roots provide stability and store nutrients. Tap roots plant can absorb and extract the nutrient needed to naturally survive by their long vertical roots. Therefore in this study, the plants with different roots structures are selected to investigate which of the two roots structure are more effective in phytoremediation process in order to treat the wastewater. *Imperata Cylindrica* plants representing fibrous roots and *Heliconia Psittacorum* is representing tap roots.

METHODOLOGY

Plants materials

In this research, *Heliconia psittacorum* plant and *Imperata Cylindrica* plant were used as hyperaccumulator of contaminant. The selection of these plants is based on differences of their root structures. *Heliconia psittacorum* plant is representing tap root structure while Imperata Cylindrica plant is representing fibrous root structure. The 40 grams of each type of plants have been taken to conduct this experiment. Root length, plant weight and plant height from both plants have been measured and recorded daily in 14 days. The *Heliconia psittacorum* and the *Imperata Cylindrica* plants root have been clean to avoid any trap matters before the plant placed in the beaker. *Heliconia psittacorum* and the *Imperata Cylindrica* plants have been place into the beaker separately and have been given one week from the time conducted to acclimatize to its new environment.

Commercial Area Waste Water Sampling and Characterization

The water sample has been collected from the Commercial Area Shah Alam, Selangor. The water sample has been specifically taken from outfallof the perimeter drain to the monsoon drain. The waste water sample will be taken during the day and non rainy day to preserve the sample from mixed with other element. Waste water has been taken at 3 different times to have mix composition characteristic of water during low and peak time. Waste water sample has been collected by using grab technique. The waste water sample has been stored in the plastic container with the volume around 3 liter. The 3 liter is decided as the volume wastewater sample due to the estimation of sample to be use in testing at the lab for BOD, COD, and Ammonical Nitrogen (NH_3N) and other basic parameter for 14 days. Besides, the estimation loss for surrounding factor such as evaporation and rate of absorption also will be noted to ensure the volume of waste water sample is enough to conduct experiment within 14 days. The water sample analysis has been carrying out according to Standard Method for the Examination of Water and Wastewater by APHA 2005. The commercial area waste water parameter which has been tested are basic parameter such as pH , temperature, turbidity, conductivity, total dissolve solid TDS , dissolve oxygen DO, Biochemical Oxygen Demand BOD, chemical Oxygen Demand COD, TSS, and Ammonical Nitrogen. The parameter selection is base on the Department of Environment DOE Malaysia Water Quality Index Classification. The parameter chosen have been calculated based on their quality index and have been compared with WQI calculation.

Experimental Set-up

The apparatus were been set up with the 2 circular water beaker with the diameter size 13cm and height 20 cm. All the apparatus have been washed by using distilled water. Secondly, the each beaker were been filling with the 1.5 liter of waste water sample from commercial area. Thirdly, the *Heliconia psittacorum* and the *Imperata Cylindrica* plants were been placed in the different beaker. The *Heliconia psittacorum* and the *Imperata Cylindrica* plant had used polystyrene board as the buoyancy aid to allow the plant floating on the wastewater. Polystyrene is chosen because it will not absorb any water or other substance and its capability in floating. Meanwhile, to allow the test sample to cooperate with natural process, the test samples were given with adequate aeration, and enough sun light. The daily observation and data have been recorded. Daily data observation method was selected to investigate the pattern of changes stimulated from the plant toward the wastewater. Most of the plants are work during day within the sunlight sources.

The waste water samples were be taken on a daily basis for 14 days basic parameter such as pH , temperature, turbidity, total dissolve solid TDS , dissolve oxygen DO will be determined by using U-50 Multiparameter Water Quality Monitor brand Horiba while the TSS, COD, Ammonical Nitrogen (NH_3N) were be analyzed by using HACH Spectrophotometer series 5000. Ammonical Nitrogen (NH_3N), BOD and COD test were been conducted by following the standard method (APHA, 2005). The suspended particles at the roots have been observed to identify the stimulation plant root against suspended particle.

Analysis of effluents Water

The effluents characteristic from the phytoremediation treatment process were determine by taking daily reading of pH , temperature, turbidity, conductivity, total dissolve solid TDS , dissolve oxygen DO, Biochemical Oxygen Demand BOD, chemical Oxygen Demand COD, TSS, and Ammonia Nitrogen (NH_3H) in everyday in 14 days during experiment. The data have been tabulated in the table. The parameter characteristics have been tabulated in data and effluent sample water quality has been calculated. The results of the calculation have been compared with water quality index (WQI) from Department of Environment Malaysia.

The formula used to calculate water quality index such as ;
WQI = (0.22* SlDO)+(0.19*SIBOD)+(0.16*SICOD)+(0.15*SIAN)+(0.16 * SISS)+(0.12 * SipH), where;

SIDO = Sublndex DO (% saturation)
SIBOD = Sublndex BOD
SICOD = Sublndex COD
SIAN = Sublndex NH_3-N
SISS = Sublndex SS
SipH = Sublndex pH
$0 \leq WQI \leq 100$

RESULTS AND DISCUSSIONS

Reduction of Contaminant from wastewater

The effectiveness of the plants in reducing contaminant from the wastewater was determined. Dissolve Oxygen parameter on wastewater sample plant *Heliconia Psittacorum* was increased about 10.83% with the initial reading was at 7.33 mg/l and the final reading is 10.37 mg/l while for the plant *Imperata Cylindrica* is increased about 21% with the initial reading 7.33mg/l which have been increased to the 9.14mg/L. On the other hand, the Biochemical Oxygen Demand (BOD) parameter shown the decreasing from both *Heliconia Psittacorum* and *Imperata Cylindrica*. Figure 1 shows the reading of wastewater sample with *Heliconia Psittacorum* was dropped from 68.6mg/l to 10.23 mg/l which is 85.08% decreasing while *Imperata Cylindrica* shown the reading dropped from 68.6 mg/l to 11.45 mg/l which is 83.30% decreasing. This result was similar with previous study by Mokhtar et. al. (2011) where the phtoremediation technology able to reduce contaminant from wastewater.

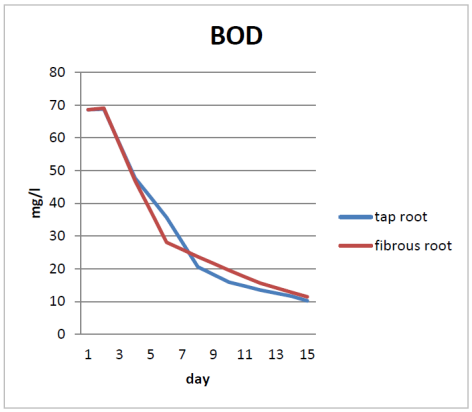

Figure 1: Reduction of Biological Oxygen Demand for both fibrous and tap root

Figure 2 shows that Chemical Oxygen Demand (COD) was decreased 95.05% from 303 mg/l to 15 mg/l for phytoremediation by *Heliconia Psittacorum* sample and decreased 86.47% from 303vmg/l to 41 mg/l for *Imperata Cylindrica* plant. These results are better compared to published results using water hyacinth for phytoremediation of automotive wastewater (Zuraisah et al., 2009). pH parameter on wastewater with the *Heliconia Psittacorum*, the initial reading was 6.7 which then increased to 7.37 which is about 10%. For *Imperata Cylindrica* the reading is increased about 6.4% from 6.7 to 7.13 pH value. Thus, the pH of wastewater was in the range of permissible pH according to Standard A for Environmental Quality Act 2009. Whereas for ammonia parameter resulted the *Heliconia Psittacorum* was decreased about 54.7% from the initial was 24.3 mg/l dropped to 11.01 mg/l while *Imperata Cylindrica* shown the 86.8% decreasing from 24.3 mg/l to 3.21 mg/l as shown in Figure 3.

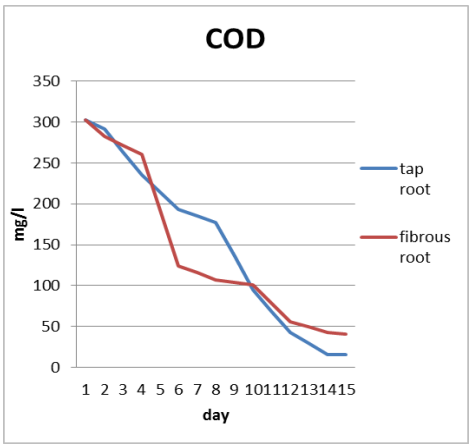

Figure 2: COD reading for 14 days period

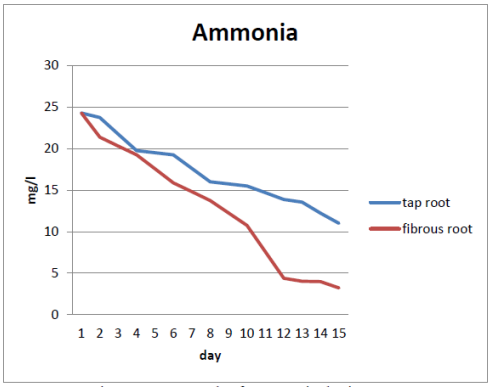

Figure 3: Ammonia reading in wastewater during the phytoremediation

Water Quality Index Analysis

The phytoremediation efficiency by *Heliconia Psittacorum* and *Imperata Cylindrica* in treating commercial area wastewater was compared with Malaysia Quality Index as a baseline.

During the experimental period, the Ammoniacal Nitrogen, BOD, COD, turbidity, and TSS content are decreases proven. On the other hand, the reduction of ammoniacal Nitrogen by tap root was in class V which s considered as unsuitable water. On the other hand, fibrous root (*Imperata Cylindrica*) able to reduce the ammoniacal Nitrogen content after 14 ways to the better level which s level IV with classified as poor water (Al-Omran et. al., 2015). Therefore, the longer the retention time for phytoremediation treatment, the better the ammoniacal Nitrogen was treated.

Table 2: The Effluent Characterstics after Phytoremediation treatment

Parameter	After Treatment *Heliconia Psittacorum*	Index	Class	After Treatment *Imperata Cylindrica*	Index	Class
Ammoniacal Nitrogen	11.01mg/l	>2.7	V	3.21mg/l	>2.7	IV
Biochemical Oxygen Demand	10.23mg/l	6-12	III	11.45mg/l	6-12	III
Chemical Oxygen Demand	15mg/l	10	I	41mg/l	25-50	IIB
Dissolved Oxygen	10.37mg/l	>7	I	9.14mg/l	>7	I
pH	7.37	6.5-8.5-9	I,II,III,IV,V	7.13	6.5-8.5-9	I.II.III,IV.V
Electrical Conductivity*						
Total Dissolved Solid	341mg/l	500	I	303mg/l	500	I
Total Suspended Solid	1.89mg/l	25	I	3.10mg/l	25	I
Turbidity	4.78ntu	5-50	I	9.21ntu	5-50	I

High Turbidity, TSS and TDS reduction was recorded in 14 days duration. This high removal of solids could be attributed to the property of proper particle sedimentation by the test plant (Malaviya et. al., 2012) or the ability of the root plant to retain both coarse and fine particle and organic materials present in the waste water. TSS value of commercial area wastewater that has undergone processing by tap root (*Heliconia Psittacorum*) in generally decreased. From the physical observations, *Heliconia Psittacorum* and *Imperata Cylindrica* had trap amount of the small particle to their roots. Therefore, the high possibility the decreases of the turbidity and TSS was because of the attraction of particle from the roots. For example, the root hairs have electrical charges. The electrical charges attract the opposite charges of colloidal particles such as suspended solids and cause them to stick on the roots where they are slowly digested and absorbed by the plant and microorganisms. According to the result, the tap root from heliconia psittacorum show the more effectiveness than fibrous root from *Imperata Cylindrica* in reducing turbidity and total suspended solid from the wastewater sample. The WQI standard also approved the TSS TDS and turbidity content after the treatment which in the class 1 classification with no harm to environment (Ghani et. al., 2018).

Dissolved oxygen (DO) is according to the level of free, non-compound oxygen present in water or other liquids. It is an essential parameter in evaluating the water quality because of its effect on the organisms living within a body of water. The level dissolved oxygen content are increases from initial experiment to the 14 days of the experiment. The incremental of the DO in sample are highly related to the open aerated. From the air, oxygen can slowly diffuse across the water's surface from the surrounding atmosphere, or be mixed in quickly through aeration. Besides, the present of the plants sample in the wastewater sample also contribute to the increment of DO content. According to Gao (2006) while most photosynthesis takes place at the surface by shallow water plants and algae, a large portion of the process takes place underwater by seaweed, sub-surface algae and phytoplankton. Light can penetrate water, though the depth that it can reach varies due to dissolved solids and other light-scattering elements present in the water. In this study, the transparent glass beaker was used to conduct the experiment. Therefore the plant and he wastewater are fully expose to the light and light can reach to the depth of the wastewater sample. The plants sample can allow the photosynthesis process to occur naturally.

The BOD during the process of phytoremediation of commercial area wastewater using Heliconia Psittacorum plant and Imperata Cylindrica plant as phytoremediator, the values of BOD at both wastewater was decreased. This was presumably because the amount of oxygen needed by microorganisms in digesting organic material is reduced with increasing dissolved oxygen (DO) in the water due to the photosynthesis activity (Morrice et al,. 2008). The presence of plants in wastewater can reduce dissolved CO2 during the phase of high photosynthetic activity. This photo-synthetic activity increases the dissolved oxygen of water, thus creating aerobic conditions in wastewater which favor the aerobic bacterial activity to reduce the BOD and COD. The high initial readings of the BOD and COD parameter are because the suspended solids rates are high which 13.30 mg/l is and the turbidity of wastewater initial sample is 229 Ntu. The high concentration of suspended solid and turbidity lead to the microorganism growth with such as many organic materials in the wastewater sample. Therefore, the reason of the BOD and COD value is high in the beginning of the experiment is because the high concentration suspended solid and turbidity. BOD and COD content after the treatment was improving the WQI standard which has been categorized in class III compared to the untreated wastewater which is in class V (Mir et. al., 2017)

An increase in pH at the concentration of commercial area wastewater occurred on day 2. Treatment wastewater by fibrous root *Imperata Cylindrica* showed the average pH value of the lowest with increased of 6.4% compared to treatment by tap root Heliconia Psittacorum which had increased by 10%. The increases in pH value are causes by activity of microorganisms and bacteria to decompose organic matter in the wastewater is also correlated with photosynthetic activity which takes CO_2 dissolved in the form H_2CO_3 that (Morrice et al., 2008). Therefore, the pH value increases as the decomposed organic increase.

CONCLUSION

Table 3: Comparison of the Phytoremediation performance of the commercial wastewater treatment with Malaysia Water Quality Index.

Index	Before Treatment	After Treatment	After Treatment
INDEX RESULT	Control	*Heliconia Psittacorum*	*Imperata Cylindrica*
	37.95	73.56	68.28

Table 4: Water Quality Classification based on Water Quality Index.

Sub Index & Water Quality Index	Index Range		
	Clean	Slightly Polluted	Polluted
Water Quality Index(WQI)	81 - 100	60 - 80	0 - 59

The phytoremediation treatment, the positive performance shows the waste water sample index are improving from polluted to slightly pollute.The result of wastewater after the phytoremediation treatment then was compared to the standard Interim National Water Quality Standard Malaysia and DOE Water Quality Index and it shows the improvement of the water quality. The ((INWQS) shows the condition of waste water after the treatment was change from class v to class III and even toward class I. Tap root by *Heliconia Psittacorum* achieve a higher water quality index performance compared to the fibrous root by *Imperata Cylindrica*. Therefore, it can be conclude that tap root by *Heliconia Psittacorum* is the best plant roots structure for phytoremediation in wastewater treatment. Throughout this study, Tap root provides the best performance in treated water quality parameter in wastewater. But, the high possibility of the terrestrial plant to live in the water surface may affect the growth due to the lack of nutrient that they might needed from soil.

REFERENCES

Al-Omran, A., Al-Barakah, F., Altuquq, A., Aly, A., & Nadeem, M. (2015). Drinking water quality assessment and water quality index of Riyadh, Saudi Arabia. *Water Quality Research Journal,* 50(3), 287-296.

Gao, F., Hong, F., Liu, C., Zheng, L., Su, M., Wu, X. and Yang, P. (2006). Mechanism of nano-anatase TiO 2 on promoting photosynthetic carbon reaction of spinach. *Biological trace element research*, 111(1-3), 239-253.

Ghani, W. M. H. W. A., Kutty, A. A., Mahazar, M. A., Al-Shami, S. A., & Ab Hamid, S. (2018). Performance of biotic indices in comparison to chemical-based Water Quality Index (WQI) in evaluating the water quality of urban river. *Environmental monitoring and assessment*, 190(5), 297.

Malaviya, P., & Singh, A. (2012). Phytoremediation strategies for remediation of uranium-contaminated environments: a review. *Critical reviews in environmental science and technology*, 42(24), 2575-2647.

Mir, S. I., Salah, M. G., Arafat, M., Syukor, A., & Razak, A. (2017). Surface water quality assessment of the Gebeng industrial area using water quality standard and index. *Journal of Engineering and Science Research*, 1(2), 118-126.

Mokhtar, H., Morad, N., & Fizri, F. F. A. (2011). Phytoaccumulation of Copper from Aqueous SolutionsUsing *Eichhornia Crassipes* and *Centella Asiatica*. *International Journal of Environmental Science and Development,* 2(3), 205.

Morrice, J.A., Danz, N.P., Regal, R.R., Kelly, J.R., Niemi, G.J., Reavie, E.D., Hollenhorst, T.P., Axler, R.P., Trebitz, A.S., Cotter, A.M. and Peterson, G.S. 2008. Human influences on water quality in Great Lakes coastal wetlands. *Environmental Management* 41:347-357.

Nuraini, Y., & Felani, M. (2015). Phytoremediation of tapioca wastewater using water hyacinth plant (*Eichhornia crassipes*). *Journal of Degraded and Mining Lands Management*, 2(2), 295-302.