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Research paper

Effect of Temperature on Nutrient Removal Efficiency of Water Hyacinth for Phytoremediation Treatment

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Abstract

Wetlands have been introduced as natural based devices for treating the stormwater runoff. Temperature plays an important role in the nutrient removal process of wetland plants. Thus, the effect of temperature on nutrient removal efficiency of the water hyacinth plant was evaluated in this study. Water quality of both tanks that containing water hyacinth plants and control tank were monitored continuously for 2 weeks. The collected water samples were examined for total phosphorous (TP), turbidity, dissolved oxygen (DO), pH, conductivity (Cond.), total dissolve solid (TDS) and water temperature. The results showed that there are changes in the water quality concentration although there is no water hyacinth in the control tank. The release of phosphorus from the organic matter and particle in the control tank is suggested that occurred during the high temperature period. The optimum removal of nutrient occurred during the water temperature at 30℃. This clearly showed the effect of temperature on the flux of phosphorus in the water tank.

Keywords: *Removal efficiency; Floating wetland; Water hyacinth; Stormwater treatment; Nutrient uptake.*

1. Introduction

Urban stormwater pollution has becoming an emerging problem in the recent decades due to the rapid urban development and population growth [1,2]. Starting from 1970s, natural or artificial wetlands are introduced as water quality treatment to treating the domestic sewage. Presently, tens of thousands of natural and artificial wetlands have been constructed around the world and adapted according to varieties climatic zones. These wetlands are used to absorb and treat a wide range of pollutants such as nutrients such as phosphorous and nitrogen, heavy metals, petroleum-based chemicals, biocides, and various human pathogens using natural processes [3]. Floating wetlands are usually come in the form of either natural or artificial. Basically the typical artificial floating wetland is a soilless plant structure consists of floating mat, floating aquatic vegetation, sediment-rooted emerged wetland vegetation and relevant ecological micronisms such as algae, zooplankton, biofilms and micro invertebrates [4,5]. The artificial floating wetland's function and operation are mimic to the nature of natural floating wetland. Water hyacinth with the scientific name of Eichhornia crassipes is knowns as natural floating wetland that has the ability to remove nutrient from aquatic environments with rapid proliferation [6].
The study by Van De Moortel *et al.,* proved that the optimum removal of total phosphorus and total nitrogen occurred during the air temperature between 5℃ to 15℃ and the removal relapsed at the higher and lower temperature [7]. When the air temperature is more than 15ºC, the floating wetland prevent the water temperature from increase. However, temperature is not a main factor that effect the removal of total phosphorus since total phosphorus are influenced by microbial activity and physico-chemical process of sorption to the sediment [8]. According to Masters, 2012 [3] to stabilize organic material in the water body for water treatment, the traditional method rely on bacteria. Nutrient are removed from the water body through assimilation by bacteria or algae, sedimentation and adsorption to bottom sludge [9] [10].
To remove total nitrogen, the nitration activity of root-associated bacteria [11] are influenced by DO [12], BOD [13], pH [14] and temperature. In the study of Sarioglu *et al.,* [15] stated that at the higher temperature around 38ºC the nitrification process are temporary affected [11]. The nitrifying bacteria growth and reproduction at 3-45ºC, and the optimum growth at 25-35ºC temperature. M.-H. Hu also stated that, nitrifying bacteria are slow growing and a high oxygen are required. Temperature influence the roots growing, new plant root production are decrease at both low temperature (10ºC) and high temperature (35ºC), compare to medium range of temperature which is 22ºC. At the high temperature, the plant grow rapidly while at the low temperature the plant growth slowing down and growing normal rate at normal range of temperature. It is proved that, the growth of the floating wetland plant are affected by changes of temperature and at the same time affect the nutrient removal efficiency [11]. Based on the literature, the studies of water hyacinth as floating wetland treatment device only focusing on the nutrient removal rate. While some of wetland studies proved that environmental mechanism effects the removal efficiency. This study is carried out to determine the effect of temperature on the nutrient removal efficiency of water hyacinth plant.

2. Materials and Methods

This study was conducted at the civil engineering laboratory in Universiti Tenaga Nasional (UNITEN). A total of two water tanks which each with no plant inside (tank 1) that acted as control while another container consists of water hyacinth plants (tank 2) were set up at the laboratory. The water samples for both tanks were taken directly from the lake. The water hyacinth plants were plotted in the water tank on 13th September 2017. Initial water quality results were determined and subsequently water samples were collected from both tanks at two days interval for about 2 weeks. The collected water samples were examined for total phosphorous (TP) and turbidity. Dissolved oxygen (DO), pH, conductivity, total dissolve solid (TDS) and water temperature were measured in situ during sampling. Fig. 1 shows the experimental setup of water tanks and Fig. 2 is the flow chart of experimental design.

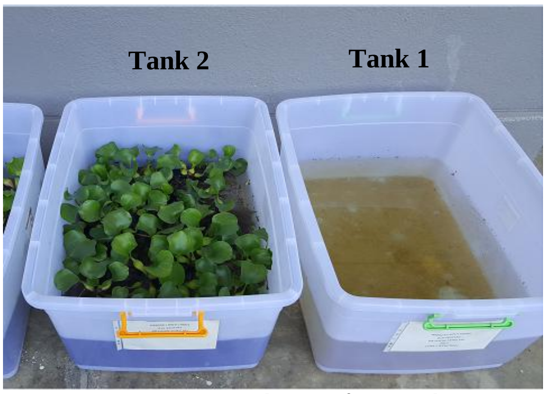

Fig. 1: Experimental set up of water tanks

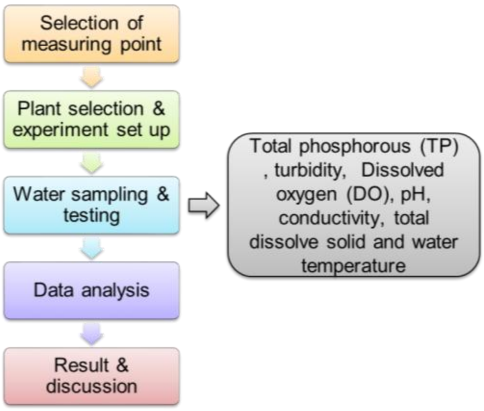

Fig. 2: Flowchart of the experimental design

3. Results and Discussion

The changes of water quality in each tank are plotted in time series graph in order to determine the nutrient removal rate of water hyacinth and the results are presented in Figs 3-7. The water temperature in both tanks reached the maximum level during the period of 14 Sep to 16 Sep 2017 which is 31.5 ºC and 30.1 ºC for tank 1 and tank 2, respectively. Meanwhile, the TP concentrations for tanks 1 and 2 also reached the maximum level of 0.54 mg/l and 0.45 mg/l, respectively. The control tank showed higher temperature is due to the direct sunlight on the water surface. Based on the results obtained, it is observed that there are some changes in the reading of water quality measurement from the control tank (tank 1) although there are no plant inside. It may suggest that other mechanism are involved in the nutrient removal process. Temperature seem playing a significant role on the nutrient cycling process [7,15,16]. The TP concentration in the control tank (tank 1) is higher than that in tank 2 with water hyacinth. The release of phosphorus from the organic matter and particle in the water tank is suggested that occurred during the high temperature period. This clearly showed the effect of temperature on the flux of phosphorus in the water tank.

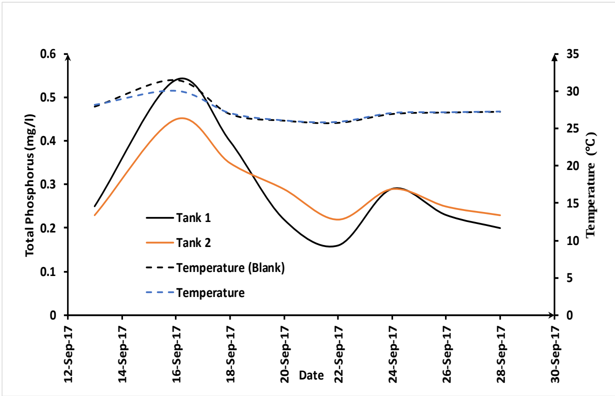

Fig. 3: Relationship between TP and water temperature

The time series of DO are plotted as shown in Fig 4. The readings of DO concentration for both tanks were decreasing drastically since 13th September 2017. This could be due to the high temperature during the first few days of experiment. The tank 2 with water hyacinth showed lower DO level compared to control tank. This aligns with the findings by Mbula, [17] that water hyacinth plant can cause reduction of DO in the water body.

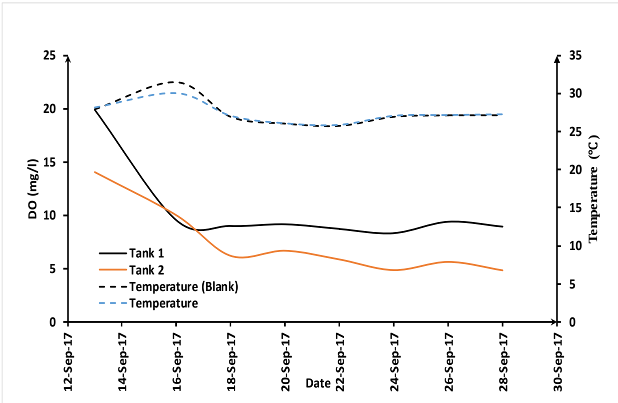

Fig. 4: Relationship between DO and water temperature

The pH measurement for control tank (tank 1) shows increasing trend as shown in Fig. 5. Xin et al., [18] reported that in aquatic system, the "carbonate system" which is typically be similar to carbonic acid, carbon dioxide, hydrogen ion and bicarbonate, carbonate are the most significant acid-base interactions. Carbon dioxide in the tank 1 decreased during the photosynthesis process where microalga uptake and this cause shift in carbonate system in an alkaline direction. This causing the increase of pH value. In contrast, the pH of tank 2 was observed that fluctuating around the value of 7.0 and becoming more constant after 14 days. It suggested that floating wetland can act as a buffer to the pH conditions in the water body. They influence the water body's acidity-base and allows the conditions to remain steady around neutral conditions [18]. It also suggested that the pH condition is not relies on the water temperature.

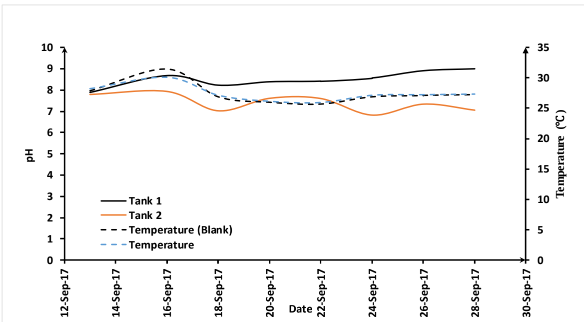

Fig. 5: Relationship between pH and water temperature

Relationships between conductivity and water temperature along time duration are plotted as shown in Fig.6. The increasing trend of conductivity in tank 1 is paired with the changes of water temperature. For tank 2, the conductivity tends to decrease toward the end of experiment period and not affected by the water temperature. Water hyacinth plant has reduces the conductivity level in the water tank.

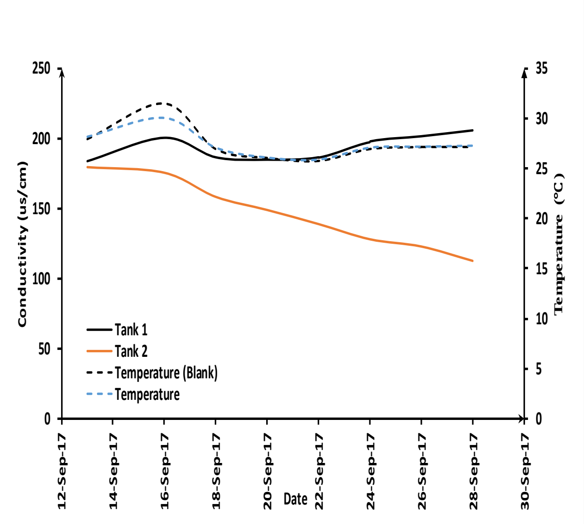

Fig. 6: Relationship between conductivity and water temperature

The reading of TDS for tank 1 is increasing while the tank 2 showed decreasing trend of TDS (Fig. 7). The reading of TDS showed similar trend with conductivity in tank 2 with water hyacinth. It is proved that water hyacinth can remove a wide range of pollutants including dissolved solid [6].

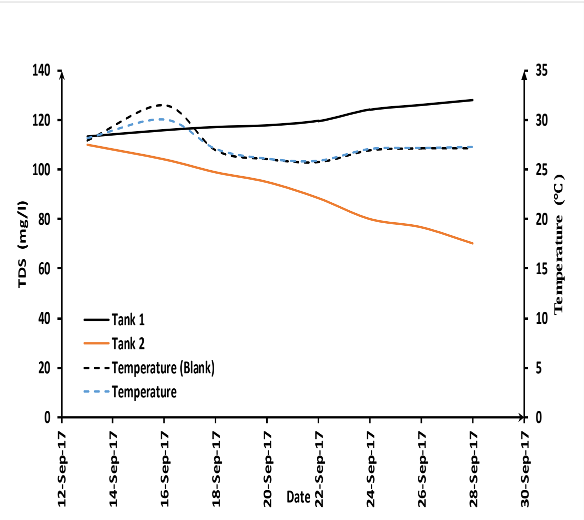

Fig. 5: Relationship between TDS and water temperature

Table 1: Removal efficiency of water hyacinth

Parameter	Removal percentage (%)
Total phosphorus	34
Dissolve oxygen	37
pH	37
Conductivity	20
Total dissolved solid	16

Table 1 shows the summary results of tank 2 with water hyacinth which can achieve average removal percentages of 34%, 37%, 37%, 20% and 16% for TP, DO, pH, conductivity and TDS, respectively. It is clearly showed that temperature has an effect on the removal efficiency of water hyacinth especially for TP. The plant itself may also possible to supply the nutrient into the water once the plant achieved maximum growth level and die off subsequently [19].

4. Conclusions

This study was carried out to determine the nutrient removal efficiency of water hyacinth. It is found that water temperature is an important factor that will influence the nutrient uptake by the floating treatment plant. The release of phosphorus from the organic matter and particle in the water tank is suggested that occurred during the high temperature period. Overall, the tank with the water hyacinth shows higher nutrient removal efficiency if compared to tank without water hyacinth.

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