Journal of ENVIRONMENTAL Treatment Techniques

Enviro. Treat. Tech.
ISSN: 2309-1185
Journal web link: http://www.jett.dormaj.com

Nutrient uptake and wastewater purification with Water Hyacinth and its effect on plant growth in batch system

Shahabaldin Rezania , Mohd Fadhil Md Din , Mohanadoss Ponraj* , Fadzlin Md Sairan, Siti Fatimah binti Kamaruddin

Institute of Environmental and Water Resources Management, Department of Environmental Engineering, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia

Received: 18/08/2013 Accepted: 12/09/2013 Published: 25/10/2013

Abstract

Nowadays, the ability of waste water purification by using Water Hyacinth has been investigated in different studies. A pilot plant fabrication was constructed near domestic water treatment plant, where water hyacinth (*Eichhornia crassipes*) was used for waste water purification. The objective of this study was to test the role of water hyacinth in purifying wastewater and also to determine its effects on nutrient uptake and biomass growth based on pollutant removal rate in a defined time. The result shows that the constructed fabrication could remove 80% of chemical oxygen demand (COD), 75% of total nitrogen (TN) and 75% of total phosphorus (TP) during the first week of experiment. Also the ratio of water loss in tanks and its effect on biomass growth was evaluated, and was found to be 20 % or 15 L of water reduction weekly and 40% of increase in plant biomass at the end of the experiment when compared to the initial growth. Thus it can be concluded that water hyacinth system was effective in purifying waste water during its optimum growth period.

Key words: Biomass growth, Nutrient uptake, Waste water purification, Water hyacinth

1- Introduction

Water hyacinth is known to produce beautiful, large purple and violet flowers of the South American (Eichhornia crassipes) which makes it a very popular decorative plant for ponds. However water hyacinth has also been identified as the world’s worst water weed and has gathered international attention as invasive species [1]. It is efficient in utilizing aquatic nutrient and solar energy for potential biomass production, but at the same time it can also cause extensive environmental, social and economic problems. It is found in lakes, estuaries, wetlands, marshes, ponds, slow flowing rivers, streams and waterways in the lower latitudes where growth is stimulated by the inflow of nutrient rich water from urban and agricultural runoffs, deforestation, products of industrial waste and insufficient wastewater treatment [2,3].

About two decades ago in Nigeria, Water hyacinth has become a source of concern to ecologists and fisher-folks since it entered the aquatic ecosystem. It can grow extremely faster and produce almost 2 tons of biomass per acre and its population doubles every 5–15 days [4]. Several intentions including mechanical, chemical and biological remedies were made to eradicate or at least control its growth to a manageable level. However, because of the plant’s prolific rate of reproduction, all these efforts were not very successful [5, 6].

There are many studies reporting for laboratory and pilot levels for using water hyacinth in removing organic matter from wastewater [7]. This plant can be used as a resource for agricultural crop production and waste management although it is an invasive plant in most countries all over the world [8]. Also some aquatic weeds like *Salvinia*, *Azolla*, *Eichhornia* (water hyacinth) have the potential to uptake and absorb heavy metal by their root, stem or leave from soil [9]. According to chemical analysis, water hyacinth is rich in nutrition, with organic matter accounting for 80.1% of dry biomass, and in particular, the crude protein content is 12.4% which includes many amino acids such as lysine and methionine and also different kinds of vitamin [10].

Higher productivity rate of water hyacinth is one of the important reasons why it has been universally used in southern France for the treatment of industrial waste water [11]. As mentioned previously, water hyacinth is very proficient in pollutant removal from wastewaters. Efficiency of nitrogen removal ranges from 10 to 90 % [12]. This phyto remediation technology is suitable in treating industrial wastewater and also can be used to treat

Corresponding Author: Mohanadoss Ponraj, Water Research Alliance, Department of Environmental Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia. Email: goldking1977@gmail.com

contaminated soils, groundwater and wastewater in both low cost application and technology [13]. Moreover, Water hyacinth consists of high biomass, fibrous tissue, high energy and protein content that can be used for a variety of useful applications like bio-fuel production, biomass and energy, waste water treatment, compost and fertilizer, animal feed and for making furniture.

2. Materials and methods

2.1 Experimental site and design

The pilot plant-ponding system was established at the Desa Bakti, University Technology Malaysia (UTM) located near the domestic waste water treatment plant in order to test the role of water hyacinth in treating domestic waste water. The system comprised of five tanks (each of it with 80 L capacity) which were operated in a stable condition (without waste water flow). The analysis includes determination of COD, phosphorous, nitrate and biomass growth rate which were carried out for a period of 14-days by sampling every 3-days (Fig.1).

Fig 1. Pilot plan fabrication for the growth of water hyacinth

3. Results and discussion

The results of the parameters in determining the removal efficiencies achieved for total nitrogen (TN), chemical oxygen demand (COD) and total phosphorus (TP) as a function of initial concentrations in the pilot plant ponding system are represented in Figure 2, 4 and 5.

3.1 Removal of COD

As shown in Fig 2, there was decline of COD during the first 7 days of the experiment due to the presence of comparatively higher temperature, which proved to the rapid and abundant growth of water hyacinth. After that, COD value increased sharply. In this research COD was found to be reduced from 50 to 7 mg/L with a removal efficiency rate of 80% (Fig 2).

There may be several reasons for the decreasing of COD value in wastewater. The first reason is due to the removal of nutrients and organic matters by water hyacinth and secondly it can transport oxygen, thereby increasing the removal of organic matter by micro-organisms present in the sediments or on the surface of plant root stocks [14].

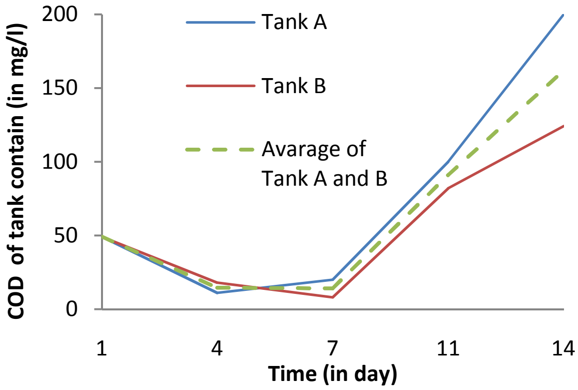

Fig. 2 COD removal during different time interval

Third reason can be related to the presence of suspended microorganisms present inside the tank, which can remove the nutrients and organic matters. The COD decreased significantly during the growth period of water hyacinth because the crop root mats were fully developed and the filtration capacity of the roots of suspended solids increased along with the absorption of dissolved nutrients [15].

Although, based on Fig. 2 at initial days (1 to 7) COD decreased from 39 to 14 mg/L and showed 64% performance of water purification by this plant, it was also found, that after 7 days the COD value increased from 14 to 160 mg/L which is 3.6 times more than the initial concentration of experimental tanks. There may be several reasons for this unusual type of results obtained. For instance, a layer of sedimentation was found at the bottom of the tank. The possible explanation for this is that plants transport oxygen, thereby increasing the removal rate of organic matter by micro-organisms in sediments or on the surface of plant rootstocks [14]. However, if plants die, their decomposition consumes oxygen, which counteracts the reduction of COD, so water hyacinth should be harvested regularly in order to avoid such complications. After day 7, the COD was found to be increased due to the biological activity of microorganism and also because of the death of some of them present in the root zone of tanks. It means by the increase in number of microbial population they can also increase the COD and thus can produce hazardous compounds.

3.2 Removal of phosphorous and nitrate

It is seen from Table 1 the removal rates for TP and TN is equal to 65%, which is far lower when compared to that of COD. Although there was a sharp decline but still the level of TP and TN were high and was related to the treatment efficiency of waste water. More over with the decline of temperature, water hyacinth as well as other biological activities, especially microbes, would have slowed down their activities thus resulting in less removal of TP and TN [16]. The measurement of phosphate and nitrate was carried out using spectrophotometer, model- DR 5000. The color for the detection of nitrate is pink and for phosphate it is blue in color (Figure3).

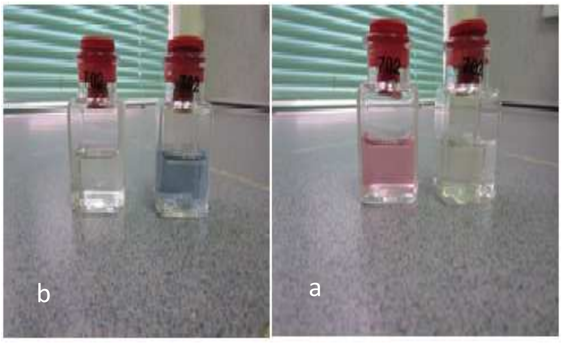

Figure 3: Determination of phosphate and nitrate A) blue color denote for phosphate B) Pink color denote for nitrate

The reports of other researchers showed that water hyacinth is very efficient in removing pollutants from wastewater, in terms of COD, BOD (biological oxygen demand), SS (suspended solids) and bacteria, but are not reliable in removing N and P [17, 18]. Mean while [19, 20], in their research on the treatment effects of *Vetiveria zizanioldes* and *Cyperus alternifotius* in pig manure, reported that the removal rates of TN and TP with water hyacinth was related to season, during which higher removal rate was observed during spring when compared to autumn.

Table 1 show that the removal rate of organic matter and the reduction rate of COD, phosphate and nitrate with water hyacinth were found to be 75, 65 and 65% respectively. All the obtained results shows that the performance was satisfactory in treating waste water with water hyacinth.

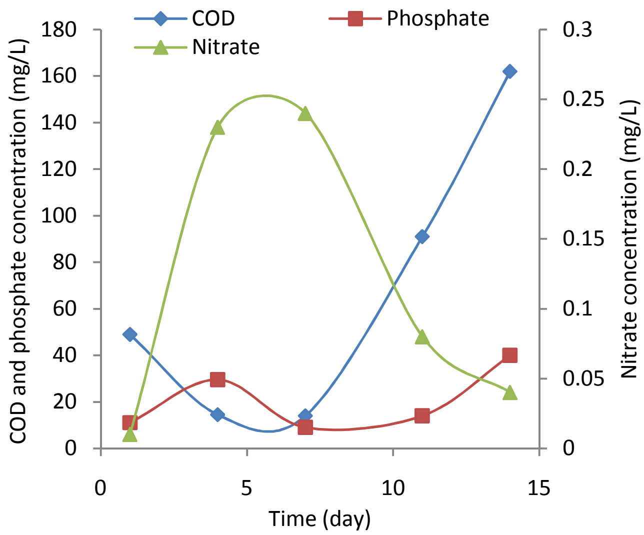

Fig 4. The reduction rate of COD, phosphate and nitrate based on different time intervals

Table 1. The removal efficiency of organic matter with water hyacinth

Removal efficiency (%)	COD removal (%)	PO_4 removal (%)	NO_3 removal (%)
Tank A	80	45	70
Tank B	70	85	60
Average	75	65	65

4. Biomass growth measurement

As shown in Fig 6, the growth of water hyacinth was monitored efficiently. The initial weight of biomass in both tanks (A, B) were 1100 g/L, meanwhile after 2 weeks the average increase in the weight of water hyacinth was found to be 300 to 400 g/L. The results showed that after day 1 to 14, about 40% increase in the plant biomass was obtained when compared to the initial (Fig 5). From Fig 6, it can be seen that the increase of biomass in both the tanks were almost similar.

Fig 6. The weight of biomass during different sampling period

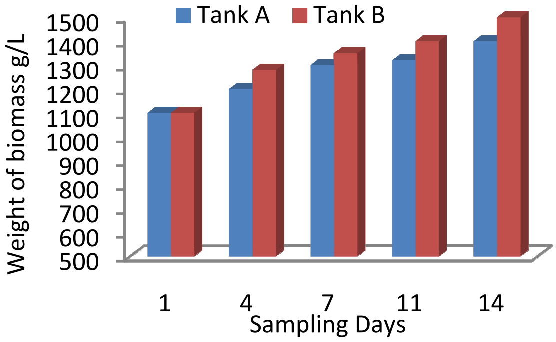

Fig 5. The growth of water hyacinth in fabricated tanks Tank A) after 1 day and Tank b) after 14 day

4.1 The relation between growth and water level reduction with water hyacinth

As discussed before, the weight of biomass increased gradually based on nutrient uptake from the waste water and Fig 7 shows the appearance of water level during the sampling periods of day 1, 7 and 14. Based on the results of water level reduction it was found to be about around 20 % or 15 L weekly. The observation revealed that the reduction of water level is linear and as expected during the experimental period of time.

a b c

Fig 7: The detection of water level during the experimental period a) day 1 b) day 7 and c) day 14

5. Conclusion

It can be concluded that water hyacinth was effective in treating wastewater located near a small stabilization pond during which the water hyacinth could grow efficiently and the harvested water hyacinth served to be an excellent lignocelluloytic containing biomass. This study observed the treatment efficiency of water hyacinth during a period of 14-days. The results showed that 80% COD removal and 40% increase of biomass during 2 weeks in a closed system and also at the same time, after 1 week increase in phosphate and decrease of nitrate content in water composition was observed.

References

1- Zhang, Y., Zhang, D., Barrett, S. 2010. Genetic uniformity characterises the invasive spread of water hyacinth (Eichhornia crassipes), a clonal aquatic plant. *Molecular Ecology* 19: 1774-1786.

2- Villamagna, A., and Murphy, B. 2010. Ecological and socio-economic impacts of invasive water hyacinth (Eichhornia crassipes): a review. *Freshwater Biology*, 55,282–298 doi:10.1111/j.1365-2427.2009.02294.x.

3- Ndimele, P., and Jimoh, A. 2011. Water Hyacinth (Eichhornia crassipes [Mart.] Solms.) in Phytoremediation of heavy Metal Polluted Water of Ologe lagoon, Lagos, Nigeria. *Research journal of Environmental Sciences*, 5(5), 424-433. DOI: 10.3923/rjes.2011.424.433.

4- Craft, C.P., Megonigal, S., Broome, J., Stevenson, R., Freese, J., Cornell, L., Zheng, S., Sacco, J., 2003. The pace of ecosystem development of constructed Spartina, alterniflora marshes. *Ecol. Appl*, 13, 1417–1432.

5- Chukwuka, K.S. and Uka, U.N. 2007. Effect of water hyacinth (Eichornia crassippes) infestation on zooplankton populations in Awba reservoir, Ibadan South-West Nigeria. *J. Boil. Sci*, 7: 865-869.

6- Ndimele, P.E. 2010. A review on the phytoremediation of petroleum hydrocarbon. Pak. J. Biol. Sci, 13: 715-722.

7- Casabianca, M.L., Laugier, T., Posada, F. 1995. Petroliferous wastewaters treatment with water hyacinths (Ra_nerie de Provence, France): Experimental statement. *Waste Management*, 15(8): 651–655.

8- Gunnarsson, C.C., Petersen, C.M. 2007. Water hyacinths as a resource in agriculture and energy production: A literature review. *Waste Management*, 27 (1): 117–129.

9- Dar, S.H., Kumawat, D.M., Singh, N., Wani, K.A. 2011. Sewage treatment potential of water hyacinth *(Eichhornia crassipes). Research journal of Environmental Sciences*, 5(4), 377-385. DOI: 10.3923/rjes.2011.377.385.

10- Lindsey, K., Hirt, H.M. 1999. Use Water Hyacinth! In: A Practical Handbook of Uses for the Water Hyacinth from Across theWorld (1st ed). Anamed: Winnenden, Germany.

11- Oso, B.A. 1988. Invasion of Nigeria waterways by water hyacinth: Ecological and Biological Observation. The Proceedings of the International Workshop/Seminar on water hyacinth, Lagos, 116-123.

12- Williams, S.R. 2009. Apparatus and Method for

Agricultural Animal Wastewater Treatment. United States Patent Application Number, 250-393.

13- Jebanesan, A. 1997. Bilological treatment of dairy waste by Eichhornia crassipes Solms. *Environ. Ecol,* 15(3):521-523.

14- Reddy K R, D'Angelo E M, 1997. Biogeochemical indicators to evaluate pollutant removal e_ciency in constructed wetlands. *Water Science and Technology*, 35(5): 1–10.

15- Ghaly, A.E., Kamal, M., Mahmoud, N.S. 2005. Phytoremediation of aquaculture wastewater for water recycling and production of fish feed. *Environ Int*, 31: 1–13.

16- Jianbo, L.U., Zhihui, F.U., Zhaozheng, Y.I.N. 2008. Performance of a water hyacinth (Eichhorniacrassipes) system in the treatment of wastewater from a duck farm and the effects of using water hyacinth as duck feed, Journal of Environmental Sciences ,20:513–519.

17- Mitsch, W.J., Home, A.J., Naim, R.W. 2000. Nitrogen and phosphorous retention in wetlands: ecological approaches to solving excess nutrient problems. *Ecological Engineering*, 14(1-2): 1–7.

18- Guo, B.H., Tang, H.C., Song, Z.W., Xi, J.X. 2003. Theory of wastewater treatment by constructed wetlands and removal of nitrogen and phosphorus. *Pollution Control Technology*, 16(4): 119–121.

19- Liao X.D., Lou, S.M. 2002a. Effects of constructed wetlands on treating with nitrogen and phosphorus in wastewater from a hoggery. *Chinese Journal of Applied Ecology,* 13(6): 719– 722.

20- Liao X D, Lou S M, 2002b. Treatment effect of constructed wetlands on organic matter in wastewater from a pig farm. Chinese Journal of Applied Ecology, 13(1): 113–117.