DOMESTIC WASTEWATER TREATMENT BY USING JASMINE-WETLAND PILOT MODEL

Thai Anh Nguyen[1], **Viet Hung Dang**[2], **Phi Yen Cao**[1], **Thi Kim Quyen Le**[1]
[1] *Ho Chi Minh City University of Technology and Education, Vietnam*
[2] *Ho Chi Minh City University of Technology, VNU-HCM, Vietnam*

Received 07/01/2020, Peer reviewed 17/01/2020, Accepted for publication 10/02/2020

ABSTRACT

The experimental model is Horizontal Subsurface Flow Constructed Wetlands that is designed as a frustum shape with the bottom is 1350mm long and 315mm wide, the top has a length of 1800mm and a width of 765mm. On the surface, there is jasmine growing with the density of 16 plants /m^2 and the slope of the model is 1%. Corresponding to the monitored flow rate of wastewater, which are 85 L/day and 115 L/day respectively, the organic loading rate is 150 kgBOD_5/ha.day and 200 kgBOD_5/ha.day. The results of the study showed that the BOD_5 loading rate of 150 kgBOD_5/ha.day and the flow rate of 85 L/day, the average processing performance value of TSS, COD, TKN, P_PO_4^{3-}, N_NH_4^+ is 92.67%, 82.40%, 75.3%, 60.04%, 80.12%, respectively. With the BOD_5 loading rate of 200 kgBOD_5/ha.day and the flow rate of 115 L/day, the average processing performance value of the TSS, COD, TKN, P_PO_4^{3-}, N_NH_4^+ is 90.96%, 68.16%, 60.75%, 50.26%, 65.23%, respectively. Also, this model is equipped with a discontinuous aeration system at the flow rate of 85 L/day to increase the treatment efficiency of COD, TKN, N_NH_4^+ to 86.05%, 79.64%, 84.29%, respectively.

Keywords: *wetlands; jasmine; domestic wastewater, the loading rate; the flow rate.*

1. INTRODUCTION

Along with the socio-economic development, environmental issues need to be seriously protected. The industrial development occurring in many places in general and in rural areas in particular has resulted in an increase in population density as well as a significant increase in domestic wastewater. However, the centralized wastewater treatment plants have not yet been formed enough to thoroughly treat this wastewater [1]. The demand of treating domestic wastewater with low price and eco-friendly is receiving great attention. The Wetland model has been known as an appropriate model for this need and has contributed to improving the quality of water resources in rural areas. This model is an ecological system used to treat wastewater in a flexible condition that adapts to the nature of the natural soil and selects plants in accordance with the desires. Other advantages of this model are simple construction, adaptation to natural conditions, ease of operation management, low chemical consumption and especially suitable for large areas [2]. And, the treatment of wastewater by this model applied to horizontal runoff is considered to have more advantages than surface runoff [3]. These advantages include high processing efficiency, minimizing unpleasant odors and less used land area. In addition, the plants grown in this model act as a natural water cleaning agent. This ecosystem changes the chemical properties of the water as well as changing the nutrients in the soil, the oxygen from the air is transported to the soil layers to provide for the living microorganisms in the roots of the above plants. Moreover, the criteria for selecting plants in the Wetland model include local dominant species, deep-rooted roots, healthy rhizomes and clustered rhizomes; Tree density and biomass must be large to achieve maximum metabolism of water and assimilation of nutrients; effectively transport oxygen to the root zone to facilitate the process of transporting oxygen to treat nitrogen, oxidize toxic heavy metals, increase the efficiency of removing suspended solids, limit the odor of wastewater, Create a sense of comfort and beauty. Jasmine is recognized as easy to grow, easy to live, has an average life expectancy of 1 year, a fast-growing time and few pests does not require much care, and is a popular plant in southern Vietnam. Therefore, Jasmine was selected for this study because it satisfies the above criteria. Hence, the study of domestic wastewater treatment using the Wetlands pilot model and combining use with jasmine-tree has been carried out in this essay. The objective of this study is to evaluate the efficiency of domestic wastewater treatment in residential areas of the pilot model based on comparison with level B of the *National Technical Regulation On Domestic Wastewater* (NTRDW) 14: 2008.

2. MATERIALS AND METHOD

- **The model set up**

This pilot model is designed based on maximum organic loading rate (L_{org} = 200 $kgBOD_5/ha.day$) and flowrate of wastewater (Q = 85 - 115 L/day) [4]. The model is arranged in the same order as Figure 1, and includes untreated wastewater container (100L), wetland model (500L) and treated wastewater container (45L).

The layers of materials inside the wetland model are arranged from the bottom up, including gravel layer (particle size 20 - 30 mm, depth 60 mm), fine stone layer (particle size 5 - 20 mm, depth 50 mm), sand layer (grain size 0.5 - 1 mm, depth 40 mm), agricultural soil layer (depth 400 mm).

The plants used were jasmine, an average height of 30-35 cm, and planted at a density of 16 plants / m^2.

- **Experiments**

Wetland model is applied to domestic wastewater treatment (the wastewater characteristics showed in Table 1) under different operating conditions:

- Start up with the flow rate 85 L/day, without the presence of jasmine tree.
- On the adaptive stage with the flowrate 85 - 115 L/day, with the presence of jasmine tree.
- On the adaptive stage with the flowrate 85 - 115 L/day, with the presence of jasmine tree and aeration steps.

***Table** 1. Wastewater characteristics*

Constituent	units	Concentration
pH	-	6.8 – 8.3
TSS	mg/L	90 ± 124
BOD_5	mg/L	90 ± 150
COD	mg/L	130 ± 200
$N\_NH_4^+$	mg/L	25 ± 40
$P\_PO_4^{3-}$	mg/L	9 ± 13
$N\_NO_3^-$	mg/l	-

3. RESULTS AND DISCUSSION

- **The change of pH value**

Not much difference in pH before and after treatment (6.0 - 8.0) is a sign of the stable treatment system (Fig. 2). On the other hand, the pH value of wastewater after treatment tends to decrease compared to the value of input wastewater. This result is consistent with the biological processes taking place in the Wetland system. These processes include anaerobic, aerobic, nitrification and denitrification, which require significant consumption of alkalinity.

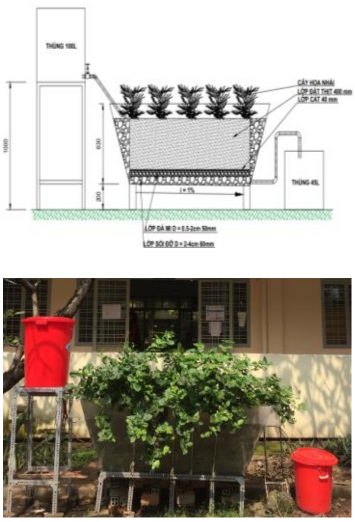
a)
b)


***Fig.1**. The pilot model (a) layout (b) in experiment*

- **The removal of COD**

COD removal of Wetland model with the presence and absence of jasmine tree is clearly shown in Fig. 3. When the wetland model *attached to plants* (atp), COD treatment efficiency is greatly increased (82.40%, flowrate 85 L/day). In addition, when the model was operated at flowrate 115 L/day, COD removal decreased from 82.40% to 68.16%. In this case, the hydraulic loading rate has been increased when the effluent flow is increased with the same amount of input pollution. The flowrate of 85 L/day corresponds to the hydraulic loading rate of 0.075 m^3/m^2/day. Observations showed that increasing the hydraulic loading rate will reduce the exposure time of microorganisms to the pollutant. The report of Ngo Thuy Diem Trang (2012) also shows that COD treatment efficiency reaches 71% at hydraulic loading rate of 0.031 m^3/m^2/day and 47% at hydraulic loading rate of 0.062 m^3/m^2/day [5]. Moreover, the study of Dang Viet Hung (2015) achieved COD removal of 91% corresponding to hydraulic loading rate of 0.067 m^3/m^2/day [6]. Therefore, the results of this research is suitable and adaptable to operating conditions in Vietnam.

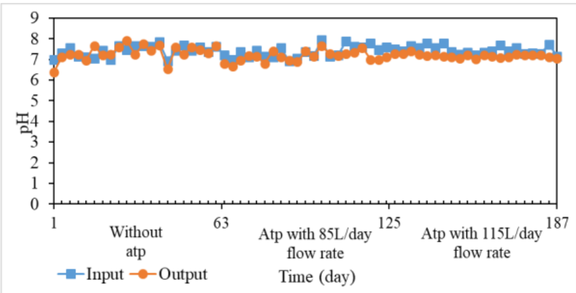


Fig.2. *pH values obtained after treatment*

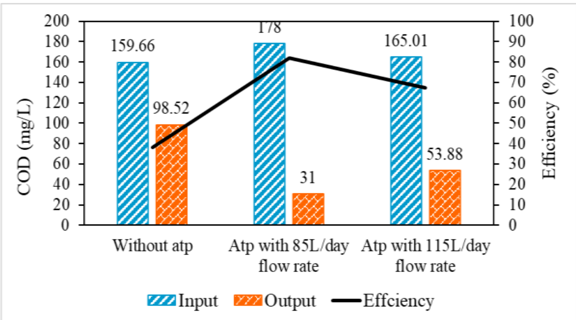
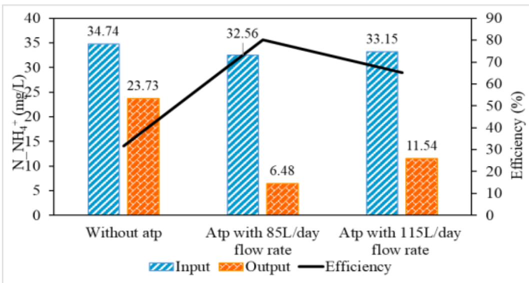


Fig.3. *COD removal of wetland model with and without presence of plants*

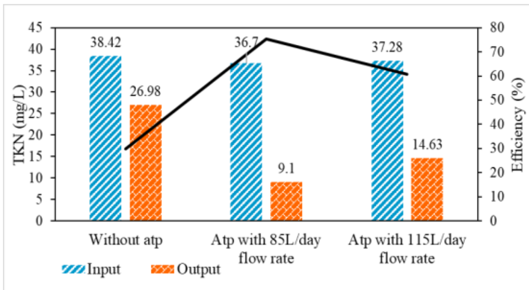
- **The removal of nutrients**

The results from Fig. 4 illustrate the nitrogen removal efficiency of the jasmine-wetland model. The initial concentrations of $N\_NH_4^+$, TKN were 32.56 - 34.8 mg/L, 36.7 - 38.42 mg/L. $N\_NH_4^+$ removal (80.12%) obtained at the flowrate of 85 L/day is higher than that of the flow rate of 115 L/day. At the flow rate of 85 L/day, with the presence of plants, the average concentration of treated $N\_NH_4^+$ was 6.48 mg/L reaching level B of NTRDW 14:2008. Without the presence of plants, the concentration of treated $N\_NH_4^+$ was still high and the average $N\_NH_4^+$ removal was only 31.67%. On the other hand, the $P\_PO_4^{3-}$ removal is not high. The initial concentrations of $P\_PO_4^{3-}$ were 12.45 - 12.91 mg/L. The average concentration of treated $P\_PO_4^{3-}$ corresponding to each experimental condition is 8.54 mg/L (31.94%), 5.14 mg/L (60.04%) and 6.19 mg/L (50.26%).

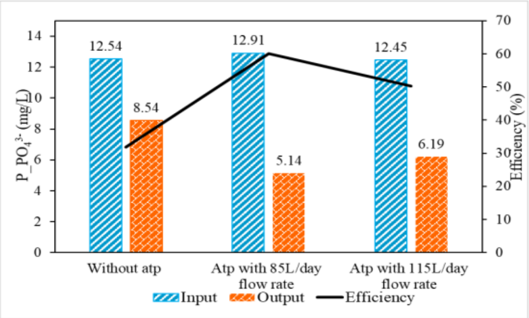
Under supplementary aeration operating condition, the removal efficiency of COD, $N\_NH_4^+$, TKN is higher than that of without aeration support and reaches 4.05%, 4.17%, 4.34%. This aeration contributes not only to increase the dissolved oxygen (DO) but also to increase nitrification and denitrification efficiency. The implications and effectiveness of this support step were also reported in articles of Jian Zhang [7-8].



(a)



(b)



(c)

Fig.4. *(a) $N\_NH_4^+$, (b) TKN, (c) $P\_PO_4^{3-}$ removal of wetland model with and without presence of plants*

4. CONCLUSION

The wetland model using jasmine plants has a performance that varies with hydraulic loading rate, organic loading rate and dissolved oxygen concentration. This pilot model shows that the ability to remove COD, $N\_NH_4^+$, $P\_PO_4^{3-}$ has high efficiency at the flow rate of 85 L/day. This model can be widely applied in domestic wastewater treatment model in rural areas.

REFERENCES

[1] Nghiên cứu quản lý môi trường nước các lưu vực sông Việt Nam, http://open_jicareport.jica.go.jp/

[2] Lê Anh Tuấn, Lê Hoàng Việt, Guido Wyseure, Đất ngập nước kiến tạo, Nhà Xuất Bản Nông Nghiệp, 2009.

[3] Vymazal, J., Horizontal sub-surface flow and hybrid constructed wetlands systems for wastewater treatment, Ecological engineering, 25(5) (2005) 478-490

[4] Crites, Ronald W. Design Manual: Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment. US Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, 1988.

[5] Ngô Thụy Diễm Trang và Hans Brix (2012), "Hiệu suất xử lý nước thải sinh hoạt của hệ thống đất ngập nước kiến tạo nền cát vận hành với mức tải nạp thủy lực cao", Tạp chí khoa học ĐH Cần Thơ, Tạp chí Khoa học 2012.

[6] Đặng Viết Hùng (2015) – Triển khai hệ thống kết hợp bể kỵ khí và đất ngập nước kiến tạo xử lý nước thải sinh hoạt cho hộ/cụm dân cư.

[7] Jian Zhang, Jinlin Fan, Wengang Wang, Bo Zhang, Yeye Guo, Huu Hao Ngo, Wenshan Guo, Haiming Wu, Nitrogen removal in intermittently aerated vertical flow constructed wetlands: Impact of influent COD/N ratios, Bioresourse Technology 143 (2013) 461 – 466.

[8] Jian Zhang, Jinlin Fan, Bo Zhang, Huu Hao Ngo, Wenshan Guo, Feifei Liu, Yeye Guo, Haiming Wu, *Intermittent aeration strategy to enhance organics and nitrogen removal in subsurface flow constructed wetlands*, Bioresourse Technology 141 (2013) 117 – 122.

Corresponding author:
PhD. Thai Anh Nguyen
Ho Chi Minh City University of Technology and Education
E-mail: anhnt@hcmute.edu.vn