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APPLICATION OF DEVELOPED WETLAND ROOF ON TREATING DOMESTIC WASTEWATER COUPLING WITH ENHANCING GREEN AREA

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ABSTRACT

The aim of this study was to investigate the performance of intermittent feeding condition on pollutants removal of shallow bed subsurface flow wetland roof (WR). The effect of new bed materials (charcoal) and two plants (*Kyllinga Nemoralis* and *Wedelia Trilobata*) on removal efficiency of WR with canteen wastewater were surveyed. The results indicated that wastewater treatment of two plants were relatively high and insignificantly different. Moreover, the intermittent feeding strategy improved the removal rate of pollutants from canteen wastewater. The WR with the bed structure equipped mainly coal showed high potential application because of their not only higher removal efficiency compared to previous studies but also lighter in weight. In addition, the wetland roof technology could be integrated in city planning to reduce the inverse effect from discharge of untreated wastewater and lack of green space.

Keywords: wetland roof; char coal; bed media; sand; feeding pattern; wastewater treatment.

1. INTRODUCTION

Most of domestic wastewater in residential areas is not properly treated. Domestic wastewater is only unsatisfactorily pre-treated by septic tanks and discharged into the sewer systems or into canals *(Qadir et al. 2010; Cao et al. 2016)* or untreated. In addition, many countries around the world are facing increasing traffic density, industrial areas grow up leading to more and more emissions, especially greenhouse gases (CO_2) contributes to global warming, causes the climate change *(Spracklen 2016).* At the same time, the densities of green area decreased considerably because of population explosion along with rapid urbanization and industrialization, e.g. average urban green coverage of Vietnam is as low as 2.2 m^2/cap (< 7 m^2/cap - Vietnamese standard for green area per capital) *(Richards et al. 2017).* Another issue concerned in urban areas is energy security. According to IEA report in 2018, the total world energy consumption increased by 2.3% and 4% compared to the average rate of ten-year period 2005 - 2015, due to the demand for heating and cooling in some urban areas *(IEA, 2019).* The above-mentioned challenges have adversely affected human activities and health as well as the ecosystem.

In recent years, Wetland roof (WR) has recently been invented as a technology was combined between green roof (GR) and constructed wetland (CW) will be promising and appropriate technology to deal with these problems. In this study, it is aimed to investigate the effects of different bed materials and feeding patterns of wastewater on the treatment performance of wetland roof systems using two different plants.

2. MATERIAL AND METHODS

In this study, WRs with selected plants, namely *Kyllinga Nemoralis* (KN) and *Wedelia Trilobata* (WT) were investigated for evaluating wastewater treatment performance, biomass growth and the investigation of removal rate constants of experimental WRs system. WRs were operated at intermittent (inter) feeding patterns.

Wastewater will be collected from a wastewater discharging source of canteen, in Ho Chi Minh City University of Technology.

2.1 Bed media (Sand vs Charcoal) and wastewater feeding pattern

Following the reducing gravitational loading of the WR, this comparative study will investigate the bed media performance between charcoal (C) (0.3 ton/m^3) and sand (S) (1.4 ton/m^3) in previous studies. In addition, the wastewater feeding patern is intermittent (or semi-continuous) feeding will be investigated.

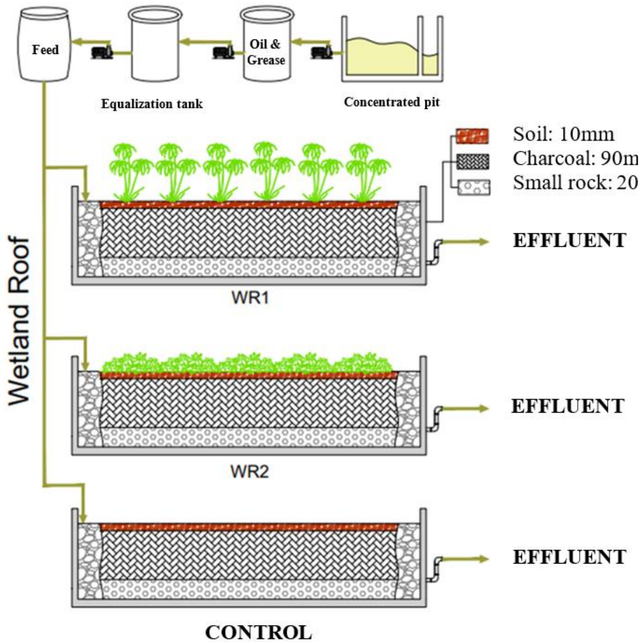

Figure 1. A simulation Wetland Roof experimental system Feed wastewater: Septic Tank Effluent.

2.2. Pilot-scale wetland roofs

In each WR, there is three consecutive channels to prevent short circuit of the wastewater flow. Each channel is designed with the dimensions of 1.8 m in length, 0.6 m in width and 0.15 m in depth. From the top, the structure consisted of a layer of soil (10 mm), a layer of sand/coal (90 mm) and a layer of small rocks (20 mm). In two ends of model, there was a 100 mm gravel layer to prevent fouling at inlet and outlet. The height of water level was 100 mm from the bottom. The system has slope of 1%.

Table 1. Characteristic of experimental wastewater

Parameters	Value	Unit
pH	7,1±2	
COD	440±90	mg/l
$N\text{-}NO_3^-$	0,22±0.18	mg/l
$N\text{-}NO_2^-$	0,07±0,06	mg/l
$N\text{-}NH_4^+$	12,4±6,4	mg/l
TKN	33,7±8,3	mg/l
TN	33,9±8,3	mg/l
TP	1,4±0,4	mg/l

2.3. Experimental plants

In this study, WRs with two selected plants were used for evaluating wastewater treatment performance, biomass growth and the correlation between these parameters.

2.4. Operating conditions of WRs

WRs will be operated at the average hydraulic loading rates of 350 ± 17 m^3/ha.day, corresponding to average organic loading rates of 144.4 ± 4 kg COD/ha.day.

2.5. Analytical methods

Wastewater analysis

Using analytical methods for wastewater quality *(APHA, 1998).*

Biomass production

The plants determined fresh weight. Amongst the chosen plants, we sampled randomly to analyze dry weight. After each experiment, the plant which includes stem and leaves, was determined fresh weight. For dry weight, we also sampled randomly to analyze. Dry weight is determined by the weight of the dried plants at 80^{o}C until weight becomes constant.

3. RESULTS AND CONCLUSIONS

Three pilot-scale WRs were used to conduct the experiments including WR1 (*Kyllinga Nemoralis)*, WR2 (*Wedelia Trilobata)*, and WR3 (Control system without plants). During the experiment time (60 days), the wet biomass growth rate of KN was 1.32 ± 0.21 g/day, dry biomass growth rate of KN was 0.22 ± 0.07 g/day. At the same time, the lower biomass growth rate was recognized in WR2 (WT) of wet biomass growth rate and dry biomass growth rate was 0.6 ± 0.22 g/day and 0.11 ± 0.22 g/day, respectively.

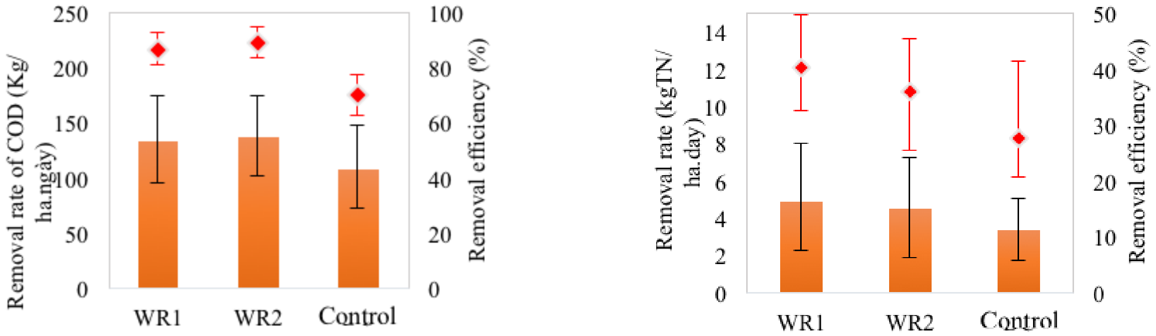

Figure 2. Pollutant removal of different WRS.

Results showed that COD removal efficiencies of WRs were 86-89% or 125 ± 3.6 kgCOD/ha.day, except control was only 69% or 99±24 kgCOD/ha.day. Nutrient removal of all WRs was insufficiently reached as indicated by TN of 35-39% or 3.5-4.17 kg TN/ha.day, similar removal performance to control WR. But TP removal efficiency was greatly reached of 67-73% (0,29 ± 0,13 kg TP/ha.day) with two planted WRs, but unplanted WR was only 28% (0,13 ± 0,05 kg TP/ha.day).

The rate of removal rate constants in planted system for COD, TN, TP were indicated in the Table 3. For non-plant systems, kinetic values are significantly lower.

Table 3. Removal rate constants of experimental WRs for COD, TP and TN

	k-COD (m^3/ m^2.day)	**k-TP** (m^3/ m^2.day)	**k-TN** (m^3/ m^2.day)
WR1	0,07	0,067	0,026
WR2	0,109	0,050	0,024
Control	0,037	0,014	0,018

In the future, the application of WRs in urban buildings would bring several benefits for urban cities of developing countries. Other interesting aspects could be investigated further such as its thermal benefit, flood control, GHGs reduction and urban biodiversity.

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